VIRGINIA
DEPARTMENT OF TRANSPORTATION

ROAD AND BRIDGE SPECIFICATIONS

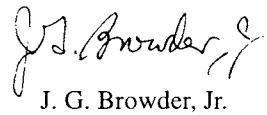
January 1997

Richmond

INTRODUCTION

These *Specifications* are standard for all *metric* contracts awarded by the Commonwealth Transportation Board. The requirements stated herein may be revised or amended from time to time but only to the extent permitted under the supplemental specifications and special provisions included in the specific contract.

Reference (date and title) will be made to these Specifications on plans and contract documents. Copies may be obtained from the Office of the Contract Engineer at 1401 East Broad Street, Richmond, Virginia 23219.



J. G. Browder, Jr.
Chief Engineer

TABLE OF CONTENTS

DIVISION I

GENERAL PROVISIONS

Section 101—Definitions of Abbreviations, Acronyms, and Terms . 3
101.01—Abbreviations and Acronyms 3
101.02—Terms 5

Section 102—Bidding Requirements and Conditions 15
102.01—Prequalification of Bidders 15
102.02—Content of Proposal 17
102.03—Interpretation of Quantities in Proposal 17
102.04—Examination of Site of Work and Proposal 17
102.05—Preparation of Bid 18
102.06—Irregular Bids 19
102.07—Proposal Guaranty 20
102.08—Disqualification of Bidder 20
102.09—Delivery of Bid 21
102.10—Withdrawal of Bid 22
102.11—Combination or Conditional Proposals 22
102.12—Public Opening of Bids 22
102.13—Material Guaranty 22
102.14—Use of Debarred Suppliers 23

Section 103—Award and Execution of Contracts 23
103.01—Consideration of Bids 23
103.02—Award of Contract 23
103.03—Cancellation of Award 24
103.04—Return of Proposal Guaranty 24
103.05—Requirements of Contract Bond 24
103.06—Contract Documents 25
103.07—Execution and Approval of Contract 27
103.08—Failure To Furnish Bonds or Certification of Insurance . . . 27

Section 104—Scope of Work 28
104.01—Intent of Contract 28
104.02—Alteration of Quantities or Character of Work 28
104.03—Differing Site Conditions 31
104.04—Maintenance During Construction 31
104.05—Removing and Disposing of Structures and Obstructions 35
104.06—Cleanup 36

Section 105—Control of Work 36
105.01—Authority of Engineer 36
105.02—Plans and Working Drawings 37
105.03—Conformity with Plans and Specifications 39

105.04—Furnishing and Erecting Precast Structures 39
105.05—Coordination of Plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, and Special Provision Copied Notes 40
105.06—Cooperation of Contractor 41
105.07—Cooperation With Regard to Utilities 41
105.08—Cooperation Among Contractors 43
105.09—Holidays 44
105.10—Construction Stakes, Lines, and Grades 44
105.11—Authority and Duties of Inspector 45
105.12—Inspection of Work 45
105.13—Removal of Unacceptable and Unauthorized Work 46
105.14—Size and Mass (Weight) Limitations 47
105.15—Acceptance 47
105.16—Submission and Disposition of Claims 48

Section 106—Control of Material 50
106.01—Source of Supply and Quality Requirements 51
106.02—Material Inspection 51
106.03—Local Material Sources (Pits and Quarries) 51
106.04—Disposal Areas 54
106.05—Rights for and Use of Materials Found on Projects 56
106.06—Samples, Tests, and Cited Specifications 56
106.07—Plant Inspection 57
106.08—Storing Materials 58
106.09—Handling Materials 58
106.10—Unacceptable Materials 58
106.11—Material Furnished by the Department 59

Section 107—Legal Relations and Responsibility to the Public ... 59
107.01—Laws To Be Observed 59
107.02—Permits, Certificates, and Licenses 60
107.03—Patented Devices, Materials, and Processes 61
107.04—Restoration of Work Performed by Others 62
107.05—Federal-Aid Provisions 62
107.06—Sanitary Provisions 62
107.07—Public Convenience and Safety 62
107.08—Railway-Highway Provisions 63
107.09—Construction Over or Adjacent to Navigable Waters 77
107.10—Barricades and Warning Signs 77
107.11—Use of Explosives 77
107.12—Protecting and Restoring Property and Landscape 78
107.13—Responsibility for Damage Claims 78
107.14—Environmental Stipulations 79
107.15—Opening Sections of Projects to Traffic 83
107.16—Contractor's Responsibility for Work 84
107.17—Contractor's Responsibility for Utility Property and Services 84

107.18—Furnishing Right of Way 85
107.19—Personal Liability of Public Officials 85
107.20—No Waiver of Legal Rights 85

Section 108—Prosecution and Progress of Work 86
108.01—Subcontracting 86
108.02—Notice to Proceed 86
108.03—Prosecution of Work 86
108.04—Critical Materials 87
108.05—Limitation of Operations 87
108.06—Gratuities 87
108.07—Character of Workers, Work Methods, and Equipment 88
108.08—Progress Schedule 89
108.09—Determination and Extension of Contract Time Limit 89
108.10—Suspension of Work Ordered by the Engineer 91
108.11—Failure To Complete on Time 92
108.12—Liquidated Damages 92
108.13—Default of Contract 92
108.14—Termination of Contract 94
108.15—Termination of Contractor's Responsibilities 95

Section 109—Measurement and Payment 95
109.01—Measurement of Quantities 95
109.02—Plan Quantities 99
109.03—Scope of Payment 100
109.04—Compensation for Altered Quantities 101
109.05—Extra and Force Account Work 101
109.06—Eliminated Items 104
109.07—Partial Payments 104
109.08—Payment for Material on Hand 107
109.09—Final Payment 108

Section 110—Miscellaneous Provisions 110
110.01—Common Carrier Rates 110
110.02—Labor and Wages 111
110.03—Equal Employment Opportunity 111
110.04—Use of Minority Business Enterprises 117
110.05—Construction Safety and Health Standards 120
110.06—Bulletin Boards and Posting Official Notes 120
110.07—Certification of Nonsegregated Facilities 121

DIVISION II

MATERIALS

Section 200—General 125
200.01—Description 125

200.02—Conformance With Specifications 125
200.03—General Sampling and Testing Procedures 125
200.04—Acceptance Procedures for Aggregates 126
200.05—Handling and Storing Aggregates 127
200.06—Technician and Batcher Certification 128

Section 201—Mineral Filler 128
201.01—Description 128
201.02—Detail Requirements 129

Section 202—Fine Aggregate 129
202.01—Description 129
202.02—Materials 129
202.03—Detail Requirements 129

Section 203—Coarse Aggregate 131
203.01—Description 131
203.02—Materials 131
203.03—Detail Requirements 132

Section 204—Stone for Masonry, Riprap, Porous Backfill, and Gabions 135
204.01—Description 135
204.02—Detail Requirements 135

Section 205—Crusher Run Aggregate 135
205.01—Description 135
205.02—Materials 135
205.03—Detail Requirements 136

Section 206—Lightweight Aggregate 136
206.01—Description 136
206.02—Detail Requirements 137

Section 207—Select Material 137
207.01—Description 137
207.02—Detail Requirements 137
207.03—Job-Mix Formula for Select Material, Type I 139
207.04—Mixing 139
207.05—Acceptance of Select Material, Type I 139
207.06—Referee System for Select Material, Type I 140
207.07—Payment Adjustment System for Select Material, Type I 140

Section 208—Subbase and Aggregate Base Material 141
208.01—Description 141
208.02—Materials 141
208.03—Detail Requirements 142
208.04—Job-Mix Formula 144

208.05—Mixing 144
208.06—Acceptance 144
208.07—Referee System 145
208.08—Payment Adjustment System 146

Section 209—Open Graded Shoulder Material 148
209.01—Description 148
209.02—Detail Requirements 148
209.03—Mixing 148

Section 210—Asphalt Materials 149
210.01—Description 149
210.02—Materials 149
210.03—Detail Requirements 150
210.04—Payment Adjustment System 150

Section 211—Asphalt Concrete 150
211.01—Description 150
211.02—Materials 150
211.03—Job-Mix Formula 153
211.04—Asphalt Concrete Mixtures 156
211.05—Testing 158
211.06—Tests 160
211.07—Plant Inspection 160
211.08—Acceptance 160
211.09—Adjustment System 163
211.10—Referee System 163
211.11—Handling and Storing Aggregates 164
211.12—Asphalt Concrete Mixing Plant 164
211.13—Preparation of Mixture 169
211.14—Storage System 169

Section 212—Joint Materials 170
212.01—Description 170
212.02—Detail Requirements 170

Section 213—Damp-Proofing Materials 180
213.01—Description 180
213.02—Detail Requirements 180

Section 214—Hydraulic Cement 184
214.01—Description 184
214.02—Detail Requirements 184

Section 215—Hydraulic Cement Concrete Admixtures 184
215.01—Description 184
215.02—Materials 185
215.03—Detail Requirements 185

Section 216—Water for Use With Cement or Lime 186
216.01—Description 186
216.02—Detail Requirements 186

Section 217—Hydraulic Cement Concrete 187
217.01—Description 187
217.02—Materials 187
217.03—Handling and Storing Materials 190
217.04—Measurement of Materials 190
217.05—Equipment 192
217.06—Classification of Concrete Mixtures 194
217.07—Proportioning Concrete Mixtures 194
217.08—Acceptance 198
217.09—Mixing 199
217.10—Placement Limitations 202

Section 218—Hydraulic Cement Mortar and Grout 203
218.01—Description 203
218.02—Materials 203
218.03—Detail Requirements 203

Section 219—Right-of-Way Monuments 204
219.01—Description 204
219.02—Detail Requirements 204

Section 220—Concrete Curing Materials 205
220.01—Description 205
220.02—Detail Requirements 205

Section 221—Guardrail 206
221.01—Description 206
221.02—Detail Requirements 206

Section 222—Masonry Units 208
222.01—Description 208
222.02—Detail Requirements 208

Section 223—Steel Reinforcement 209
223.01—Description 209
223.02—Detail Requirements 209

Section 224—Castings 211
224.01—Description 211
224.02—Materials 211
224.03—Detail Requirements 211

Section 225—Steel Forgings and Steel Shafting 211
225.01—Description 211
225.02—Detail Requirements 212

Section 226—Structural Steel 212
226.01—Description 212
226.02—Detail Requirements 212

Section 227—Steel Grid Flooring 217
227.01—Description 217
227.02—Materials 218
227.03—Detail Requirements 218

Section 228—Steel Piles 218
228.01—Description 218
228.02—Detail Requirements 218

Section 229—Aluminum Alloy 219
229.01—Description 219
229.02—Detail Requirements 219

Section 230—Bronze and Copper Alloy 221
230.01—Description 221
230.02—Detail Requirements 221

Section 231—Paint 221
231.01—Description 221
231.02—Materials 221
231.03—Detail Requirements 223

Section 232—Pipe and Pipe Arches 231
232.01—Description 231
232.02—Detail Requirements 231

Section 233—Galvanizing 240
233.01—Description 240
233.02—Detail Requirements 240
233.03—Repair of Galvanized Surfaces 240

Section 234—Glass Beads for Reflectorizing Traffic Markings ... 241
234.01—Description 241
234.02—Detail Requirements 241

Section 235—Retroreflectors 241
235.01—Description 241
235.02—Detail Requirements 242

Section 236—Wood Products **244**
236.01—Description 244
236.02—Detail Requirements 244

Section 237—Bedding Materials and Bearing Pads **246**
237.01—Description 246
237.02—Detail Requirements 247

Section 238—Electrical and Signal Components **251**
238.01—Description 251
238.02—Detail Requirements 251

Section 239—Sodium Chloride and Calcium Chloride **258**
239.01—Description 258
239.02—Detail Requirements 259

Section 240—Lime **259**
240.01—Description 259
240.02—Detail Requirements 260

Section 241—Fly Ash **260**
241.01—Description 260
241.02—Detail Requirements 260

Section 242—Fences **261**
242.01—Description 261
242.02—Detail Requirements 261

Section 243—Epoxy-Resin Systems **266**
243.01—Description 266
243.02—Detail Requirements 266
243.03—Handling and Storing Materials 270
243.04—Acceptance 270

Section 244—Roadside Development Materials **271**
244.01—Description 271
244.02—Detail Requirements 271

Section 245—Geosynthetics **281**
245.01—Description 281
245.02—Detail Requirements 281
245.03—Testing and Documentation 281

Section 246—Pavement Marking **283**
246.01—Description 283
246.02—Detail Requirements 283

Section 247—Reflective Sheeting **290**
247.01—Description 290
247.02—Detail Requirements 290

DIVISION III

ROADWAY CONSTRUCTION

Section 301—Clearing and Grubbing **299**
301.01—Description 299
301.02—Procedures 299
301.03—Measurement and Payment 300

Section 302—Drainage Structures **301**
302.01—Description 301
302.02—Materials 301
302.03—Procedures 302
302.04—Measurement and Payment 311

Section 303—Earthwork **316**
303.01—Description 316
303.02—Materials 316
303.03—Erosion and Siltation Control 316
303.04—Procedures 319
303.05—Tolerances 329
303.06—Measurement and Payment 330

Section 304—Constructing Density Control Strips **338**
304.01—Description 338
304.02—Materials 338
304.03—Equipment 339
304.04—Procedures 339
303.05—Tolerances 340
303.06—Measurement and Payment 340

Section 305—Subgrade and Shoulders **341**
305.01—Description 341
305.02—Materials 341
305.03—Procedures 341
305.04—Measurement and Payment 344

Section 306—Lime Stabilization **346**
306.01—Description 346
306.02—Materials 346
306.03—Procedures 346
306.04—Measurement and Payment 349

Section 307—Hydraulic Cement Stabilization 350
307.01—Description 350
307.02—Materials 350
307.03—Field Laboratory 350
307.04—Weather Limitations 351
307.05—Procedures 351
307.06—Measurement and Payment 356

Section 308—Subbase Course 357
308.01—Description 357
308.02—Materials 357
308.03—Procedures 357
308.04—Tolerances 358
308.05—Measurement and Payment 359

Section 309—Aggregate Base Course 360
309.01—Description 360
309.02—Materials 360
309.03—Equipment 360
309.04—Procedures 360
309.05—Density Requirements 361
309.06—Measurement and Payment 362

Section 310—Tack Coat 362
310.01—Description 362
310.02—Materials 362
310.03—Procedures 363
310.04—Measurement and Payment 364

Section 311—Prime Coat 364
311.01—Description 364
311.02—Materials 364
311.03—Procedures 365
311.04—Measurement and Payment 366

Section 312—Seal Coat 366
312.01—Description 366
312.02—Materials 366
312.03—Equipment 366
312.04—Procedures 367
312.05—Measurement and Payment 368

Section 313—Asphalt Surface Treatment 368
313.01—Description 368
313.02—Materials 368
313.03—Procedures 369
313.04—Measurement and Payment 369

Section 314—Penetration Surface Courses 370
314.01—Description 370
314.02—Materials 370
314.03—Weather Limitations 370
314.04—Equipment 370
314.05—Procedures 371
314.06—Measurement and Payment 373

Section 315—Asphalt Concrete Pavement 373
315.01—Description 373
315.02—Materials 374
315.03—Equipment 374
315.04—Placement Limitations 375
315.05—Procedures 377
315.06—Pavement Samples 385
315.07—Pavement Tolerances 385
315.08—Measurement and Payment 389

Section 316—Hydraulic Cement Concrete Pavement 390
316.01—Description 390
316.02—Materials 390
316.03—Equipment 391
316.04—Procedures 393
316.05—Tolerances 409
316.06—Measurement and Payment 409

DIVISION IV

BRIDGES AND STRUCTURES

Section 401—Structure Excavation 413
401.01—Description 413
401.02—Materials 413
401.03—Procedures 413
401.04—Measurement and Payment 417

Section 402—Sheet Piles 419
402.01—Description 419
402.02—Materials 419
402.03—Procedures 419
402.04—Measurement and Payment 420

Section 403—Bearing Piles 421
403.01—Description 421
403.02—Materials 421
403.03—Pile Types 421
403.04—Determination of Pile Lengths 426

403.05—Order List 427
403.06—Procedures 427
403.07—Determination of Bearing Capacities 432
403.08—Measurement and Payment 437

Section 404—Hydraulic Cement Concrete Operations 439
404.01—Description 439
404.02—Materials 439
404.03—Procedures 439
404.04—Bridge Deck Construction 459
404.05—Expansion and Fixed Joints 460
404.06—Bridge Seat Bearing Areas 462
404.07—Finishing Concrete Surfaces 462
404.08—Measurement and Payment 465

Section 405—Prestressed Concrete 466
405.01—Description 466
405.02—Materials 466
405.03—Plant Review 467
405.04—Concrete Controls 468
405.05—Procedures 468
405.06—Tolerances 476
405.07—Measurement and Payment 479

Section 406—Reinforcing Steel 480
406.01—Description 480
406.02—Materials 480
406.03—Procedures 480
406.04—Measurement and Payment 483

Section 407—Steel Structures 484
407.01—Description 484
407.02—Materials 485
407.03—Working Drawings 485
407.04—Fabrication Procedures 485
407.05—Handling, Storing, and Shipping Materials 495
407.06—Erection Procedures 495
407.07—Measurement and Payment 504

Section 408—Bearing Devices and Anchors 506
408.01—Description 506
408.02—Materials and Fabrication 506
408.03—Procedures 507
408.04—Measurement and Payment 526

Section 409—Steel Grid Floors 526
409.01—Description 526
409.02—Materials 526

409.03—Procedures 527
409.04—Measurement and Payment 528

Section 410—Railings and Parapets 528
410.01—Description 528
410.02—Materials 529
410.03—Procedures 529
410.04—Measurement and Payment 531

Section 411—Protective Coating of Metal in Structures 532
411.01—Description 532
411.02—Materials 532
411.03—Procedures 533
411.04—New Structures 537
411.05—Existing Structures 538
411.06—Painting Galvanized Surfaces 539
411.07—Environmental Protection 539
411.08—Measurement and Payment 541

Section 412—Widening, Repairing, and Reconstructing Existing Structures 542
412.01—Description 542
412.02—Materials 543
412.03—Procedures 544
412.04—Measurement and Payment 555

Section 413—Dismantling and Removing Existing Structures or Removing Portions of Existing Structures 557
413.01—Description 557
413.02—Procedures 558
413.03—Measurement and Payment 558

Section 414—Riprap 559
414.01—Description 559
414.02—Materials 559
414.03—Procedures 559
414.04—Measurement and Payment 565

Section 415—Concrete Slope Protection 566
415.01—Description 566
415.02—Materials 566
415.03—Procedures 567
415.04—Measurement and Payment 568

Section 416—Waterproofing 568
416.01—Description 568
416.02—Materials 569
416.03—Procedures 569

416.04—Measurement and Payment 570

Section 417—Damp-Proofing 571
417.01—Description 571
417.02—Materials 571
417.03—Procedures 571
417.04—Measurement and Payment 571

Section 418—Timber Structures 572
418.01—Description 572
418.02—Materials 572
418.03—Procedures 572
418.04—Measurement and Payment 576

Section 419—Bridge Conduit Systems and Lighting Systems 577
419.01—Description 577
419.02—Materials 577
419.03—Procedures 577
419.04—Measurement and Payment 577

Section 420—Preformed Elastomeric Joint Sealer 578
420.01—Description 578
420.02—Materials 578
420.03—Procedures 578
420.04—Measurement and Payment 578

Section 421—Elastomeric Expansion Dams 579
421.01—Description 579
421.02—Materials 580
421.03—Procedures 580
421.04—Measurement and Payment 580

Section 422—Navigation Lights 581
422.01—Description 581
422.02—Materials 581
422.03—Procedures 581
422.04—Measurement and Payment 582

DIVISION V

INCIDENTAL CONSTRUCTION

Section 501—Underdrains 585
501.01—Description 585
501.02—Materials 585

501.03—Procedures 585
501.04—Measurement and Payment 586

Section 502—Incidental Concrete Items 586
502.01—Description 586
502.02—Materials 587
502.03—Procedures 587
502.04—Measurement and Payment 591

Section 503—Right-of-Way Monuments 593
503.01—Description 593
503.02—Materials 593
503.03—Procedures 593
503.04—Measurement and Payment 593

Section 504—Sidewalks, Steps, and Handrails 594
504.01—Description 594
504.02—Materials 594
504.03—Procedures 594
504.04—Measurement and Payment 597

Section 505—Guardrail and Steel Median Barriers 598
505.01—Description 598
505.02—Materials 599
505.03—Procedures 599
505.04—Measurement and Payment 600

Section 506—Retaining Walls 602
506.01—Description 602
506.02—Materials 602
506.03—Procedures 603
506.04—Measurement and Payment 605

Section 507—Fences 606
507.01—Description 606
507.02—Materials 606
507.03—Procedures 606
507.04—Measurement and Payment 608

Section 508—Demolition of Pavement and Obscuring Roadway .. 609
508.01—Description 609
508.02—Procedures 609
508.03—Measurement and Payment 610

Section 509—Patching Hydraulic Cement Concrete Pavement ... 611
509.01—Description 611

509.02—Materials 611
509.03—Procedures 612
509.04—Measurement and Payment 614

Section 510—Relocating or Modifying Existing Miscellaneous Items 614
510.01—Description 614
510.02—Materials 614
510.03—Procedures 615
510.04—Measurement and Payment 615

Section 511—Allaying Dust 616
511.01—Description 616
511.02—Procedures 616
511.03—Measurement and Payment 616

Section 512—Maintaining Traffic 616
512.01—Description 616
512.02—Materials 617
512.03—Procedures 617
512.04—Measurement and Payment 624

Section 513—Mobilization 628
513.01—Description 628
513.02—Measurement and Payment 628

Section 514—Field Office 629
514.01—Description 629
514.02—Procedures 629
514.03—Measurement and Payment 632

Section 515—Planing Pavement 632
515.01—Description 632
515.02—Procedures 633
515.03—Measurement and Payment 633

Section 516—Demolition of Buildings and Clearing Parcels 634
516.01—Description 634
516.02—Procedures 634
516.03—Measurement and Payment 635

Section 517—Utility Coordinator 636
517.01—Description 636
517.02—Procedures 636
517.03—Measurement and Payment 637

Section 518—Trainees on Construction Projects **637**
518.01—Description 637
518.02—Procedures 637
518.03—Measurement and Payment 639

Section 519—Sound Barrier Walls **640**
519.01—Description 640
519.02—Materials 640
519.03—Procedures 644
519.04—Measurement and Payment 645

Section 520—Water and Sanitary Sewer Facilities **646**
520.01—Description 646
520.02—Materials 646
520.03—Procedures 647
520.04—Testing 653
520.05—Disinfecting Water Mains 657
520.06—Measurement and Payment 658

DIVISION VI

ROADSIDE DEVELOPMENT

Section 601—Selective Tree Removal, Trimming, and Cleanup ... **665**
601.01—Description 665
601.02—Materials 665
601.03—Procedures 665
601.04—Measurement and Payment 666

Section 602—Topsoil **666**
602.01—Description 666
602.02—Materials 666
602.03—Procedures 666
602.04—Measurement and Payment 667

Section 603—Seeding **667**
603.01—Description 667
603.02—Materials 667
603.03—Procedures 668
603.04—Measurement and Payment 669

Section 604—Sodding **670**
604.01—Description 670
604.02—Materials 670

604.03—Procedures 671
604.04—Measurement and Payment 672

Section 605—Planting 672
605.01—Description 672
605.02—Materials 672
605.03—Procedures 672
605.04—Care of Plants 676
605.05—Establishment Period 676
605.06—Guarantee 678
605.07—Measurement and Payment 678

Section 606—Soil Retention Coverings 679
606.01—Description 679
606.02—Materials 679
606.03—Procedures 679
606.04—Measurement and Payment 680

Section 607—Herbicide Spraying 680
607.01—Description 680
607.02—Materials 681
607.03—Procedures 681
607.04—Measurement and Payment 681

Section 608—Mowing 681
608.01—Description 681
608.02—Equipment 681
608.03—Measurement and Payment 682

Section 609—Tree Wells and Tree Walls 682
609.01—Description 682
609.02—Procedures 682
609.03—Measurement and Payment 682

Section 610—Gabions 683
610.01—Description 683
610.02—Materials 683
610.03—Procedures 683
610.04—Measurement and Payment 684

DIVISION VII

TRAFFIC CONTROL DEVICES

Section 700—General 689
700.01—Description 689
700.02—Materials 689

700.03—Working Drawings 691
700.04—Procedures 691
700.05—Measurement and Payment 698

Section 701—Traffic Signs 700
701.01—Description 700
701.02—Materials 700
701.03—Procedures 700
701.04—Measurement and Payment 705

Section 702—Delineators 706
702.01—Description 706
702.02—Materials 706
702.03—General Requirements 706
702.04—Procedures 707
702.05—Measurement and Payment 708

Section 703—Traffic Signals 708
703.01—Description 708
703.02—Equipment 709
703.03—Procedures 729
703.04—Measurement and Payment 736

Section 704—Pavement Markings and Markers 738
704.01—Description 738
704.02—Materials 738
704.03—Procedures 739
704.04—Measurement and Payment 745

Section 705—Lighting Systems 746
705.01—Description 746
705.02—Materials 746
705.03—Procedures 746
705.04—Measurement and Payment 748

LIST OF TABLES

I-1—Schedule of Liquidated Damages 92

II-1—Fine Aggregate 130
II-2—Soundness 130
II-3—Sizes of Open Graded Coarse Aggregates 133
II-4—Soundness 134
II-5—Abrasion 134
II-6—Design Range: Select Material, Type I 137
II-7—Process (P) and Range (R) Tolerance: Select Material, Type I 138
II-8—Atterberg Limits: Select Material, Type I 138
II-9—Design Range for Dense Graded Aggregates 142
II-10—Process Tolerances for Each Laboratory Sieve (%) 143
II-11—Atterberg Limits 143
II-12—Standard Deviation 147
II-13—Mixture Design Criteria 155
II-14—Design Range: Asphalt Concrete Mixtures 159
II-15—Process Tolerance on Each Laboratory Sieve and Asphalt Content (%) 161
II-16—Standard Deviation 164
II-17—Requirements for Hydraulic Cement Concrete 195
II-18—(Deleted)
II-19—Epoxide Equivalent 266
II-20—(Deleted)
II-21—Requirements: Mixed Epoxy Systems 267
II-22—Fine Aggregate (Silica Sand) 269
II-23—Preformed Tape Pavement Markings 288

III-1—Limited Asphalt Application Temperature 363
III-2—Asphalt Concrete Paving Limitations 376
III-3—Density Requirements 383
III-4—Payment Schedule for Lot Densities 384

IV-1—Pile Tolerance Criteria 431
IV-2—Requirements for Removing Formwork and Constructing Superimposed Elements 453
IV-3—Bolt Tension 498
IV-4—Nut Rotation From Snug Tight Condition 500
IV-6—Paint Systems 536

VII-1—Pavement Markings 740

Division I

GENERAL PROVISIONS

SECTION 101—DEFINITIONS OF ABBREVIATIONS, ACRONYMS, AND TERMS

101.01—Abbreviations and Acronyms.

In these specifications and in other contract documents, the following abbreviations and acronyms shall be interpreted as follows:

AAR ..... Association of American Railroads
AASHTO ..... American Association of State Highway and Transportation Officials
ABS ..... Acrylonitrilebutadienestyrene (an elastomer)
AC ..... Alternating current
ACI ..... American Concrete Institute
ADT ..... Annual average daily traffic
AED ..... Associated Equipment Distributors
AISC ..... American Institute of Steel Construction
AISI ..... American Iron and Steel Institute
ANSI ..... American National Standards Institute
APA ..... American Plywood Association
API ..... American Petroleum Institute; American Pipe Institute
AREA ..... American Railway Engineering Association
ASCE ..... American Society of Civil Engineers
ASME ..... American Society of Mechanical Engineers
ASTM ..... American Society for Testing and Materials
AWG ..... American wire gage
AWPA ..... American Wood Preservers Association
AWS ..... American Welding Society
AWWA ..... American Water Works Association

BOCA ..... Building Officials and Code Administrators

CBR ..... California bearing ratio
CRSI ..... Concrete Reinforcing Steel Institute

DBE ..... Disadvantaged Business Enterprise
DC ..... Direct current
DHV ..... Design hourly volume

EEI ..... Edison Electric Institute
EEO ..... Equal employment opportunity
EIA ..... Electronic Industries Association
EPA ..... Environmental Protection Agency
EPDM ..... Ethylenepropylenedienemonomer (an elastomer)

F/A ..... Filler/asphalt ratio
FHWA ..... Federal Highway Administration
FS ..... Federal Specifications, General Services Administration

ICEA ..... Insulated Cable Engineers Association
IMSA ..... International Municipal Signal Association
ITE ..... Institute of Transportation Engineers

LCD ..... Liquid crystal display
LPG ..... Liquid petroleum gas

MBE ..... Minority Business Enterprise
MEKP ..... Methyl ethyl ketone peroxide
MIL ..... Military specifications
MSDS ..... Materials Safety Data Sheet
MUTCD ..... *Manual on Uniform Traffic Control Devices for Streets and Highways* and the Virginia supplement to same

NEC ..... National Electrical Code
NEMA ..... National Electrical Manufacturers Association
NIST ..... National Institute of Standards and Technology
NRC ..... Nuclear Regulatory Commission

PCI ..... Prestressed Concrete Institute
PE ..... Polyethylene
PTL ..... Plywood Testing Laboratory
PVC ..... Polyvinylchloride
PVF ..... Polyvinylfluoride

REA ..... Rural Electrification Administration

SAE ..... Society of Automotive Engineers
SI ..... The International System of Units
SPIB ..... Southern Pine Inspection Bureau
SSPC ..... Steel Structures Painting Council

TAPPI ..... Technical Association of Pulp and Paper Industry
TFE ..... Polytetrafluoroethylene

UL ..... Underwriters' Laboratories, Inc.

VAC ..... Volts alternating current
VDC ..... Volts direct current
VDOT ..... Virginia Department of Transportation
VEP ..... Value engineering proposal
VFA ..... Voids filled with asphalt
VMA ..... Voids in mineral aggregate
VOSH ..... Virginia Occupational and Health Administration
VTM ..... Virginia test methods; voids in total mix

WBE ..... Women Business Enterprise

101.02—Terms.

In these specifications and in other contract documents, the following terms and pronouns used in place of them shall be interpreted as follows:

- A -

Advertisement, Notice of. A public announcement, as required by law, inviting bids for work to be performed or materials to be furnished that indicates approximate principal quantities, location of work to be performed, character and quantity of materials to be furnished, and time and place for opening bids.

Alkali soil. Soil in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent based on total solids.

Award. The decision of the Board to accept the bid of the lowest responsive and responsible bidder for the work. The award is subject to the execution and approval of a satisfactory Contract therefor, and such conditions as may be specified or required by law.

Award date. The date on which the decision is made by the Board to accept the bid of the lowest responsive and responsible bidder.

- B -

Backfill. Material used to replace or the act of replacing material removed during construction; may also denote material placed or the act of placing material adjacent to structures.

Balance point. The approximate point, based on estimated shrinkage or swell, where the quantity of earthwork excavation and borrow, if required, is equal to the quantity of embankment material plus any surplus excavation material.

Base course. A layer of material of specified thickness on which the intermediate or surface course is placed.

Base flood. The flood or tide having a one percent chance of being exceeded in any given year.

Bid. The offer of a bidder, submitted on the proposal, to perform the work and furnish the materials and labor at the prices set forth therein; valid only when properly signed and guaranteed.

Bidder. Any individual, partnership, corporation, or joint venture that formally submits a bid for the work contemplated, or for any portion thereof, acting directly or through a duly authorized representative.

Bids, Invitation for. See **Advertisement, Notice of.**

Board. Commonwealth Transportation Board of Virginia.

Borrow. Suitable material from sources outside the roadway that is used primarily for embankments.

Brackish water. Water in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent based on total solids.

Bridge. A structure, including supports, that is erected over a depression or an obstruction, such as water, a highway, or a railway, that has a track or passageway for carrying traffic.

- C -

Calendar day. Any day shown on the calendar.

Camber. A vertical curvature induced or fabricated into beams or girders and a deck slab or slab span formwork; a vertical curvature set in the grade line of a pipe culvert to accommodate differential settlement.

Channel. A water course or drainage way.

Commissioner. Commonwealth Transportation Commissioner.

Composite hydrograph. A graph showing the mean daily discharge versus the calendar day, indicating trends in high and low flow for a 1-year period.

Construction area. The area where authorized construction occurs.

Construction limits. The intersection of side slopes, including slope rounding, with the original ground, plus slopes for drainage ditches or incidental construction.

Contract. The written agreement executed between the Department and the Contractor that sets forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, furnishing of materials and labor, and basis of payment. The Contract also includes these specifications; supplemental specifications; special provisions; special provision copied notes; plans; standard drawings; change orders; and work orders and agreements that are required to complete the construction of the specified work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument. Oral representations or promises shall not be considered a part of the Contract.

Contract Engineer. The Engineer's authorized representative for administering the advertisement, receiving bids, and awarding contracts for the Department.

Contract item. A specifically described unit of work for which a price is provided in the Contract.

Contract time limit. The number of calendar days or calendar date that specifies the time allowed for completion of the work described in the Contract, including authorized extensions.

Contractor. Any individual, partnership, corporation, or joint venture that contracts with the Department to perform the prescribed work.

Cul-de-sac. An area at the terminus of a dead-end street or road that is constructed for the purpose of allowing vehicles to turn around.

Culvert. A structure that is not classified as a bridge that provides an opening under any roadway.

Cut. The portion of a roadway formed by excavating below the surface of the earth.

- D -

Day. Unless otherwise stated, a calendar day.

Deflection. The vertical movement occurring between the supports of a bridge superstructure or its components (beams, girders, and slabs) that results from their own weight and from dead and live loads. Although all parts of a structure are subject to deflections, usually only those deflections that occur in the superstructure are of significance during construction.

Department. Virginia Department of Transportation.

Deputy Commissioner. The assistant to the Commissioner who performs such of the Commissioner's duties as have been delegated to him by the Commissioner.

Design flood. The magnitude of flood that a given structure can convey without exceeding a designated flood level.

Disincentive. A monetary deterrent used to discourage the Contractor from exceeding the contract time limit.

Disposable material. Material generally found to be unsuitable for roadway construction or material that is surplus.

Disposal areas. Areas generally located off the project right of way where unsuitable or surplus material is deposited.

Drainage ditch. An artificial depression constructed to carry off surface water.

- E -

Earthwork. The work consisting of grubbing, drainage, roadway excavation, embankment excavation, borrowing, grading, placing rock, and preparing subgrades.

Easement (Right of way). A grant of the right to use property for a specific use.

Embankment. A structure of soil, soil aggregate, or broken rock between the existing ground and subgrade.

Employee. Any person working on the project specified in the Contract who is under the direction or control of or receives compensation from the Contractor or subcontractor.

Engineer. The Chief Engineer, who acts directly or through his duly authorized representative. The representative acts within the scope of the particular duties assigned to him or the authority given to him.

Equipment. Machinery, tools, and other apparatus, together with the necessary supplies for upkeep and maintenance, that are necessary for acceptable completion of the work.

Extra work. An item of work that is not provided for in the Contract as awarded but that is found to be essential to the satisfactory fulfillment of the Contract within its intended scope.

- F -

Falsework. A framework of wood or steel used to support forms for the construction of concrete slab spans or t-beams, or provide temporary support for structural units during the construction or reconstruction of permanent supports.

Federal agencies or officers. An agency or officer of the federal government and any agency or officer succeeding in accordance with the law to the powers, duties, jurisdictions, and authority of the agency or officer mentioned.

Flood frequency. A statistical average recurrence interval of floods of a given magnitude.

Force account work. Prescribed work of a contractual status performed by the Contractor and compensated for as specified in Section 109.05.

Formwork. A temporary structure or mold used to retain the plastic or fluid concrete in its designated shape until it hardens. Formwork shall be designed to resist the fluid pressure exerted by plastic concrete and additional fluid pressure generated by vibration and temporary construction loads.

Frontage street or road. A local street or road auxiliary to and located on the side of a highway for service to abutting property and adjacent areas and control of access.

- G -

Gage. U.S. Standard Gage.

Grade separation. Any structure that provides a traveled way over or under another traveled way or stream.

- H -

Highway. The entire right of way reserved for use in constructing or maintaining the roadway and its appurtenances.

Historical flood level. The highest flood level that is known to have occurred at a given location.

Holidays. The days specifically set forth in Section 105.09.

Hydrologic data sheet. A tabulation of hydrologic data for facilities conveying a 100-year discharge equal to or greater than 14.15 cubic meters per second.

- I -

Incentive. A monetary amount used to encourage the Contractor to complete work prior to the time limit specified in the Contract.

Inspector. The Engineer's authorized representative who is assigned to make detailed inspections of the quality and quantity of the work and its conformance to the provisions of the Contract.

Invert. The lowest point in the internal cross section of a pipe or other drainage structure.

- J -

Joint venture. Two or more individuals, partnerships, corporations, or combinations thereof that join together for the purpose of bidding on and constructing a project.

- L -

Laboratory. The testing laboratory of the Department or any other testing laboratory that may be designated by the Engineer.

Liquidated damages. Compensatory damages as set forth in the Contract, paid by the Contractor to the Department when the Contractor fails to complete the project within the time frame specified in the Contract. These damages include, but are not limited to, additional costs associated with administration, engineering, supervision, and inspection of the project.

- M -

Material. Any substance that is used in the work specified in the Contract.

Median. The portion of a divided highway that separates the traveled ways.

- N -

Notice to Proceed. A written notice to the Contractor that advises him of the date on which prosecution of the work shall begin.

- O -

Ordinary high water. A water elevation based on analysis of all daily high waters that will be exceeded approximately 25 percent of the time during any 12-month period.

Overtopping flood. The magnitude of flood that just overflows the traveled way at a given structure and/or on the approach traveled way of such structure.

- P -

Pavement structure. The combination of subbase, base, and surface courses that is placed on a subgrade to support the traffic load and distribute it to the roadbed.

Pay item. A specifically described unit of work for which a price is provided in the Contract.

Phase inspection. The inspection of work at predetermined stages in lieu of continuous inspection.

Plans. The approved plans and standard drawings, profiles, typical cross sections, computer output listings, supplemental drawings or exact reproductions thereof, and all subsequent approved revisions thereto that show the location, character, dimensions, and details of the work specified in the Contract.

Prequalification. The procedure used to assure the Department of the Contractor's ability to perform the work, experience in similar work, and sufficiency of equipment to accomplish the work and that the Contractor's financial resources will permit financing the work.

Profile grade. The line of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal center line of the roadbed.

Project. The work specified to be performed in the Contract.

Project showing. The scheduled event at which the Department's representative meets with prospective bidders to describe and answer questions regarding the proposed work.

Proposal. The document sent by the Department to prospective bidders that describes the work for which bids will be accepted; includes the official form on which the Department requires bids to be submitted for the work described.

- R -

Ramp. A connecting roadway between two highways or traveled ways or between two intersecting highways at a grade separation.

Right of way. A general term denoting land, property, or interest therein, usually in a strip, that is acquired for or devoted to transportation facilities but is not meant to denote the legal nature of ownership.

Road. A general term denoting a public way for purposes of vehicular travel including the entire area within the right of way; the entire area reserved for use in constructing or maintaining the roadway and its appurtenances.

Roadbed. The graded portion of a highway within the top and side slopes that is prepared as a foundation for the pavement structure and shoulders.

Roadbed material. The material below the subgrade in cuts, embankments, and embankment foundations that extends to a depth that affects the support of the pavement structure.

Roadside. A general term that denotes the area within the right of way that adjoins the outer edges of the roadway; extensive areas between the roadways of a divided highway.

Roadside development. Items that are necessary to complete a highway that provide for the preservation of landscape materials and features; rehabilitation and protection against erosion of areas disturbed by construction through placing seed, sod, mulch, and other ground covers; and such suitable plantings and other improvements as may increase the effectiveness and enhance the appearance of the highway.

Roadway. The portion of a highway within the limits of construction and all structures, ditches, channels, and waterways that are necessary for the correct drainage thereof.

- S -

Sea water. Water in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent of total solids.

Select borrow. Borrow material that has specified physical characteristics.

Select material. Material obtained from roadway cuts, borrow areas, or commercial sources that is designated or reserved for use as a foundation for the subbase, subbase material, shoulder surfacing, or other specified purposes.

Shoulder. The portion of the roadway contiguous with the traveled way that is for the accommodation of stopped vehicles, emergency use, and lateral support of the base and surface courses.

Sidewalk. The portion of the roadway constructed primarily for the use of pedestrians.

Skew. The acute angle formed by the intersection of a line normal to the center line of the roadway with a line parallel to the face of the abutments or, in the case of culverts, with the center line of the culverts.

Special provision. A document that sets forth specifications or requirements for a particular project.

Special provision copied note. A document that sets forth specifications or requirements, usually limited in scope, for a particular project.

Specialty item. An item of work designated as "Specialty Item" in the proposal that is limited to work that requires highly specialized knowledge, craftsmanship, or equipment that is not ordinarily available in contracting organizations prequalified to bid and is usually limited to minor components of the overall Contract.

Specifications. A general term that includes all directions, provisions, and requirements contained herein and those that may be added or adopted as supplemental specifications, special provisions, or special provision copied notes. All are necessary for the proper fulfillment of the Contract.

Standard drawings. Unless otherwise specified, applicable drawings in VDOT's *Road and Bridge Standards* and such other standard drawings as are referred to on the plans.

State. Commonwealth of Virginia.

Station. When used as a definition or term of measurement, 100 meters.

Street. A general term denoting a public way for purposes of vehicular travel including the entire area within the right of way; the entire right of way reserved for use in constructing or maintaining the roadway and its appurtenances.

Structures. Bridges, culverts, catch basins, inlets, retaining walls, cribs, manholes, end walls, buildings, steps, fences, sewers, service pipes, underdrains, foundation drains, and other features that may be encountered in the work and are not otherwise classed herein.

Subbase. A layer(s) of specified or selected material of designed thickness that is placed on a subgrade to support a base course.

Subcontractor. Any individual, partnership, corporation, or joint venture to whom the Contractor, with the written consent of the Department, subcontracts part of the Contract.

Subgrade. The top surface of a roadbed shaped to conform to the typical section on which the pavement structure and shoulders are constructed.

Subgrade stabilization. The modification of roadbed soils by admixing with stabilizing or chemical agents that will increase the load bearing capacity, firmness, and resistance to weathering or displacement.

Substructure. The part of a structure that is below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the back walls, wingwalls, and wing protection railings.

Superintendent. The executive representative of the Contractor who is authorized to receive and fulfill instructions from the Engineer and who supervises and directs the construction.

Superstructure. The portion of a structure that is not defined as substructure.

Supplemental specifications. Additions and revisions to these specifications that are adopted after the issuance of the printed book.

Surety. A corporate entity bound with and for the Contractor for full and complete fulfillment of the Contract and for payment of debts pertaining to the work. When applied to the proposal guaranty, it refers to the corporate body that engages to be responsible in the execution by the bidder, within the specified time, of a satisfactory Contract and the furnishing of an acceptable payment and contract bond.

Surface course. One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and disintegrating effects of weather. The top layer is sometimes called the wearing course.

Surplus material. Material that is present on a project as a result of unbalanced earthwork quantities, excessive swell, slides, undercutting, or other conditions beyond the control of the Contractor.

Suspension. A written notice issued by the Engineer to the Contractor that orders the work on a project to be stopped wholly or in part as specified. The notice will include the reason for the suspension.

- T -

Temporary structure. Any structure that is required to maintain traffic while permanent structures or parts of structures specified in the Contract are constructed or reconstructed. The temporary structure shall include earth approaches.

Ton. A metric ton; 1,000 kilograms.

Top of earthwork. The uppermost surface of the embankment excavation, exclusive of select material, that is shaped to conform with the typical section.

Traveled way. The portion of the roadway for the movement of vehicles, exclusive of shoulders.

- V -

Vouchered. The action of approval by the Department; constitutes the date of release to the State Comptroller for payment.

- W -

Wearing course. See **Surface course**.

Work. The furnishing of all materials, labor, tools, equipment, and incidentals necessary or convenient for the successful completion of the project and the carrying out of the duties and obligations specified in the Contract.

Working drawings. Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data the Contractor is required to submit to the Engineer for review.

Work order. A written order issued by the Engineer to the Contractor that specifies changes in the plans or quantities or both within the scope of the Contract and that establishes the basis of payment and time adjustments for the work affected by the changes.

SECTION 102—BIDDING REQUIREMENTS AND CONDITIONS

102.01—Prequalification of Bidders.

Prospective bidders shall prequalify with the Department and shall have received a certification of qualification in accordance with the rules and regulations adopted by the Board. However, unless otherwise required in the proposal, prequalification will not be required for items noted in the proposal as "Specialty Items."

The names of persons authorized to sign bids shall be on file with the Department. A name will be considered to be on file if it appears as that of an officer, a partner, or an owner on the current Contractor's Financial Statement. Requests by the bidder to revise the list of persons authorized to sign bids shall be submitted in writing and approved prior to the date bids are opened. A bid signed by someone whose name is not on file may be rejected.

The bidder shall certify on the Bidder Certification of Prequalification Classification and Work Capacity Form provided in the proposal that the necessary classification, type, and current maximum capacity rating are sufficient

to cover the amount of the bid and any uncompleted work under contract. Allowance will be made for subcontract work only on contracts with the Department, and then only if the work is listed on the Contractor's Proposal to Subcontract Form provided in the proposal.

Unless otherwise designated by the bidders, the bid amount of a joint venture will be divided equally to determine if the maximum capacity rating for each bidder is within each bidder's range.

When an individual is prequalified to bid jointly only with a specific company, the joint venture will be considered a unified entity for qualification purposes.

A bidder who makes a false certification on the Bidder Certification of Prequalification Classification and Work Capacity Form will be subject to forfeiture of the bid bond or disqualification from bidding on future work for a 90-day period, or both.

Bidders intending to submit bids consistently shall prequalify at least once a year. However, the maximum capacity rating or classification, or both, may be changed during that period if additional favorable reports are submitted or upon unsatisfactory performance. The Department may require a Contractor to furnish a current financial and experience statement at any time.

A Contractor may be temporarily disqualified from bidding on contracts with the Department when the dollar value of work completed on a current contract is more than 10 percent less than the dollar value of the work that should have been completed on the basis of the Contractor's latest approved progress schedule. Progress will be determined at the time of the monthly progress estimate. If the Contractor is delinquent by more than 10 percent, he may be notified that if the next monthly progress estimate shows a delinquency of more than 10 percent, his name may be removed from the list of prequalified bidders unless he can establish that the delinquency was attributable to conditions beyond his control. If his name is removed, the Contractor will not be reinstated as a prequalified bidder until the Engineer deems that his progress has improved to the extent that the work can be completed within the contract time limit or until final acceptance.

Temporary disqualification of a Contractor as provided herein will result in the temporary disqualification of each member of a joint venture and any affiliate having substantially the same operational management or drawing from the same equipment or labor resource pool. Temporary disqualification will also result in non-approval of the Contractor and each member of a joint venture, and affiliates as defined herein, for performance of work as subcontractors, which, in the opinion of the Engineer, could adversely affect other work under contract to the Department.

When the dollar value of the work completed has reached 90 percent of the dollar value of the Contractor's latest approved progress schedule, progress

will be determined at the time of the monthly progress estimate by comparing the percentage of time used with the percentage of work completed. When the percentage of time used exceeds the percentage of work completed by 10 percent or more, a notice of potential loss of prequalification may be issued. If the Contractor does not complete the work within 30 days or does not establish that the delinquency was attributable to conditions beyond his control, he may be removed from the list of prequalified bidders until final acceptance.

102.02—Content of Proposal.

Upon request, the Department will furnish a proposal to any interested party. The proposal will specify the location and description of the contemplated construction, the estimate of the various quantities and kinds of work to be performed or materials to be furnished, and a schedule of items for which unit bid prices are invited. The proposal will specify the time in which the work shall be completed and the date and time by which bids must be filed. The proposal will also include any applicable supplemental specifications, special provisions, or special provision copied notes.

Papers bound with or attached to the proposal will be considered a part of the bid. Unless otherwise permitted, they shall not be detached or altered when the bid is submitted. The plans, specifications, and other documents specified in the proposal will be considered a part of the proposal whether or not they are attached.

102.03—Interpretation of Quantities in Proposal.

The quantities appearing in the proposal are approximate only. The Contractor will be paid for the quantities of work accepted and materials furnished in accordance with the requirements of the Contract. The scheduled quantities of work to be performed and materials to be furnished may be increased, diminished, or omitted as hereinafter provided. When payment of any item in the Contract is indicated to be on the basis of plan quantities, the Contractor will be paid in accordance with the requirements of Section 109.02.

102.04—Examination of Site of Work and Proposal.

The submission of a bid will be considered conclusive evidence that the bidder has examined the site of the proposed work, proposal, plans, standard drawings, specifications, supplemental specifications, special provisions, special provision copied notes, and any other documents specified in the proposal before submitting a bid and is satisfied as to the conditions to be encountered in performing the work and requirements specified in the proposal.

Subsurface data may be available for review by the bidder in the office of the District or State Materials Division Administrator. Such data are accurate with

regard to test holes and are made available to the bidder in good faith in order to apprise him of information in possession of the Department. Any conclusions drawn by the Department concerning subsurface conditions are based solely on the data and are merely indications of what appear to be existing subsurface conditions. The Department does not warrant these conclusions to be correct, either expressly or by implication. Nor does the Department warrant the condition, amount, or nature of the material that may be encountered or the sufficiency of the data, either expressly or by implication. The bidder shall make his own interpretation of the subsurface data that may be available and satisfy himself with regard to the nature, condition, and extent of the material to be excavated, graded, or driven through. The submission of a bid will be considered conclusive evidence that the bidder is satisfied with regard to the subsurface conditions to be encountered in the work.

If a word, phrase, clause, or any other portion of the proposal is alleged to be ambiguous, the bidder shall submit written notice of the same to the Contract Engineer at least 10 days prior to the date bids are to be received and shall request an interpretation. Authorized interpretations will be issued by the Contract Engineer to each person who received a proposal and will be mailed to the address registered at the Contract Engineer's office when the proposal was requested. The Department will not be responsible for any other explanations or interpretations of the proposal. No employee or agent of the Department shall have the authority to furnish any other explanation or interpretation, verbal or written.

If the bidder fails to give written notice and request an interpretation of the alleged ambiguity within the specified time, he shall waive any right he may have had to his own interpretation of the alleged ambiguity. The true meaning of the alleged ambiguity will be as interpreted by the Department through the Contract Engineer.

102.05—Preparation of Bid.

The bidder shall submit his bid on the proposal form. The bidder shall furnish a unit or lump sum price as called for in the proposal, in numerical figures, for each pay item listed. The bidder shall also show the products of the unit prices and quantities in numerical figures in the column provided for that purpose and the total amount of the bid. Figures shall be written in ink or typed. The bidder may submit an electronically generated proposal form (C-7A) provided the bidder has written approval from the Contract Engineer.

If there is a discrepancy between the unit price and its extensions, the unit price will govern. If a unit or lump sum price is omitted, the bid will be rejected. In the event there is a discrepancy between the bidder's electronically generated proposal form (C-7A) and the proposal form as furnished by the Department, the Department proposal form will govern.

When design options are shown in the proposal, the bidder shall submit a bid price for at least one design option. The award of the Contract will be made on the basis of the lowest responsible bid submitted. Except as otherwise specified in the proposal, when regular and alternate designs are shown in the proposal, the bidder shall submit a bid price for at least one design. The Department may award the Contract to the bidder who submitted the lowest bid for the regular design or the lowest bid for the alternate design, whichever is deemed to be in the best interest of the State.

The bid shall be signed in ink by the individual, one or more members of a partnership, or one or more of the officers of a corporation, whichever is applicable. For a joint venture, the bid shall be signed in ink by each individual involved, each partnership through one or more of its members, or each corporation through one or more officers of the corporation, whichever is applicable.

If the bid is made by an individual, the name and address of the individual shall be shown; if by a partnership, its name and address and the name and title of the partner signing the bid shall be shown; if by a corporation, the name of the corporation, its address, and the name and title of the officer signing the bid shall be shown; if by a joint venture, the aforementioned information shall be shown for each party.

A sworn statement shall be executed by the bidder or his agent on behalf of each person, firm, association, or corporation submitting a bid. The statement shall certify that the person, firm, association, or corporation has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action to restrain free competitive bidding in connection with the proposal. The sworn statement shall be in the form of an affidavit furnished by the Department and shall be sworn to before a person who is authorized by the laws of the State to administer oaths. The original of the sworn statement shall be filed with the Department when the bid is submitted.

102.06—Irregular Bids.

Bids will be considered irregular and may be rejected for *any* of the following reasons:

1. if the bidder fails to comply with the requirements of Sections 102.05 and 102.07

2. if the bid is not written in ink or typed

3. if the bidder adds any provisions reserving the right to accept or reject an award or enter into a contract pursuant to an award except as otherwise permitted in these specifications

4. if the bid is not totaled

5. if the bid is not properly signed

6. if erasures or alterations in the bidder's entries are not initialed by the bidder

7. if there are unauthorized additions, conditional or alternate bids, or irregularities of any kind that may make the bid incomplete, indefinite, or ambiguous

8. if the unit prices in the bid are obviously unbalanced, either in excess or below the cost analysis values as determined by the Department

9. if any papers included in the bid are detached or altered when the bid is submitted except as otherwise provided for herein

10. if bids are submitted in envelopes showing a designation for a project other than the project for which the bid is made

11. if the bidder fails to submit a statement concerning collusion

102.07—Proposal Guaranty.

A bid in excess of $100,000 will not be accepted or considered unless accompanied by a guaranty in the form of a certified check, cash escrow, or bid bond made payable to the Treasurer of Virginia. A bid bond will be accepted only if executed on a form that contains the exact wording as the form furnished by the Department. Any bid accompanied by a bond having wording that differs in any respect from that furnished by the Department may be rejected. The amount of the proposal guaranty shall be 5 percent of the total bid.

When the principal is a joint venture, each party thereof shall be named and shall execute the proposal guaranty. Each surety to the bid bond shall be named and shall execute the bid bond. The bid bond shall be accompanied by a certified copy of the power of attorney for the surety's attorney-in-fact.

102.08—Disqualification of Bidder.

Any of the following causes may be considered sufficient for the disqualification of a bidder and rejection of his bid:

1. more than one proposal for the same work from an individual, partnership, corporation, or joint venture under the same or different name. A proposal submitted by an affiliate of an individual, partnership,

corporation, or any party of a joint venture will be considered as more than one proposal submitted for the same work.

Affiliate as used here is defined as: Any business entity that is closely associated with another business entity so that one has the power to control the other either directly or indirectly; or, when a third party has the power to control both; or, where one business entity has been so closely allied with another through an established course of dealings, including but not limited to the lending of financial wherewithal or engaging in joint ventures, so as to cause a public perception that the two firms are one entity.

2. evidence of collusion among bidders; participants in such collusion will not be considered for future bids until requalified by the Board

3. incompetency or inadequate machinery, plants, or other equipment as revealed by the bidder's financial and experience statements required by these specifications

4. unsatisfactory workmanship or progress as demonstrated by performance records of current or past work for the Department, other agencies or departments of the State, or agencies or departments of other states in the United States or federal government

5. uncompleted work with the Department that in the judgment of the Engineer might hinder or prevent prompt completion of additional work if awarded

6. failure to pay or settle satisfactorily all bills for materials, labor, equipment, supplies, or other items specified in contracts in force at the time the new work comes before the Board for award

7. failure to comply with any prequalification regulation of the Department

8. failure to cooperate properly with representatives of the State supervising construction or disorderly conduct toward any such representative

9. default under a previous contract

102.09—Delivery of Bid.

Each bid may be submitted in the envelope furnished by the Department. The blank spaces on the envelope shall be filled in correctly. When any other envelope is used, it shall be the same general size and shape as the envelope furnished by the Department and shall be marked to indicate its contents clearly. Bids shall be sealed in an envelope and addressed to: Contract Engineer's Office, VDOT, 1401 E. Broad Street, Richmond, VA 23219.

Bids shall be filed prior to the time and at the place specified in the Notice of Advertisement. Bids received after that time will be returned to the bidder unopened. The date for the opening of bids may be deferred by the Department, in which case the bidders will be notified.

102.10—Withdrawal of Bid.

A bidder may withdraw a bid in accordance with the following.

(a) **Standard Withdrawal:** A bidder may withdraw a bid provided the request for the withdrawal is written and signed by a person(s) who qualifies to execute the bid in accordance with the requirements of Section 102.05. The request must be received by the Contract Engineer at least 1 hour prior to the time specified for receiving bids.

(b) **Conditional Withdrawal:** A bidder who desires to bid on more than one project for which bids are to be opened on the same date and desires to protect himself against receiving an award of more projects than he is equipped to handle may secure the protection desired by completing the forms for the conditional withdrawal of bids included in the proposal.

102.11—Combination or Conditional Proposals.

If the Department so elects, proposals may be issued for projects in combination or separately. Bids may be submitted for either the combination or separate units of the combination. The Department may make awards on combination bids or separate bids to its best advantage. Combination bids other than those set up in the proposals by the Department will not be considered.

Conditional bids will be considered only when so stated in the proposal.

102.12—Public Opening of Bids.

Bids will be opened and read publicly at the time and place specified in the Notice of Advertisement. Interested parties are invited to be present.

102.13—Material Guaranty.

Before a contract is awarded, a bidder may be required to furnish a complete statement concerning the origin, composition, and manufacture of the materials to be used in the work, together with samples.

102.14—Use of Debarred Suppliers.

In accordance with the requirements of Section 200.02, the Engineer will not approve for use any material furnished by a supplier debarred by the Department. The bidder shall ascertain from the Department's listings which suppliers are debarred. Listings will be posted in the Contract Engineer's office, VDOT, 1401 E. Broad Street, Richmond, Virginia, and in each district office.

If a previously debarred supplier is reinstated to eligibility subsequent to the award of a contract, the Engineer may approve the use of the supplier when requested by the Contractor.

SECTION 103—AWARD AND EXECUTION OF CONTRACTS

103.01—Consideration of Bids.

After bids have been opened and read, they will be compared on the basis of the summation of the products of the approximate quantities shown in the bid schedule and the unit bid prices.

The Department may correct arithmetical errors in the bid prior to such comparison. The results of the comparisons will be available to the public after the determination has been made by the Board to award the Contract.

The Board reserves the right to reject any or all bids, waive technicalities, advertise for new bids, or proceed to do the work otherwise if it deems that the best interest of the State would be promoted thereby.

103.02—Award of Contract.

If the Contract is awarded, the award will be made to the lowest responsive and responsible bidder without discrimination on the grounds of race, color, sex, or national origin. In the event of tie bids, preference will be given to Virginia persons, firms, or corporations; otherwise, the tie will be decided by lot. Whenever any bidder is a resident of any other state and such state under its laws allows a resident contractor of that state a preference, a like preference may be allowed to the lowest responsible bidder who is a resident of Virginia. The award date will not be later than midnight on the 60th day after the opening of bids. If the Board has not awarded the Contract within this period, the bidder may withdraw his bid without penalty or prejudice unless the time limit is extended by mutual consent.

103.03—Cancellation of Award.

The Board may cancel the award of any contract at any time before the execution of the contract by all parties without liability to the State.

103.04—Return of Proposal Guaranty.

Proposal guaranties, except those of the two lowest bidders, will be returned immediately after the examination of bids. The proposal guaranties of the two lowest bidders will be returned within 5 days after a satisfactory bond has been furnished and the Contract has been duly executed. Proposal guaranties in the form of bid bonds will be retained by the Department if the bidder does not request their return.

103.05—Requirements of Contract Bond.

Within 15 calendar days after notification, the successful bidder shall furnish the following bonds for contracts in excess of $100,000:

1. a performance bond in the sum of the Contract amount, conditioned upon the faithful performance of the Contract in strict conformity with the plans, specifications, and conditions of the Contract, and

2. a payment bond in the sum of the Contract amount, conditioned upon the prompt payment for all labor, materials, public utility services, and rental of equipment used in the prosecution of the work for the Contract.

Bidders will not be awarded an unbonded contract when their bid plus the balance of other unbonded contracts exceed $100,000 or if their current ability factor is less than 8.0, as determined by their prequalification status.

The bonds shall be made on official forms furnished by the Department and shall be executed by the Contractor and a surety company authorized to do business in Virginia in accordance with the laws of Virginia and the rules and regulations of the State Corporation Commission. In order to be considered properly executed, the bonds shall include authorized signatures and titles.

In lieu of payment or performance bonds, the Contractor may furnish a certified check or cash escrow in the face amount required for each of the bonds, which will be held for the full statutory period as applicable for each bond.

Upon written request from the Contractor, the contract bonds may be reduced on contracts having planting items with an establishment period after acceptance of all contract work and during the establishment period. The amount of contract bonds for the duration of the remaining establishment period shall be equal to 35 percent of the total contract price of the planting items.

103.06—Contract Documents.

The portion of the executed Contract submitted by the Contractor shall include the following documents unless the filing of any of them at a later date is specifically permitted by other sections of these specifications or by special provisions:

(a) **Contract:** The Contract shall include the schedule of prices submitted by the bidder, plans, standard drawings, these specifications, supplemental specifications, special provisions, special provision copied notes, and the standard form of the Contract, all as furnished by the Department.

(b) **Contract Bonds:** Contract bonds shall conform to the requirements of Section 103.05.

(c) **Affidavits and Documents:** Affidavits and documents shall include those required to be made a part of the Contract by any federal or state law in effect on the date of the Notice of Advertisement.

(d) **Workers' Compensation Insurance Certificate:** The certificate shall be filed on forms furnished by the Department within 15 calendar days after notification of award of the Contract. The certificate shall be executed by an approved and authorized insurance company as required by state law and shall cover the Contract it accompanies.

The Contractor shall file notice with the Department at least 30 days prior to the cancellation of any required workers' compensation coverage. If any of his insurance of this class is cancelled, the Contractor shall cease operations on the date of the cancellation and shall not resume operations until new insurance is certified as being in force.

(e) **Progress Schedule:** The Contractor shall submit a progress schedule on forms furnished by the Department. The schedule shall set forth the best estimate of the time required for completion of the items of work specified in the Contract. The schedule shall be submitted no later than 30 days after the date specified in the Notice to Proceed and prior to the first monthly progress estimate. The progress schedule shall be duly executed by the Contractor after it has been accepted by the Engineer. If conditions change that would require a change in the Contractor's operations, the Contractor shall submit a revised progress schedule that has been mutually agreed on.

The Contractor shall attend a conference called by the Engineer at which the Contractor's planned or contemplated operations will be discussed. The Contractor shall keep the Engineer informed of his planned or contemplated operations on a continuing basis. Every 30 days, the Contractor shall meet with the Engineer and establish the approximate

date for starting each critical inspection stage during the following 30 days. At least once a week, the Contractor shall advise the Engineer of the approximate timing for anticipated critical stages for the subsequent week. The Engineer shall be advised at least 24 hours in advance of any changes in planned operations or critical staging mentioned herein and in Section 105.12.

The review and acceptance by the Department of the Contractor's progress schedule shall in no way relieve the Contractor of his responsibility to complete the work within the contract time limit, adjusted in accordance with the requirements of Section 108.09.

Delays in work resulting from the Contractor's failure to provide the progress schedule will not be considered just cause for extension of the contract time limit or for additional compensation.

(f) **Contractor's Bodily Injury and Property Damage Liability Insurance:** The Contractor shall procure and maintain at his own expense, until final acceptance of the work covered by the Contract, insurance of the kinds and in the amounts specified herein. The minimum limits of liability for this insurance shall be as indicated in either 1. or 2. as follows:

1.	A Combined Single Limit for Bodily Injury Liability and Property Damage Liability	$1,000,000 Each Person	$2,000,000 Aggregate
2.	Bodily Injury Liability	$1,000,000 Each Person	$1,000,000 Each Occurrence
	Property Damage Liability	$1,000,000 Each Occurrence	$1,000,000 Aggregate

Evidence of insurance in compliance with the above shall be filed on forms approved by the Department within 15 calendar days after notification of award of the Contract. The evidence shall be executed by an approved and authorized insurance company authorized to do business in Virginia and with a minimum "Best Rating" of "B" and shall cover the Contract it accompanies.

The Contractor shall file notice with the Department at least 30 days prior to the cancellation or reduction of the required insurance and shall cease operations on the date of the cancellation or reduction until new insurance is in force and the same evidence of insurance is provided to the Department.

The Contractor's Bodily Injury and Property Damage Liability Insurance shall cover liability of the Contractor for damage because of bodily

injury to or death of persons and damage to or destruction of property that may be suffered by persons other than the Contractor's own employees as a result of the negligence of the Contractor in performing the work covered by the Contract.

Insurance provided in compliance with this section shall include liability of the Contractor for damage to or destruction of property that may be suffered by persons other than the Contractor's own employees as a result of blasting operations of the Contractor in performing the work covered by the Contract.

If any part of the work is sublet, insurance meeting the same requirements shall be provided by or in behalf of the subcontractors, and evidence of such insurance shall be submitted with the sublet request.

Insurance coverage in the minimum amounts set forth herein shall not be construed to relieve the Contractor or subcontractor(s) for liability in excess of such coverage, nor shall it preclude the State from taking such actions as is available to it under any other provision of the Contract or otherwise in law.

103.07—Execution and Approval of Contract.

The bid as submitted by the Contractor, including the documents specified in Section 103.06(a), shall constitute the Contract upon submittal of the contract bond and workers' compensation insurance certificate and the final execution by the Department. If the Contract is not awarded within the time limit specified in Section 103.02, the bidder may withdraw his bid without penalty or prejudice. No contract shall be considered effective until it has been fully executed by all parties.

103.08—Failure To Furnish Bonds or Certificate of Insurance.

Failure by the successful bidder to furnish the Department acceptable bonds, workers' compensation insurance, or the Contractor's Bodily Injury and Property Damage Liability Insurance policy within 15 calendar days after being notified of the award of the Contract shall be considered just cause for cancellation of award and forfeiture of the proposal guaranty. In such event, the proposal guaranty shall become the property of the State, not as a penalty but in liquidation of damages sustained. The Contract may then be awarded to the next lowest responsible bidder, or the work may be readvertised or constructed otherwise, as determined by the Board.

No plea of mistake in the bid shall be available to the bidder for the recovery of his proposal guaranty or in defense of action taken by the Department as a result of his neglect or refusal to execute the Contract.

In the event the successful bidder on a non-guaranteed contract is unwilling or unable to fulfill the Contract and fails to notify the Department prior to execution of the Contract by the Department, the bidder will be declared in default in accordance with the requirements of Section 108.13. In the event the bidder notifies the Department prior to execution of the Contract by the Department of such unwillingness or inability to fulfill the contract, the bidder will be enjoined from bidding on contracts without furnishing guarantee for a period of no less than 90 days from the date of notice by the Department. A bidder who has never been enjoined or defaulted on a non-guaranteed contract and who notifies the Department prior to contract execution of an unwillingness or inability to fulfill the Contract will not be enjoined for the first occurrence; however, such bidder will not be permitted to rebid or perform work on the Contract.

SECTION 104—SCOPE OF WORK

104.01—Intent of Contract.

The intent of the Contract is to provide for completion of the work specified therein.

104.02—Alteration of Quantities or Character of Work.

The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the Contract nor release the surety, and the Contractor agrees to perform the work as altered.

If the alterations or changes in quantities significantly change the character of the work under the Contract, whether or not changed by any such different quantities or alterations, an adjustment, excluding anticipated profits, will be made to the Contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

At the option of the Engineer, the Contractor may be directed to accomplish the work on a force account basis in accordance with the requirements of Section 109.05.

If the alterations or changes in quantities do not significantly change the character of the work to be performed under the Contract, the altered work will be paid for as provided elsewhere in the Contract.

The term "significant change" shall be construed to apply only to the following circumstances:

(a) When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction *or*

(b) When a major item of work, as defined elsewhere in the Contract is increased or decreased more than 25 percent of the original contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125 percent of original contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed *or*

(c) When overruns and underruns of piling amount to more than 25 percent of the original bid quantity, whether or not such item has been designated as a major item.

Value engineering proposals: The Contractor may submit to the Engineer written VEPs for modifying the plans, specifications, or other requirements of the Contract for the purpose of reducing the total cost of construction without reducing the design capacity or quality of the finished product. If the VEP is accepted by the Department, the net savings will be equally divided by the Department and Contractor.

Each VEP shall result in a net savings over the contract cost without impairing essential functions and characteristics of the item(s) or of any other part of the project, including, but not limited to, service life, reliability, economy of operation, ease of maintenance, aesthetics, and safety. At least the following information shall be submitted with each VEP:

(a) statement that the proposal is submitted as a VEP

(b) statement concerning the basis for the VEP and benefits to the Department and an itemization of the contract items and requirements affected by the VEP

(c) detailed estimate of the cost under the existing Contract and under the VEP

(d) proposed specifications and recommendations as to the manner in which the VEP changes are to be accomplished

(e) statement as to the time by which a contract work order adopting the VEP must be issued so as to obtain the maximum cost-effectiveness

The Department will process the VEP in the same manner as prescribed for any other proposal that would necessitate issuance of a work order. The Department

may accept a VEP in whole or part by issuing a work order that will identify the VEP on which it is based. The Department will not be liable to the Contractor for failure to accept or act on any VEP submitted pursuant to these requirements or for delays in the work attributable to any VEP. Until a VEP is put into effect by a work order, the Contractor shall remain obligated to the terms and conditions of the existing Contract. If an executed work order has not been issued by the date on which the Contractor's proposal specifies that a decision should be made or such other date as the Contractor may subsequently have specified in writing, the VEP shall be deemed rejected.

The work order effecting the necessary modification of the Contract will establish the net savings agreed on, provide for adjustment of the contract prices, and indicate the net savings. The Contractor shall absorb all costs incurred in preparing a VEP. Reasonably incurred costs for reviewing and administering a VEP will be borne by the Department. The Department may include in the agreement any conditions it deems appropriate for consideration, approval, and implementation of the VEP. The Contractor's 50 percent share of the net savings shall constitute full compensation to him for effecting all changes pursuant to the agreement.

Unless specifically provided for in the work order authorizing the VEP, acceptance of the VEP and performance of the work thereunder will not change the contract time limit.

The Department may adopt a VEP for general use in contracts administered by the Department if it determines that the VEP is suitable for application to other contracts. VEPs identical with or similar to previously submitted VEPs will be eligible for consideration and compensation under these provisions if they have not been previously adopted for general application to other contracts administered by the Department. When a VEP is adopted for general use, compensation pursuant to these requirements will be applied only to those awarded contracts for which the VEP was submitted prior to the date of adoption of the VEP.

Proposed changes in the basic design of a bridge or pavement type or that require different right-of-way limits will not normally be considered an acceptable VEP. If a VEP is based on or is similar to a change in the plans, specifications, or special provisions adopted by the Department prior to submission of the VEP, the Engineer will not accept the VEP.

The Engineer will be the sole judge of the acceptability of a VEP. The requirements herein apply to each VEP initiated, developed, and identified as such by the Contractor at the time of its submission to the Engineer. However, nothing herein shall be construed as requiring the Engineer to consider or approve a VEP.

Subject to the provisions contained herein, the Department or any other public agency shall have the right to use all or part of an accepted VEP without obligation or compensation of any kind to the Contractor.

If a VEP is accepted by the Department, the provisions of (a) herein that pertain to the adjustment of contract unit prices attributable to alterations of contract quantities will not apply to the items adjusted or deleted as a result of putting the VEP into effect by a work order.

104.03—Differing Site Conditions.

During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the Contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before they are disturbed and before the affected work is performed.

Upon written notification, the Engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding anticipated profits, will be made and the Contract modified in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted.

No contract adjustment that results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

No contract adjustment will be allowed under this clause for any effects caused on unchanged work.

104.04—Maintenance During Construction.

The Contractor shall maintain the work from the beginning of construction operations until final acceptance. Maintenance shall constitute continuous and effective work prosecuted day by day with adequate equipment and forces to such end that the roadway and structures, including barricades and warning signs as provided for in accordance with the requirements of Section 107.10, are maintained in a satisfactory condition at all times.

When a Contract specifies placing a course on another course or subgrade previously constructed, the Contractor shall maintain the previous course or subgrade during all construction operations.

The road shall be kept open to all traffic while undergoing improvements. The Contractor shall keep the portion of the project being used by public, pedestrian,

and vehicular traffic in such condition that traffic will be adequately accommodated. However, removal of snow and control of ice on roads open to public travel will be performed by the Department.

The Contractor shall bear all costs of performing maintenance work before final acceptance and of constructing and maintaining necessary approaches, crossings, intersections, and other features without direct compensation except as provided for herein. However, when the Contractor confines his operation to the surface of the roadway and reasonable width of the shoulder and the surface is not disturbed or damaged by his operations or equipment, he shall not be responsible for the maintenance of the surface that remains undisturbed or undamaged.

The Contractor shall keep the portions of the road being used by the public free from irregularities and obstructions that could present a hazard or annoyance to traffic. When directed by the Engineer, allaying of dust shall be performed and paid for in accordance with the requirements of Section 511. Holes in hard surface pavements shall be filled with approved asphalt patching material.

(a) **Detours:** Detours may be indicated on the plans or in the special provisions or used with the approval of the Engineer. Detours over existing state roads will be designated, marked, and maintained by the Department. If any project is located wholly or in part within the corporate limits of a municipality and through traffic is to be detoured at the request of the municipality, the municipality will provide and maintain the detours within the corporate limits and will furnish and erect all directional markings. The Department will furnish and erect all directional markings for through traffic on off-project detours authorized or requested by the Engineer. The provision of detours and marking of alternate routes will not relieve the Contractor of the responsibility for ensuring the safety of the public or from complying with any requirements of these specifications affecting the rights of the public, including those concerning lights and barricades. Maintenance of all other detours shall be the responsibility of the Contractor.

Right of way for temporary highways or bridges required by these provisions will be furnished by the Department.

(b) **Maintenance of Traffic During Suspension of Work:** During any suspension of work, the Contractor shall temporarily open to traffic such portions of the project and temporary roadways as may be agreed on by the Contractor and Engineer.

(c) **Flagging Traffic:** Certified flaggers shall be provided in sufficient number and locations as necessary for control and protection of vehicular and pedestrian traffic in accordance with the *MUTCD*. Flaggers shall use sign paddles to regulate traffic in accordance with the *MUTCD*.

Certification for flaggers will be awarded upon a candidate's satisfactory completion of an examination. Certification cards shall be carried by flaggers while performing flagging duties. Flaggers found not in possession of their certification card shall be removed from the flagging site and operations requiring flagging will be suspended by the Engineer. Further, flaggers performing duties improperly will have their certifications revoked.

(d) **Delays:** Unless otherwise approved, two-way traffic shall be maintained at all times. The Contractor shall not stop traffic without permission.

If one-way traffic is approved, the Contractor shall provide flaggers to direct the traffic. When specified in the Contract as a pay item, pilot vehicles shall be furnished in accordance with the requirements of Section 512. Upon request from the Contractor and where deemed appropriate by the Department, the Department will install traffic signals that may be used for the control of one-way traffic. The Contractor shall pay the costs of installation, removal when no longer needed, electrical service, maintenance or repair work, and a predetermined rental charge per day for the signals.

(e) **Connections and Entrances:** Connections with other roads and public and private entrances shall be kept in a reasonably smooth condition at all times. Connections or entrances shall not be disturbed by the Contractor until necessary. Once connections or entrances have been disturbed, they shall be maintained and completed as follows:

1. **Connections:** Connections that had an original paved surface shall be brought to final grade through the intersection. At least two lanes shall be paved as soon as possible after connections are disturbed. Other connections shall be brought to final grade through the intersection, and the required material or a temporary aggregate stabilization course shall be placed as soon as possible after connections are disturbed.

   If there are delays in prosecution of work for connections, connections that were originally paved shall have at least two lanes maintained with a temporary paved surface. Those that were not originally paved shall be maintained with a temporary aggregate stabilization course.

2. **Entrances:** Entrances shall be graded concurrently with the roadway with which they intersect. Once an entrance has been disturbed, it shall be completed as soon as is practicable, including placing the required base and surface course or stabilization. If the entrance must be constructed in stages, such as when there is a substantial change in the elevation of the roadway with which it

intersects, the surface shall be covered with a temporary aggregate stabilization course or other salvaged material until the entrance can be completed and the required base and surface or stabilization course can be placed.

When directed by the Engineer, stabilization or surfacing material shall be applied to connections and entrances. When specified in the Contract, such material will be paid for at the contract unit price. Otherwise, the cost shall be included in other pay items of the Contract.

The Contractor shall schedule construction operations so that approved continuous access is provided for all property adjacent to the construction when the property is shown on the plans to require access. When frontage roads are shown on the plans, they shall be constructed prior to the closing of any access routes unless other approved access is provided and is acceptable to the property owner.

(f) **Grading Operations:** When the Contractor elects to complete the rough grading operations for the entire project or exceed the length of one full day's surfacing operations, the rough grade shall be machined to a uniform slope from the top edge of the existing pavement to the ditch line.

When the surface is to be widened on both sides of the existing pavement, construction operations involving grading or paving shall not be conducted simultaneously on sections directly opposite each other.

The surface of pavement shall be kept free from soil and other materials that might be hazardous to traffic. Prior to opening of new pavement to traffic, shoulders shall be roughly dressed for a distance of 1 meter from the edge of the paved surface.

(g) **Hydraulic Embankment:** Where the Contractor's suction or discharge pipes cross the surface of an existing traveled highway, they shall be bridged as directed by the Engineer. Traffic shall be protected by the display of warning signals both day and night. If dredging operations damage an existing traveled highway, the Contractor shall cease operations and repair damages to the highway.

(h) **Patching Operations:** Where existing hydraulic cement concrete pavement is to be patched, the operation of breaking and excavating old pavement shall extend for a distance of not more than 3 kilometers. Patching shall be coordinated with excavating so that an area of not more than 1 kilometer in which excavated patches are located shall be left at the end of any day's work. Necessary precautions shall be taken to protect traffic during patching operations.

(i) **Temporary Structures:** The Contractor shall construct, maintain, and remove temporary structures and approaches necessary for use by traffic. Unless otherwise specified in the Contract, the cost of these operations shall be included in pay items for the new structure. After new structures have been opened to traffic, temporary structures and approaches shall be removed. The materials contained therein shall remain the property of the Contractor.

The proposed design of temporary structures shall be submitted to the Engineer prior to the beginning of construction in accordance with the requirements of Section 105.02.

(j) **Failure To Maintain Roadway or Structures:** If the Contractor fails to remedy unsatisfactory maintenance immediately after receipt of a notice by the Engineer, the Engineer may proceed with adequate forces, equipment, and material to maintain the project. The cost of the maintenance, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due the Contractor for the project.

(k) **Haul Route:** The Contractor shall select haul routes between the project and material source(s) that will minimize disturbance to the community. The Contractor shall furnish the Engineer, for review, his plan for the haul route and for minimizing the adverse effects of hauling operations on persons who reside adjacent to the haul route or who otherwise use a portion of the haul route for ingress or egress to their residential area. The Department may select alternate haul routes, divide the hauling traffic over several routes, and impose other restrictions deemed necessary to minimize the impact of the hauling operation on local residents.

104.05—Removing and Disposing of Structures and Obstructions.

The Contractor shall remove and dispose of or store, as directed by the Engineer, fences, buildings, structures, or encumbrances within the construction limits unless separate pay items for this work are included in the Contract. Payment for these operations will be in accordance with the requirements of Section 301.03. Materials so removed, including existing drains or pipe culverts, shall become the property of the Contractor.

(a) **Signs:** The Contractor shall relocate street name signs, no parking signs, and other traffic signs within the construction limits that conflict with construction work as approved by the Engineer. Signs that are not needed for the safe and orderly control of traffic during construction as determined by the Engineer shall be removed and stored at a designated location within the project limits. The removed signs shall be stored above ground in a manner that will preclude damage and shall be

reinstalled in their permanent locations prior to final acceptance. If any of the removed signs are not to be reinstalled, the Contractor shall notify the Engineer at the time the signs have been properly stored. Such signs will be removed from the storage area by the Department. Any sign that is damaged or lost because of the fault of the Contractor shall be repaired or replaced at his expense. Costs for removing, storing, protecting, and reinstalling such signs shall be included in the price bid for other items in the Contract, and no additional compensation will be made

(b) **Mailboxes and Newspaper Boxes:** When removal of mailboxes and newspaper boxes is made necessary by construction operations, the Contractor shall place them in temporary locations so that access to them will not be impaired. Prior to final acceptance, boxes shall be placed in their permanent locations as designated by the Engineer and left in as good condition as when found. Boxes or their supports that are damaged through negligence on the part of the Contractor shall be replaced at his expense. The cost of removing and resetting boxes shall be included in other pay items of the Contract.

104.06—Cleanup.

Removal from the project of rubbish, scrap material, and debris caused by the Contractor's personnel or construction operations shall be a continuing process throughout the course of the work. The work site shall have a neat and orderly appearance at all times.

Before final acceptance, the highway, borrow pits, quarries, disposal areas, storage areas, and all ground occupied by the Contractor in connection with the work shall be cleaned of rubbish, surplus materials, and temporary structures. All parts of the work shall be left in a neat and orderly condition.

Within 30 days after final acceptance, the Contractor shall remove his equipment from the right of way and property adjacent to the project that he does not own or control.

SECTION 105—CONTROL OF WORK

105.01—Authority of Engineer.

During prosecution of the work, the Engineer will answer all questions that may arise as to the quantity, quality, and acceptability of materials furnished

and work performed; rate of progress of the work; interpretation of the plans and specifications; acceptable fulfillment of the Contract by the Contractor; disputes and mutual rights between contractors; and compensation.

The Engineer has the authority to suspend the work wholly or in part if the Contractor fails to correct conditions that are unsafe for workers or the general public or carry out the provisions of the Contract. The Engineer may also suspend work for such periods as he may deem necessary because of unsuitable weather in accordance with the requirements of Section 108.10, conditions considered unsuitable for prosecution of the work, or any other condition or reason deemed to be in the public interest.

105.02—Plans and Working Drawings.

Plans consisting of general drawings and showing such details as are necessary to give a comprehensive understanding of the work specified will be furnished by the Department. Except as otherwise shown on the plans, dimensions shown on the plans are measured in the respective horizontal or vertical planes. Dimensions that are affected by gradients or vertical curvatures shall be adjusted as necessary to accommodate actual field conditions and shall be specifically denoted on the working drawings.

The Contractor shall furnish working drawings as may be required. Working drawings shall not incorporate any changes from the requirements of the Contract unless the changes are specifically denoted, together with justification, and are approved in writing by the Engineer. Working drawings and submittals shall be identified by the complete state project and job designation numbers. Items or component materials shall be identified by the specific contract item number and specification reference in the Contract.

The Contractor may authorize the fabricator in writing to act for him in matters relating to working drawings. Such authorization shall have the force and effect of any other representative of the Contractor's organization.

Working drawings for steel structures, including metal handrails, shall consist of shop detail, erection, and other working drawings showing details, dimensions, sizes of units, and other information necessary for the fabrication and erection of metal work.

Working drawings for falsework supporting a bridge superstructure shall be certified by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia.

Working drawings for concrete structures and prestressed concrete members shall provide such details as required for the successful prosecution of the work and which are not included in the plans furnished by the Department. Drawings shall include plans for items such as prestressing strand details and elongation calculations, falsework, bracing, centering, form work, masonry, layout diagrams, and bending diagrams for reinforcing steel when necessary or when requested.

The Contractor shall submit to the Department for review three sets of required working drawings. Working drawings shall be submitted in sufficient time to allow discussion and correction prior to the beginning of the work they reference. Work shall not be performed or materials ordered prior to review of the working drawings. One set of working drawings marked with any suggested modifications or comments will be returned to the Contractor. The other sets will be retained by the Department.

Reviewed working drawings will be returned to the Contractor within 30 days from the date of receipt by the Department. If a railroad, municipality, or other entity as specified in the Contract or on the plans is required to review the working drawings, the reviewed working drawings will be returned within 45 days from the date of receipt by the Department. If the working drawings are not returned by the time specified, no additional compensation will be allowed except that an extension of time in accordance with the requirements of Section 108.09 will be considered. Upon completion of the work, the original tracings, if required, shall be supplied to the Department.

Prior to fabrication or construction, the Contractor shall submit for review one original and six copies of each working drawing and design calculation and a Professional Engineer's certification of such design for lighting, signal and pedestal poles, overhead and bridge mounted sign structures, breakaway support systems, anchor bolts, framing units, panels, and foundations. All sheets of these submittals shall include the Professional Engineer's stamp or seal. Certification for foundations will be required only when the designs are furnished by the Contractor. The design shall be in accordance with *AASHTO'S Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals*. The certification shall be made by a Professional Engineer holding a valid license to practice engineering in Virginia.

When specified, and prior to manufacture of reinforced concrete pipe, the Contractor shall furnish to the Department a certification of the acceptability of the design of such pipe, as determined from a review which shall be made for the Contractor by a Professional Engineer holding a valid license in the Commonwealth of Virginia. Such certification shall cover all design data, supporting calculations, and materials. Pipe designs previously certified or approved by the Department will not require recertification.

The Department's review of the Contractor's working drawings will relate to conformance to the requirements of the Contract. The review shall not be considered as authorization for any deviation from the requirements of the

Contract unless the deviation, including explicit supporting justification, is specifically described. The review will not relieve the Contractor from responsibility for errors in the working drawings. If working drawings detailing a change(s) initiated by the Contractor require more than two resubmissions or revisions, the cost of additional reviews by the Department or its designated representative(s) will be assessed to the Contractor.

The cost of working drawings furnished by the Contractor shall be included in the cost of appropriate contract items.

105.03—Conformity With Plans and Specifications.

Values for materials to be used in the work shall be in close conformity with the specified values or range of values specified in the Contract. Less than complete conformity may be tolerated if obtaining exact or complete conformity would not be feasible and if authorized by the Engineer.

Permissible tolerances for the elevation of earthwork and thickness of the several courses of select material, subbases, and bases are specified in these specifications. If permissive tolerances are exceeded or if consistent deviations from the plans or abrupt changes in grade occur, even though within the tolerances, the affected areas shall be reconstructed to conform to the specified tolerance and provide a smooth riding surface. When it is not feasible to reconstruct the areas, payment will be made in accordance with the requirements of the applicable specification for each material placed.

When the plans require the finished surface to tie into any structural item whose elevation is fixed, the elevation of the finished surface shall coincide with the elevation of the structural item.

105.04—Furnishing and Erecting Precast Structures.

Precast units will be allowed by the Department for the construction of standard drainage units and minor structures. The use of precast box culverts, precast arch, and special design precast structures will be considered provided the design for the structures is submitted to the Department for approval prior to performance of the work.

Approval by the Department for the use of precast units is permissive only. The Contractor shall ensure that the precast unit, as installed at each specific location, will possess the specified structural, functional, aesthetic, and serviceability characteristics of the cast-in-place design. If field conditions make the precast unit unsuitable, the Contractor may modify the unit in a manner that will not be detrimental to the structural design, as approved by the Engineer, or shall replace the unit with the originally designed cast-in-place unit at his own expense.

Submittal of designs for precast items included in the standard drawings will not be required provided fabrication is in accordance with the standard details. Submittal of designs for precast box culverts on the Department's approval list will not be required provided the Contractor submits a certification that it will be fabricated in accordance with the preapproved design drawings.

Requests for approval of a precast design shall include detailed plans and supporting computations that have been reviewed and approved by a registered Professional Engineer having at least 5 years experience in structural design of the type of precast structures or components proposed. Concrete shall have a design strength at 28 days of at least 30 megapascals and an air content of 6±2 percent. The design of the concrete mixture and the method of casting, curing, handling, and erecting shall be subject to review by the Engineer. Precast units may be shipped after reaching 85 percent of the design compressive strength as determined by control cylinders tested in accordance with the requirements of Section 404. Units shall retain their structural integrity during shipment and shall be subject to inspection at the job site. Approval to use precast units shall not be construed as waiving the size and weight hauling limitations of Section 105.14.

105.05—Coordination of Plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, and Special Provision Copied Notes.

The plans, standard drawings, these specifications, supplemental specifications, special provisions, special provision copied notes, and supplementary documents are parts of the Contract. A requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of a discrepancy, the following will apply:

1. Calculated dimensions, unless obviously incorrect, will govern over scaled dimensions.

2. Supplemental specifications will govern over these specifications.

3. Plans will govern over these specifications, supplemental specifications, and the standard drawings.

4. Special provisions will govern over these specifications, supplemental specifications, and plans.

5. Special provision copied notes will govern over these specifications, supplemental specifications, plans, and special provisions. The pay items and pay units listed in the proposal have the same status as special provision copied notes.

The Contractor shall not take advantage of any apparent error or omission in the plans or specifications. If the Contractor discovers an error or omission, he shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the Contract.

105.06—Cooperation of Contractor.

The Contractor will be supplied with at least two sets of approved plans and contract assemblies. Two copies of VDOT's *Road and Bridge Specifications* and two copies of VDOT's *Road and Bridge Standards* will be furnished on request without charge. The Contractor shall keep one complete set of plans, standard drawings, contract assemblies, and specifications available on the project at all times except for maintenance projects, certain sign projects, and other projects having no field office or on which the Contractor has no office.

The Contractor shall give the work the constant attention necessary to facilitate progress and shall cooperate with the Engineer, Inspector, and other contractors in every way possible. If any portion of a project is located within the limits of a municipality, military installation, or other federally owned property, the Contractor shall cooperate with the appropriate officials and agents in the prosecution of the work to the same extent as with the Department.

The Contractor shall have on the project at all times a competent superintendent capable of reading and understanding the plans and specifications and experienced in the type of work being performed who shall receive instructions from the Engineer or his authorized representatives. The superintendent shall have full authority to execute the orders and directions of the Engineer without delay and supply promptly such materials, equipment, tools, labor, and incidentals as may be required.

105.07—Cooperation With Regard to Utilities.

The adjustment of utilities consists of the relocation, removal, replacement, rearrangement, reconstruction, improvement, disconnection, connection, shifting, or altering of an existing utility facility in any manner.

Existing utilities at the design stage of the project will be indicated on the plans. Preliminary arrangements for adjusting these utilities will be made by the Department prior to project construction. Existing private and public utilities that require adjustment will be adjusted by the utility owner or shall be adjusted by the Contractor as a contract item. The new location of such utilities will not normally be shown on the plans. Some utilities may remain or be adjusted within the construction limits simultaneously with project construction operations.

The Contractor shall coordinate project construction with planned utility adjustments and take all necessary precautions to prevent disturbance of the utility facilities. The Contractor shall report to the Engineer any failure on the part of the utility owner to cooperate or proceed with the planned utility adjustments.

The Contractor shall perform contract utility work in a manner that will cause the least inconvenience to the utility owner and those being served by the utility owner.

Existing, adjusted, or new utility facilities that are to remain within the right of way shall be properly protected by the Contractor to prevent disturbance or damage resulting from construction operations. If an existing utility that requires adjustment is encountered by the Contractor, he shall not interfere with the utility but shall take the proper precautions to protect the facility and shall promptly notify the Engineer of the need for adjustment.

Prior to preparing a bid, the bidder shall contact known utility owners to determine the nature, extent, and location of existing, adjusted, or new utility facilities. Any additional cost resulting therefrom shall be reflected in the bid price for other items in the Contract.

If the Contractor desires the temporary or permanent adjustment of utilities for his own benefit, he shall conduct all negotiations with the utility owners and pay all costs in connection with the adjustment.

Except as otherwise specified herein, the Department will not be responsible for any claims for additional compensation from the Contractor resulting from delays, inconvenience, or damage sustained by him attributable to interference by utility appurtenances, or the operation of moving the same, other than a consideration of an extension of time.

If it is determined that interference by utility appurtenances caused a delay of such magnitude or otherwise altered project operations so as to increase significantly the Contractor's cost of performing the work, the Engineer may consider additional compensation limited to the actual costs incurred by the Contractor. The determination of the severity of the interference, its impact on the Contractor's costs, and the amount, if any, of compensation shall be at the sole discretion of the Engineer. Prior to the Engineer's review, the Contractor shall present sufficient documentation to substantiate fully the request for additional compensation. Nothing herein shall be construed as requiring acceptance of the Contractor's presentation or payment of additional compensation.

105.08—Cooperation Among Contractors.

The Department may at any time contract or approve concurrent contracts for performance of other work on, near, or within the same geographical area of the work specified in an existing contract. Contractors shall not impede or limit access to such work by others.

When separate contracts are awarded within the limits of one project, contractors shall not hinder the work being performed by other contractors. Contractors working on the same project shall cooperate with each other. In case of dispute, the Engineer shall be the referee, and his decision shall be binding on all parties.

When contracts are awarded to separate contractors for concurrent construction in a common area, the contractors, in conference with the Engineer, shall establish a written joint schedule of operations based on the limitations of the individual contracts and the joining of the work of one contract with the others. The schedule shall set forth the approximate dates and sequences for the several items of work to be performed and shall ensure completion within the contract time limit. The schedule shall be submitted to the Engineer for review and approval no later than 30 days after the award date of the later contract and prior to the first monthly progress estimate. The schedule shall be agreeable to, signed by, and binding on each contractor. The Engineer may allow modifications of the schedule when benefit to the contractors and the Department will result.

Any modification of the schedule shall be in writing, mutually agreed to and signed by the contractors, and shall be binding on the contractors in the same manner as the original agreement.

If the contractors fail to agree on a joint schedule of operations, they shall submit their individual schedules to the Engineer, who will prepare a schedule that will be binding on each contractor.

The joint schedule and any modification thereof shall become a part of each contract involved. The failure of any contractor to abide by the terms of the joint schedule shall be justification for declaring the contractor in default of his contract.

Each contractor shall assume all liability, financial or otherwise, in connection with his contract and shall protect and save harmless the State from any and all damages and claims that may arise because of any inconvenience, delay, or loss he experiences as a result of the presence and operations of other contractors working in or near the work covered by his contract. He shall also assume all responsibility for any of his work not completed because of the presence or operation of other contractors.

Except for an extension of the contract time limit, the Department will not be responsible for any inconvenience, delay, or loss experienced by a contractor as a result of his failure to gain access to the work at the time contemplated. When the failure to gain access is not due to any fault or negligence of the contractor, an extension of the contract time limit will be allowed on the basis of the amount of time delayed.

The Department will not assume any responsibility for acts, failures, or omissions of one contractor that delay the work of another except as provided herein.

105.09—Holidays.

Except as is necessary to maintain traffic, work shall not be performed on Sundays or the following holidays without the permission of the Engineer: January 1, Memorial Day, July 4, Labor Day, Thanksgiving Day, and Christmas Day.

If any of these holidays occurs on a Sunday, the following Monday shall be considered the holiday.

105.10—Construction Stakes, Lines, and Grades.

Unless otherwise specified, the Engineer will furnish and set construction stakes on all projects in accordance with the following:

1. **Grading construction:** The Engineer will furnish and set center-line stakes, slope stakes, stakes locating right-of-way markers, culverts, and protective accessory structures as he deems necessary. When select material is included in the Contract, fine grade stakes specifying the elevations, center line, or edge of pavement will be set on one side of each lane on tangents and on both sides on curves and transitions.

2. **Paving construction:** The Engineer will furnish and set line and fine grade stakes specifying the elevations, center line, or edge of pavement on one side of each lane on tangents and on both sides on curves and transitions.

3. **Bridge construction:** The Engineer will furnish and set stakes locating the designated longitudinal reference line common to the roadway and structure, the transverse reference line for each abutment and pier, and necessary bench marks. The Contractor will be furnished a layout sketch showing the location and designation of the stakes as set by the Engineer.

The Engineer will furnish the Contractor all necessary information relating to lines, slopes, and grades. The stakes and marks shall constitute the field control by and in accordance with which the Contractor shall establish other

necessary controls and perform the work. Additional stakes and bench marks will be provided if deemed necessary by the Engineer.

The Contractor shall be responsible for preserving stakes and marks. If any of the construction stakes or marks is destroyed or disturbed by the Contractor, the cost of replacing it will be deducted from the payment for the work.

The Department will be responsible for the accuracy of the lines, slopes, grades, and other engineering work it furnishes. Unless otherwise indicated, the grade shown on the profile will represent the center of the crown on the finished surface.

105.11—Authority and Duties of Inspector.

Inspectors employed by the Department are authorized to inspect all work performed and materials furnished. Inspection may extend to all or any part of the work and to the preparation, fabrication, and manufacture of the materials to be used. The Inspector is not authorized to alter or waive the provisions of these specifications or make changes in the plans.

The Inspector is not authorized to make final acceptance of the project, approve any operation or item, or act as foreman for the Contractor. However, the Inspector will have the authority to reject defective work and material and suspend work that is being improperly performed, subject to the concurrence of the Engineer. Such inspection shall not relieve the Contractor of any obligation to furnish acceptable materials or provide completed construction that is in accordance with the plans and specifications.

The Inspector will exercise only such additional authority as may be delegated by the Engineer. The Engineer will advise the Contractor in writing of delegations of authority that will affect his operations.

105.12—Inspection of Work.

Inspection will be performed at critical stages. However, all stages, materials, and details of the work are subject to inspection. The Engineer shall be allowed access to all parts of the work and shall be furnished such information and assistance by the Contractor as are required to make a complete and detailed inspection. The Engineer and his appointed representatives shall have ready access to machines and plant equipment used in processing or placing materials.

Prior to the beginning of operations, the Engineer will meet with the Contractor to establish an understanding of the critical stages of work that shall be performed in the presence of the Inspector. In order for the Department to schedule inspection of the work, the Contractor shall keep the Engineer informed of planned operations in accordance with the requirements of Section 103.06(e).

If the Engineer requests it, the Contractor shall remove or uncover such portions of the finished work as may be directed at any time before final acceptance. If necessary, the Contractor shall restore such portions of the work to comply with the specifications. If the work exposed is acceptable, the uncovering or removing and replacing the covering or making good the parts removed will be paid for as extra work in accordance with the requirements of Section 104.03. If the work is unacceptable, the cost of uncovering or removing and replacing the covering or making good the parts removed shall be borne by the Contractor.

When any unit of government, political subdivision, or public or private corporation is to pay a portion of the cost of the work specified in the Contract, its representatives shall have the right to inspect the work. The exercise of this right shall not be construed as making them a party or parties to the Contract or conferring on them the right to issue instructions or orders to the Contractor.

If materials are used or work is performed without inspection by an authorized representative of the Department, the Contractor may be ordered to remove and replace the work or material at his own expense unless the Department's representative failed to inspect the work or material after having been given reasonable notice in writing that the material was to be used or the work was to be performed.

If an inspection reveals that work has not been properly performed, the Contractor will be so advised and shall immediately inform the Department of his schedule for correcting such work and the time at which a reinspection can be made.

105.13—Removal of Unacceptable and Unauthorized Work.

Work that does not conform to the requirements of the Contract will be considered unacceptable work.

Unacceptable work shall be remedied or removed immediately and replaced in an acceptable manner at the Contractor's expense. The Engineer may accept the work at a reduced price when acceptance is considered to be in the best interest of the public.

No work shall be done until the lines and grades have been established by the Engineer. Work that is done contrary to the instructions of the Engineer, beyond the lines shown on the plans or as designated by the Engineer except as specified herein, or without authority will be considered unauthorized and will not be paid for. Such work may be ordered removed or replaced at the Contractor's expense.

The Contractor shall not perform destructive sampling or testing of the work without written authorization of the Engineer. Unauthorized destructive sampling or testing will cause the work to be considered unacceptable.

In the event the Contractor is granted authorization to perform destructive sampling or testing, the Engineer must approve the method and location of each test prior to beginning such sampling or testing. In addition, destructive sampling and testing shall be performed in the presence of the Engineer.

If the Contractor fails to comply immediately with any order of the Engineer made under the provisions of this section, the Engineer will have the authority to cause unacceptable work to be removed and replaced and unauthorized work to be removed and to deduct the cost from any monies due or to become due the Contractor.

105.14—Size and Mass (Weight) Limitations.

(a) **Hauling or Moving Material and Equipment on Public Roads Open to Traffic:** The Contractor shall comply with legal size and mass (weight) limitations in the hauling or moving of material and equipment on public roads open to traffic unless the hauling or moving is covered by a hauling permit.

(b) **Hauling or Moving Material and Equipment on Public Roads Not Open to Traffic:** The Contractor shall comply with legal mass (weight) limitations in the hauling or moving of material and equipment on public roads that are not open to traffic unless the hauling or moving is permitted elsewhere herein or is otherwise covered by a hauling permit. The Contractor shall be liable for damage that results from the hauling or moving of material and equipment. The hauling or moving of material and equipment on the pavement structure or across any structure during various stages of construction shall be subject to additional restrictions as specified or directed by the Engineer.

(c) **Furnishing Items in Component Parts of Sections:** If the size or mass of fabricated or manufactured items together with that of the hauling or moving vehicle exceeds the limitations covered by hauling permit policies and other means of transportation are not available, permission will be given to furnish the items in component parts of sections with adequately designed splices or connections at appropriate points. Permission for such adjustments shall be requested in writing, and approval in writing shall be secured from the Department prior to fabrication or manufacture of the items. The request shall state the reasons for adjustment and shall be accompanied by supporting data, including working drawings where necessary.

105.15—Acceptance.

(a) **Partial Acceptance:** If at any time during the prosecution of the project the Contractor completes a unit or portion of the project, such as a

structure, an interchange, slopes, pavement, or a section of a roadway, in its entirety, he may ask the Engineer to make final inspection of such work. If the Engineer finds upon inspection that the work conforms to the requirements of the Contract and that acceptance is in the interest of the public, he may accept the work as being completed, and the Contractor will be relieved of further responsibility for the work as specified in Section 107.16. Partial acceptance shall in no way void or alter any terms of the Contract.

If any damage attributable to causes beyond the control of the Contractor is sustained by the accepted unit or portion of the project, the Engineer may authorize the Contractor to make necessary repairs. In the absence of contract prices covering the items of repair, the work will be paid for in accordance with the requirements of Section 109.05.

(b) **Final Acceptance:** Upon receipt of a written notice from the Contractor of presumptive completion of the entire project, the Engineer will make an inspection. If all work specified in the Contract has been completed, the inspection will constitute the final inspection and the Engineer will make the final acceptance. The Contractor will be notified of final acceptance in writing within 5 days.

If the inspection discloses that any work, in whole or in part, is incomplete or unacceptable, the Contractor shall immediately correct the deficiency. Upon completion or correction of the work, another inspection will be made that will constitute the final inspection. In such event, the Engineer will make the final acceptance and the Contractor will be notified of final acceptance in writing within 5 days. In any event, the Contractor shall maintain the project until final acceptance except under conditions that may be specifically exempted.

105.16—Submission and Disposition of Claims.

Early or prior knowledge by the Department of an existing or impending claim for damages could alter the plans, scheduling, or other action of the Department or result in mitigation or elimination of the effect of the act objected to by the Contractor. Therefore, a written statement describing the act of omission or commission by the Department or its agents that allegedly caused damage to the Contractor and the nature of the claimed damage shall be submitted to the Engineer at the time of occurrence or beginning of the work upon which the claim and subsequent action are based. If such damage is deemed certain in the opinion of the Contractor to result from his acting on an order from the Engineer, he shall immediately take written exception to the order. Submission of a notice of claim as specified shall be mandatory. Failure to submit such notice shall be a conclusive waiver to such claim for damages by the Contractor. An oral

notice or statement will not be sufficient nor will a notice or statement after the event.

At the time of occurrence or prior to beginning the work, the Contractor shall furnish the Engineer an itemized list of materials, equipment, and labor for which additional compensation will be claimed. Only actual cost for materials, labor, and equipment will be considered. The Contractor shall afford the Engineer every facility for keeping an actual cost record of the work. The Contractor and the Engineer shall compare records and bring them into agreement at the end of each day. Failure on the part of the Contractor to afford the Engineer proper facilities for keeping a record of actual costs will constitute a waiver of a claim for such extra compensation except to the extent that it is substantiated by the Department's records. The filing of such notice by the Contractor and the keeping of cost records by the Engineer shall in no way establish the validity of a claim.

If the Contractor's claim contains data furnished by the Contractor that cannot be verified by the Department's records, the data shall be subject to a complete audit by the Department or its authorized representative if they are to be used as a basis for claim settlement.

Upon completion of the Contract, the Contractor may, within 60 days from the time the final estimate is paid, submit to the Department a written claim, an original and three legible copies, for the amount he deems he is entitled to under the Contract. For the purpose of this section, the final estimate date shall be that date set forth in a letter from the Construction Engineer to the Contractor at the time the final estimate is submitted to the Fiscal Division for vouchering. The claim shall set forth the facts upon which the claim is based. The Contractor shall include all pertinent data and correspondence that may substantiate the claim. Only actual cost for materials, labor, and equipment will be considered. Within 90 days from the receipt of the claim, the Department will make an investigation and notify the Contractor by registered mail of its decision. However, by mutual agreement, the Department and Contractor may extend the 90-day period for another 30 days.

If the Contractor is dissatisfied with the decision, he shall notify the Commissioner in writing within 30 days from receipt of the Department's decision that he desires to appear before him, whether in person or through counsel, and present additional facts and arguments in support of his claim. The Commissioner will schedule and meet with the Contractor within 30 days after receiving the request. However, the Commissioner and Contractor, by mutual agreement, may schedule the meeting to be held after 30 days but before the 60th day from the receipt of the Contractor's written request. Within 45 days from the date of the meeting, the Commissioner will investigate the claim, including the additional facts presented, and notify the Contractor in writing of his decision. However, the Commissioner and Contractor, by mutual agreement, may extend the 45-day period for another 30 days. If the Commissioner deems that all or any portion of a claim is valid, he shall have the authority to negotiate

a settlement with the Contractor subject to the provisions of Section 2.1-127 of the Code of Virginia 1950 as amended.

Any monies that become payable as the result of claim settlement after payment of the final estimate will not be subject to payment of interest unless such payment is specified as a condition of the claim settlement.

SECTION 106—CONTROL OF MATERIAL

106.01—Source of Supply and Quality Requirements.

The materials used throughout the work shall conform to the requirements of the Contract. The Contractor shall regulate his supplies so that there will be a sufficient quantity of tested material on hand at all times to prevent any delay of work. Except as otherwise specified, materials, equipment, and components shall be new. Within 30 days after the date of the letter to the Contractor advising that the Department will recommend that the Board award the Contract, but not later than 7 days prior to beginning construction operations under the Contract, the Contractor shall file a statement of the origin, composition, and manufacture of all materials to be used in the work, including optional or alternate items. The Contractor's statement shall be identified by the complete state project number, and all items or component materials shall be identified by the specific contract item number and the specification reference shown in the Contract.

At the option of the Engineer, materials may be approved at the source of supply. If it is found during the life of the Contract that previously approved sources of supply do not supply materials or equipment conforming to the requirements of the Contract, do not furnish the valid test data required to document the quality of the material or equipment, or do not furnish valid quantities to document payment, the Contractor shall change the source of supply and furnish material or equipment from other approved sources.

Materials shall not be furnished from a source that has been identified by the Office of Federal Activities as being on the EPA's list of violating facilities.

When materials are required to have approved mixture design(s) or job-mix formula(s), the most recently approved design(s) or formula(s) for the applicable source(s) of supply will be indicated by the Department by reference on the Contractor's copy of the approved source of supply statement. The Contractor shall be responsible for determining from his source(s) of supply the actual design(s) or formula(s) shown by the reference and shall keep informed as to any subsequently approved revisions and new designs or formulas for such source(s).

When optional materials are included in the Contract, the Contractor shall advise the Engineer in writing of the specific materials selected. Thereafter, the Contractor shall use the selected materials throughout the project unless a change is authorized in writing by the Engineer. However, when the Contractor has an option as to the type of pipe that may be used, he may use any one of the approved types for each size of pipe, but he shall use the same type for a particular line. The Engineer may authorize other types and sources in an emergency that will unreasonably delay delivery of the selected material.

Equipment and material guaranties or warranties that are normally given by a manufacturer or supplier, or are otherwise required in the Contract, shall be obtained by the Contractor and assigned to the State in writing. The Contractor shall also provide an inservice operation guaranty for at least 6 months, beginning on the date of final acceptance, on all mechanical and electrical equipment and related components.

106.02—Material Inspection.

The Contractor shall advise the Engineer at least 2 weeks prior to the delivery of any material from a commercial source. The Contractor shall provide the Engineer with one copy of all invoices (prices are not required) for materials delivered to the project with the following exceptions: asphalt concrete; dense graded aggregate, to include aggregate base, subbase, and select material; fine aggregate; open graded coarse aggregate; crusher run aggregate; and road stabilization aggregate. The printed weights of each load of these materials, as specified in Section 109.01, shall accompany the delivery, and such information shall be made available to the Inspector at the project.

106.03—Local Material Sources (Pits and Quarries).

The requirements set forth herein apply exclusively to pits and quarries from which materials are obtained for use on contracts awarded by the Department.

Local material sources shall be concealed from view from the completed roadway and any existing public roadway. Concealment shall be accomplished by selectively locating the pit or quarry and spoil pile, providing environmentally compatible screening between the pit or quarry site and the roadway, or using the site for another purpose after removal of the material. The foregoing requirements shall also apply to any pit or quarry opened or reopened by a subcontractor or supplier. However, the requirements will not apply to commercial sand and gravel and quarry operations actively processing material at the site prior to the date of the Notice of Advertisement.

The Contractor shall furnish the Engineer a statement signed by the property owner in which the property owner agrees to the use of his property as a source of material for the project. Upon completion of the use of the property as a

material source, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored. This requirement will be waived for commercial sources, sources owned by the Contractor, and sources furnished by the Department.

Local material pits and quarries shall not be opened or reopened without authorization by the Engineer. The Contractor shall submit for approval a site plan, including, but not limited to, (1) the location and approximate boundaries of the excavation with a slope gradient of 3:1 or greater; (2) procedures to minimize erosion and siltation; (3) provision of environmentally compatible screening; (4) restoration; (5) cover vegetation; (6) other use of the pit or quarry after removal of material, including the spoil pile; (7) the drainage pattern on and away from the area of land affected, including the directional flow of water; (8) constructed or natural waterways used for discharge; and (9) a sequence and schedule to achieve the approved plan. The site plan shall also include sediment basins if required. Sediment basins are required if the runoff from a watershed area of 1.2 hectares or more flows across a disturbed area of 930 square meters or greater. The Contractor shall design, construct, and maintain the basin to accommodate the anticipated sediment loading from the land disturbing activity. The Contractor shall certify that the sediment basin design is in compliance with the Virginia Erosion and Sediment Control Regulations.

The Contractor's design and restoration shall be in accordance with the Contract and in accordance with the requirements of federal, state, and local laws and regulations.

If the approved plan provides for the continued use or other use of the pit or quarry beyond the date of final acceptance, the Contractor shall furnish the Department a bond made payable to the Commonwealth of Virginia in an amount equal to the Engineer's estimate of the cost of performing the restoration work. If the pit or quarry is not used in accordance with the approved plan within 8 months after final acceptance, the Contractor shall perform restoration work as directed by the Engineer, forfeit his bond, or furnish the Engineer with evidence that he has complied with the applicable requirements of the State Mining Law.

Topsoil on borrow sites shall be stripped and stockpiled as directed by the Engineer for use as needed within the construction limits of the project or in the reclamation of borrow and disposal areas.

If the Contractor fails to provide necessary controls to prevent erosion and siltation, such efforts are not made in accordance with the approved sequence, or the efforts are found to be inadequate, he shall take immediate action to abate erosion and siltation. The Department may cause the Contractor to cease all contributing operations and direct efforts toward corrective action or may perform the work with state forces or other means determined by the Engineer. If the work is not performed by the Contractor, the cost of performing the work, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due the Contractor.

Costs for applying seed, fertilizer, lime, and mulch; restoration; drainage; erosion and siltation control; regrading; haul roads; and screening shall be included in the contract price for the type of excavation or other appropriate items.

If the Contractor fails to fulfill the provisions of the approved plan for screening or restoring material sources, the Department may withhold and use for the purpose of performing such work any monies due the Contractor at the time of the final estimate. The Contractor will be held liable for penalties, fines, or damages incurred by the Department as a result of his failure to prevent erosion or siltation.

After removing the material, the Contractor shall remove metal, lumber, and other debris resulting from his operations and shall shape and landscape the area in accordance with the approved plan for such work.

If payment is to be made for material measured in its original position, material shall not be removed until cross sections have been taken. The material shall be reserved exclusively for use on the project until completion of the project or until final cross sections have been taken.

(a) **Sources Located by the Department:** The Department may indicate on the plans where certain materials are known to exist. The Department usually holds no title in such sources. However, an option for the use of the material may have been obtained by the Department. Existing exploration and test data for such sources, together with existing options, will be available for inspection upon request at the office of the District or State Materials Division Administrator. The Contractor may have such instruments of option assigned to him. In such event, the Contractor shall advise the property owner of his acceptance in accordance with the instrument prior to entering such pits or quarries and shall assume all responsibility for doing so. The Department makes no guarantee as to the legal sufficiency of the instruments obtained hereunder.

The Department's exploration and test data for a local material source shall in no way constitute a guarantee of the quality and quantity of materials in the deposit. The Contractor shall perform exploration and tests as is necessary to determine the amount of selective excavating, processing, and admixing he must perform in order to furnish the specified material. The cost of exploring, testing, processing, and admixing, including the cost of the admixture material, shall be borne by the Contractor.

(b) **Sources Furnished by the Department:** Sources furnished by the Department will be made available to the Contractor together with the right to use such property as may be required for a plant site, stockpiles, and haul roads. The Contractor shall confine his excavation operations to those areas of the property specified in the Contract.

The Contractor shall be responsible for excavation that must be performed in order to furnish the specified material.

(c) **Sources Furnished by the Contractor:** When the Contractor desires to use local material from sources other than those located or furnished by the Department, he shall first secure the approval of the Engineer. The use of material from such sources will not be permitted until test results have been approved by the Engineer and written authority for its use has been issued.

The Contractor shall acquire the necessary rights to take material from sources he locates and shall pay all related costs, including costs that may result from an increase in the length of the haul. Costs of exploring, sampling, testing, and developing such sources shall be borne by the Contractor. The Contractor shall obtain representative samples from at least two borings in parcels of 4 hectares or less and at least three additional borings per increment of 2 hectares or portion thereof to ensure that lateral changes in material are recorded. Drill logs for each test shall include a soil description and the moisture content at intervals where a soil change is observed or at least every 1.5 meters of depth for consistent material. Samples obtained from the boring shall be tested by an approved laboratory for grading, Atterberg limits, CBR, maximum density, and optimum moisture. The Department will review and evaluate the material based on test results provided by the Contractor. The Department may reject any material from a previously approved source that fails a visual examination or whose test results show that it does not conform to the specifications.

106.04—Disposal Areas.

Unsuitable or surplus material whose presence is shown on the plans shall be deposited on approved areas located off the right of way. The Contractor shall obtain the necessary rights to such property provided at least one property owner having a suitable location is willing to enter a reasonable agreement. The Department will act to obtain rights to such property when the Engineer deems that the Contractor has made a reasonable but unsuccessful effort to fulfill his responsibility to obtain the right.

When neither unsuitable nor surplus material is shown on the plans, the Department will obtain the rights to property upon which to deposit such material when it is encountered on the project.

The Contractor shall furnish the Engineer a statement signed by the property owner in which the owner agrees to the use of his property for the deposit of material from the project. Upon completion of the use of the property as a disposal area, the Contractor shall furnish the Engineer a release signed by the

property owner indicating that the property has been satisfactorily restored. This requirement will be waived for property that is owned by the Contractor or the Department or for which rights have been procured by the Department.

Prior to opening a disposal area, the Contractor shall submit a site plan for the approval of the Engineer. The plan shall show (1) the location and approximate boundaries of the disposal area; (2) all procedures to minimize erosion and siltation; (3) haul roads; (4) provision for environmentally compatible screening; (5) restoration of and cover vegetation for the area following the deposit of material; (6) the drainage pattern on and away from the area affected, including constructed or natural waterways used for drainage; (7) the streams or tributaries receiving the discharge; and (8) a sequence and schedule to complete the work. The site plan shall also include sediment basins if required. Sediment basins are required if the runoff from a watershed area of 1.2 hectares or more flows across a disturbed area of 930 square meters or greater. The Contractor shall design, construct, and maintain the basin to accommodate the anticipated sediment loading from the land disturbing activity. The Contractor shall certify that the sediment basin design is in compliance with the Virginia Erosion and Sediment Control Regulations.

Disposal areas shall be cleared but need not be grubbed. The clearing work shall not damage grass, shrubs, or vegetation outside the limits of the approved area and haul roads thereto. After the material has been deposited, the area shall be shaped to minimize erosion and siltation of nearby streams and landscaped in accordance with the approved plan for such work or shall be used as approved by the Engineer.

Excavated rock in excess of that used in embankments in accordance with the requirements of Section 303 shall be deposited off the right of way in an approved disposal area. Deposits whose surface is composed largely of rock shall be leveled by special arrangement of the material or reduction of the irregularity of the surface by crushing projections to create a reasonably uniform and neat appearance.

The Contractor's design and restoration shall be in accordance with the requirements of the Contract and federal, state, and local laws and regulations.

If the Contractor fails to provide the necessary controls to prevent erosion and siltation, such efforts are not made in accordance with the approved sequence, or the efforts are found to be inadequate, he shall take immediate action to abate erosion and siltation. The Department may cause the Contractor to cease all contributing operations and direct efforts toward corrective action or may perform the work with state forces or other means determined by the Engineer. If the work is not performed by the Contractor, the entire cost of performing the work, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due the Contractor.

Costs for applying seed, lime, fertilizer, and mulch; reforestation; drainage; erosion and siltation control; regrading; haul roads; and screening shall be included in the contract price for excavation.

If the Contractor fails to fulfill the provisions of the approved plan for screening or restoring disposal areas, the Department may withhold and use for the purpose of performing such work any monies due the Contractor at the time of the final progress estimate. The Contractor shall be held liable for all penalties, fines, or damages incurred by the Department as a result of his failure to prevent erosion or siltation.

106.05—Rights for and Use of Materials Found on Project.

With the approval of the Engineer, the Contractor may use in the project any materials found in the excavation that comply with the specifications. Unless otherwise specified, the Contractor will be paid for both the excavation of such materials at the contract unit price and for the pay item for which the excavated material is used. However, the Contractor shall replace at his own expense with other acceptable material the excavation material removed and used that is needed for use in embankments, backfills, approaches, or otherwise. The Contractor shall not excavate or remove any material from within the construction limits that is not within the grading limits, as indicated by the slope and grade lines, without authorization by the Engineer.

106.06—Samples, Tests, and Cited Specifications.

Materials will be inspected and tested by the Engineer before or during incorporation in the work. However, the inspection and testing of such material shall not relieve the Contractor of the responsibility for furnishing material that conforms to the specifications. The Department may retest all materials that have been accepted at the source of supply after delivery and may reject those that do not conform to the specifications. Stored material may be reinspected prior to use. Work in which untested materials are used without the written permission of the Engineer may be considered unacceptable.

Unless reference is made to a specific dated specification, references in these specifications to AASHTO, ASTM, VTM, and other standard test methods and materials requirements shall refer to either the test specifications that have been formally adopted or the latest "interim" or "tentative" specifications that have been published by the appropriate committee of such organizations as of the date of the Notice of Advertisement. Unless otherwise indicated, tests for compliance with specification requirements will be made by the Department and at its expense except that the cost of retests, exclusive of the first retest, shall be borne by the Contractor. Samples shall be furnished by the Contractor at his expense, and those that are not tested by the Contractor will be tested by a representative of the Department.

The inspection cost of structural steel items fabricated in a country other than the continental United States shall be borne by the Contractor. Inspection of structural fabrication shall be performed in accordance with the requirements of the appropriate VTM by a commercial laboratory approved by the Department. Additional cleaning or repair necessary because of environmental conditions in transit shall be at the Contractor's expense.

In lieu of testing, the Engineer may approve the use of materials based on the receipt of a certification furnished by the Contractor from the manufacturer. However, furnishing the certificate shall not relieve the Contractor of the responsibility for furnishing materials that conform to the specifications.

Materials requiring an MSDS will not be accepted at the project site for sampling or at the Department's laboratories for testing without the document.

106.07—Plant Inspection.

If the Engineer inspects materials at the source, the following conditions shall be met:

1. The Engineer shall have the cooperation and assistance of the Contractor and producer of the materials.

2. The Engineer shall have full access to parts of the plant that concern the manufacture or production of the materials being furnished.

3. For materials accepted under a quality assurance plan, the Contractor shall furnish equipment and maintain a plant laboratory at locations approved for plant processing of materials. The Contractor shall use the laboratory and equipment to perform quality control testing.

   The laboratory shall be of weatherproof construction, tightly floored and roofed, and shall have adequate lighting, heating, running water, ventilation, and electrical service. The ambient temperature shall be maintained between 20 °C and 30 °C and thermostatically controlled. The laboratory shall have a telephone, intercom, or other electronic communication system connecting the laboratory and scale house if the facilities are not in close proximity. The laboratory shall be constructed in accordance with the requirements of local building codes.

   The Contractor shall furnish, install, maintain, and replace, as conditions necessitate, testing equipment specified by the appropriate AASHTO method or VTM being used and provide necessary office equipment and supplies to facilitate keeping records and generating test reports. The Contractor's technician shall maintain current copies of the appropriate test procedures. The Contractor shall also provide and maintain an approved test stand for accessing truck beds for the purpose

of sampling and inspection. Cast iron grinding pots and rubber mauls will be furnished by the Department where required. The Department may approve a single laboratory to service more than one plant belonging to the same Contractor.

4. Adequate safety measures shall be provided and maintained.

106.08—Storing Materials.

Materials shall be stored in a manner so as to ensure the preservation of their quality and fitness for the work. When considered necessary by the Engineer, materials shall be stored in weatherproof buildings on wooden platforms or other hard, clean surfaces that will keep the material off the ground. Materials shall be covered when directed by the Engineer. Stored material shall be located so as to facilitate its prompt inspection. Approved portions of the right of way may be used for storage of material and equipment and for plant operations. However, equipment and materials shall not be stored within the clear zone of the travel lanes open to traffic.

Additional required storage space shall be provided by the Contractor at his expense. Private property shall not be used for storage purposes without the written permission of the owner or lessee. Copies of the written permission shall be furnished the Engineer. Upon completion of the use of the property, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored.

106.09—Handling Materials.

Materials shall be handled in a manner that will preserve their quality and fitness for the work. Aggregates shall be transported from storage to the work in vehicles constructed to prevent loss or segregation of materials.

106.10—Unacceptable Materials.

Materials that do not conform to the specifications shall be considered unacceptable. Such materials, whether in place or not, will be rejected and shall be removed from the site of the work. If it is not practical for the Contractor to remove rejected material immediately, the Engineer will mark the material for identification. Rejected material whose defects have been corrected shall not be used until approval has been given by the Engineer.

106.11—Material Furnished by the Department.

The Contractor shall furnish all materials required to complete the work except those specified to be furnished by the Department.

Material furnished by the Department will be delivered or made available to the Contractor at the points specified in the Contract. The cost of handling and placing materials after delivery to the Contractor shall be included in the contract price for the item with which they are used.

The Contractor shall be responsible for material delivered to him, including shortages, deficiencies, and damages that occur after delivery, and any demurrage charges.

SECTION 107—LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01—Laws To Be Observed.

The Contractor shall keep fully informed of federal, state, and local laws, bylaws, ordinances, orders, decrees, and regulations of governing bodies, courts, and agencies having any jurisdiction or authority that affects those engaged or employed on the work, the conduct of the work, or the execution of any documents in connection with the work. The Contractor shall observe and comply with such laws, ordinances, regulations, orders, or decrees and shall indemnify and hold harmless the State and its agents, officers, or employees against any claim for liability arising from or based on their violation, whether by himself, his agents, his employees, or subcontractors. The Contractor shall execute and file the documents, statements, and affidavits required under any applicable federal or state law or regulation affecting his bid or Contract or prosecution of the work thereunder. The Contractor shall permit examination of any records made subject to such examination by any federal or state law or by regulations promulgated thereunder by any state or federal agency charged with enforcement of such law.

In accordance with Article 2.1 of Chapter 7 of Title 11 of the Code of Virginia (Virginia Public Procurement Act), the Contractor shall make payment to all subcontractors, as defined in the Code, within seven days after receipt of payment from the Department; or, shall notify the Department and subcontractor in writing of the intention to withhold all or a part of the amount due along with the reason for nonpayment.

In the event payment is not made as noted, the Contractor shall pay interest at the rate of 1 percent per month, unless otherwise provided in the contract, to the

subcontractor on all amounts that remain unpaid after seven days except for the amounts withheld as provided hereinbefore.

These same requirements shall be included in each subcontract and shall be applicable to each lower-tier subcontractor.

107.02—Permits, Certificates, and Licenses.

Permits and certificates obtained by the Department will be included in the contract documents. Construction methods shall conform to the stipulations of the permit. The Contractor shall assume all obligations and cost he incurs by complying with the terms and conditions of the permits and certificates.

If a U.S. Army Corps of Engineers permit is not applicable and additional permits or certificates are required to perform dredging for flotation of construction equipment or for other temporary work as indicated in the Contractor's accepted plan of operations but have not been obtained by the Department, the Contractor shall furnish the Engineer, at least 75 days prior to the proposed activity, all necessary information pertaining to the proposed activity in order for the Department to make application for the permit(s) or certificate(s). The Contractor shall not begin the proposed activity until the additional permit(s) or certificate(s) has been secured and the Contractor has been advised by the Engineer that the proposed activity may proceed. Additional compensation will not be made for delay(s) to the work or for change(s) in the Contractor's proposed methods that may result from the jurisdictional agencies' review process or disapproval of the Contractor's proposed methods except that an extension of time will be considered in accordance with the requirements of Section 108.09 if a permit or permit denial is not issued within the specified 75 days.

(a) **U.S. Army Corps of Engineers Permit:** If a U.S. Army Corps of Engineers permit is applicable to the project, the proposal will so indicate and the Department will obtain it. If the permit obtained does not cover construction activities that require a permit and the Department determines that the activities are necessary for completion of the work, the Contractor shall furnish the Engineer all necessary information pertaining to the activity so that the Department can apply for an addendum to the permit. Such information shall be furnished at least 180 days prior to the date the activity is to begin. The Contractor shall not begin the activity until directed to do so by the Engineer. Additional compensation will not be made for delay(s) to the work or change(s) in the Contractor's proposed methods of construction that may result from the jurisdictional agencies' review process or disapproval of the Contractor's proposed methods. However, an extension of time will be considered in accordance with the requirements of Section 108.09 if notification to proceed or denial of the proposed construction activity is not issued within 180 days.

The Contractor shall not proceed with work covered by the permit until the work is released in writing by the Engineer. The Engineer may release a portion or all of such work but may order a suspension of the same work after its release.

If the Department has not released work covered by the Corps of Engineers permit and the Contractor has completed all other work within the limits of the project, the Contractor shall so advise the Engineer in writing. Upon receipt of the notification, the Engineer will evaluate the status of the project and advise the Contractor within 45 days of the portion of the project that is acceptable under Section 105.15. If the Engineer determines that all of the work except that encumbered by the permit application is acceptable under Section 105.15, the Contractor will be notified accordingly. The Department or Contractor may then elect to continue or terminate the remaining portion of the Contract.

The party electing to terminate the Contract shall so advise the other party in writing after the 45-day period. The terms of contract termination will be in accordance with the requirements of Section 108.14. No compensation will be made for delays encountered or for work not performed except for an extension of time as determined in accordance with the requirements of Section 108.09.

If the Contractor elects to maintain contractual obligations with the approval of the Engineer, he shall continue maintenance of uncompleted work and disturbed areas. Upon release by the Department in writing, the Contractor shall complete the remaining work in accordance with the contract requirements.

(b) **Nationwide Federal Permit:** If a Nationwide Federal Permit is applicable to the project, the proposal will so indicate and a Corps of Engineers permit will not be required. However, the Department may have obtained other permits or certificates for the project.

(c) **Other Permits, Certificates, and Licenses:** Except as otherwise specified herein, the Contractor shall procure necessary permits, certificates, or licenses that have not been obtained by the Department. The Contractor shall pay all charges, fees, and taxes and give all notices necessary and incidental to the due and lawful prosecution of the work.

107.03—Patented Devices, Materials, and Processes.

If the Contractor employs any design, device, material, or process covered by a patent or copyright, he shall provide for its use by obtaining a legal agreement with the patentee or owner. The Contractor and the surety shall indemnify and save harmless the State, any affected third party, or political subdivision from claims for infringement because of such use. The Contractor shall indemnify

the State for costs, expenses, or damages resulting from infringement during prosecution or after completion of the work.

107.04—Restoration of Work Performed by Others.

The Department may construct or reconstruct any utility service in the highway or street or grant a permit for the same at any time. The Contractor shall not be entitled to any damages occasioned thereby other than a consideration of an extension of time.

When authorized by the Engineer, the Contractor shall allow any person, firm, or corporation to make an opening in the highway within the limits of the project upon presentation of a duly executed permit from the Department or any municipality for sections within its corporate limits. When directed by the Engineer, the Contractor shall satisfactorily repair portions of the work disturbed by the openings. The necessary work will be paid for as extra work in accordance with the requirements of these specifications and shall be subject to the same conditions as the original work performed.

107.05—Federal-Aid Provisions.

When the U.S. government pays all or any portion of the cost of a project, the Contractor shall observe the federal laws and rules and regulations made pursuant to such laws. The work shall be subject to inspection by the appropriate federal agency.

Such inspection shall in no sense make the federal government a party of the Contract and will in no way interfere with the rights of either party.

107.06—Sanitary Provisions.

The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of employees as may be necessary to comply with the requirements of the state and local Board of Health or other bodies or tribunals having jurisdiction.

107.07—Public Convenience and Safety.

The Contractor shall conduct his work so as to ensure the least possible obstruction to traffic. The Contractor shall provide for the safety and convenience of the general public and residents along the highway and the protection of persons and property as specified in Section 104.04.

107.08—Railway-Highway Provisions.

If the Contractor's work requires hauling materials across the tracks of a railway, he shall make arrangements with the railway for any new crossing(s) required or the use of any existing crossing. Charges made by the railway company for the construction or use of new or existing crossings and their subsequent removal and for watchperson or flagger service at such crossings shall be reimbursed by the Contractor directly to the railway company under the terms of their own arrangements before final acceptance.

Work to be performed by the Contractor in construction on or over the railway right of way shall be performed at times and in a manner that will not interfere unnecessarily with the movement of trains or traffic on the railway track. The Contractor shall use care to avoid accidents, damage, or unnecessary delay or interference with the railway company's trains or other property. If any interruption of railway traffic is required by the Contractor's actions, he shall obtain prior written approval from the railway company.

The Contractor shall conduct operations that occur on or over the right of way of any railway company fully within the rules, regulations, and requirements of the railway company and in accordance with the requirements of any agreements made between the Department and railway company that are made a part of the Contract.

(a) **Flagger or Watchperson Services:** Flagger or watchperson services required by the railway company for the safety of railroad operations because of work being performed by the Contractor or incidental thereto will be provided by the railway company. The cost for such services as required for work shown on the plans will be borne by the Department. Any cost of such services resulting from work not shown on the plans or for the Contractor's convenience shall be borne by the Contractor and shall be paid directly to the railway company(s) under the terms of their own agreement.

No work shall be undertaken on or over the railway right of way until the watchpersons or flaggers are present at the project site. The Contractor shall continuously prosecute the affected work to completion to minimize the need for flagger or watchperson services. Costs for such services that the Engineer determines to be unnecessary because of the Contractor's failure to give notice as required herein before initially starting, intermittently continuing, or discontinuing work on or over the railway right of way shall be borne by the Contractor and will be deducted from monies due him.

(b) **Approval of Construction Methods on Railway Right of Way:** The Contractor shall submit to the Department a plan of operations showing the design and method of proposed structural operations and shall obtain

its approval before performing any work on the railway company's right of way unless otherwise indicated in the railroad agreement. The plan shall be clear and legible, and details shall be drawn to scale. The plan shall show, but not be limited to, the following:

1. proximity of construction operations to tracks
2. depth of excavation with respect to tracks
3. description of structural units
4. vertical and horizontal clearances to be afforded the railroad during installation and upon completion of excavation
5. sheeting and bracing
6. method and sequence of operations

Approval shall not relieve the Contractor of any liability under the Contract. The Contractor shall arrange the work so as not to interfere with the railway company's operation except by agreement with the railway company.

(c) **Insurance:** In addition to insurance or bonds required under the terms of the Contract, the Contractor shall carry insurance covering operations affecting the property of the railway company. The original railroad protective liability insurance policy and certificate of insurance showing insurance carried by the Contractor and any subcontractors shall be submitted to the railway company for approval and retention.

Neither the Contractor nor any subcontractor shall begin any work affecting the railway company until the railway company has received the insurance.

Notice of any material change in or cancellation of the required policies shall be furnished the Department and the railway company at least 30 days prior to the effective date of the change or cancellation. The insurance shall be of the following kinds and amounts:

1. **Contractor's public liability and property damage insurance:** The Contractor shall furnish evidence to the Department with respect to the operations to be performed that he carries regular contractor's public liability insurance. The insurance shall provide for a limit of at least the dollar value specified in the Contract for all damages arising out of bodily injuries to or the death of one person, and subject to that limit for each person, a total limit of at least the dollar value specified in the Contract for all damages arising out of bodily injuries to or death of two or more persons in any one

occurrence, and regular contractor's property damage insurance providing for a limit of at least the dollar value specified in the Contract for all damages arising out of bodily injury to or destruction of property in any one occurrence, and subject to that limit per occurrence, a total or aggregate limit of at least the dollar value specified in the Contract for all damages arising out of injury to or destruction of property during the policy period. The Contractor's public liability and property damage insurance shall include explosion, collapse, and underground damage coverage. If the Contractor subcontracts any portion of the work, he shall secure insurance protection in his own behalf under the Contract's public liability and property damage insurance policies to cover any liability imposed on him by law for damages because of bodily injury to or death of persons and injury to or destruction of property as a result of work undertaken by the subcontractors. In addition, the Contractor shall provide similar insurance protection for and on behalf of any subcontractors to cover their operation by means of separate and individual contractor's public liability and property damage policies. As an alternative, he shall require each subcontractor to provide such insurance in his own behalf.

2. **Railroad protective insurance and public liability and property damage:** The policy furnished the railway company shall include coverage for contamination, pollution, explosion, collapse, and underground damage. The policy shall be of the type specified hereinafter and shall be expressed in standard language that may not be amended. No part may be omitted except as indicated hereinafter or by an endorsement that states an amendment or exclusion of some provision of the form in accordance with the provisions of a manual rule. The form of the endorsement shall be approved as may be required by the supervising authority of the state in which the policy is issued. A facsimile of the Declarations form as shown in the proposal shall be made a part of the policy and shall be executed by an officer of the insurance company. The several parts of the requirements and stipulations specified or inferred herein may appear in the policy in such sequence as the company may elect.

   a. **For a policy issued by one company:**

      (NAME AND LOCATION OF INDEMNITY COMPANY), a _____ Insurance Company, herein called the
      (Type of Company)
      Company, agrees with the insured named in the Declarations made a part hereof, in consideration of the payment of the premium and in reliance upon the statements in the Declarations made by the named insured and subject to all of the terms of his policy.

For a policy issued by two companies:

(NAME AND LOCATION OF INDEMNITY COMPANY)
and
(NAME AND LOCATION OF INDEMNITY COMPANY),
each a _____ Insurance Company, herein called
(Type of Company)
the Company, severally agree with the insured named in the Declarations made a part hereof, in consideration of the payment of the premium and in reliance upon the statements in the Declaration made by the named insured and subject to all of the terms of this policy, provided the named Indemnity Company shall be the insured with respect to Coverage _____ and no other and the named Insurance Company shall be the insurer with respect to Coverage _____ and no other.

b. **Insuring agreements:**

(1) **Coverages: Coverage A—Bodily injury liability:** To pay on behalf of the insured all sums that the insured shall become legally obligated to pay as damages because of bodily injury, sickness, or disease including death at any time resulting therefrom (hereinafter called bodily injury) either (1) sustained by any person arising out of acts or omissions at the designated job site that are related to or are in connection with the work described in Item 6 of the Declarations; or (2) sustained at the designated job site by the Contractor, any employee of the Contractor, any employee of the governmental authority specified in Item 5 of the Declarations, or any designated employee of the insured, whether or not arising out of such acts or omissions.

Coverage B—Property damage liability: To pay on behalf of the insured all sums the insured shall become legally obligated to pay as damages because of physical injury to or destruction of property, including loss of use of any property because of such injury or destruction (hereinafter called property damage) arising out of acts or omissions at the designated job site that are related to or are in connection with the work described in Item 6 of the Declarations.

Coverage C—Physical damage to property: To pay for direct and accidental loss of or damage to rolling stock and other contents, mechanical construction equipment, or motive power equipment (hereinafter called loss)

arising out of acts or omissions at the designated job site that are related to or are in connection with the work described in Item 6 of the Declarations; provided such property is owned by the named insured or is leased or entrusted to the named insured under a lease or trust agreement.

(2) **Definitions:** *Insured* includes the named insured and any executive officer, director, or stockholder thereof while acting within the scope of his duties as such.

Contractor means the Contractor designated in Item 4 of the Declarations and includes all subcontractors of the Contractor but not the named insured.

Designated employee of the insured means (1) any supervisory employee of the insured at the job site; (2) any employee of the insured while operating, attached to, or engaged on work trains or other railroad equipment at the job site that is assigned exclusively to the Contractor; or (3) any employee of the insured not within (1) or (2) who is specifically loaned or assigned to the work of the Contractor for prevention of accidents or protection of property, the cost of whose services is borne specifically by the Contractor or governmental authority.

Contract means any contract or agreement to carry a person or property for a consideration or any lease, trust, or interchange contract or agreement respecting motive power, rolling stock, or mechanical construction equipment.

(3) **Defense and settlement supplementary payments:** With respect to such insurance as is afforded by this policy under Coverages A and B, the Company shall defend any suit against the insured alleging such bodily injury or property damage and seeking damages that are payable under the terms of this policy, even if any of the allegations of the suit are groundless, false, or fraudulent. However, the Company may make such investigation and settlement of any claim or suit as it deems expedient.

In addition to the applicable limits of liability, the Company shall pay (1) all expenses incurred by the company, all costs taxed against the insured in any such suit, and all interest on the entire amount of any judgment therein that accrues after entry of the judgment and before the Company has paid or tendered or deposited in court

that part of the judgment that does not exceed the limit of the Company's liability thereon; (2) premiums on appeal bonds required in any such suit and premiums on bonds to release attachments for an amount not in excess of the applicable limit of liability of this policy, but without obligation to apply for or furnish any such bonds; (3) expenses incurred by the insured for first aid to others that shall be imperative at the time of the occurrence; and (4) all reasonable expenses, other than loss of earnings, incurred by the insured at the Company's request.

(4) **Policy period and territory:** This policy applies only to occurrences and losses during the policy period and within the United States, its territories or possessions, or Canada.

c. **Exclusions:** This policy does not apply to the following:

(1) liability assumed by the insured under any contract or agreement except a contract as defined herein

(2) bodily injury or property damage caused intentionally by or at the direction of the insured

(3) bodily injury, property damage, or loss that occurs after notification to the named insured of the acceptance of the work by the governmental authority, other than bodily injury, property damage, or loss resulting from the existence or removal of tools, uninstalled equipment, and abandoned or unused materials

(4) under Coverage A(1), B, and C, to bodily injury, property damage, or loss, the sole proximate cause of which is an act or omission of any insured

(5) under Coverage A, to any obligation for which the insured or any carrier as his insurer may be held liable under any workers' compensation, employment compensation, or disability benefits law or under any similar law; provided that the Federal Employer's Liability Act, U.S. Code (1946) Title 45, Sections 51-60, as amended, shall for the purpose of this insurance be deemed not to be any similar law

(6) under Coverage B, to injury to or destruction of property owned by the named insured or leased or entrusted to the named insured under a lease or trust agreement

(7) under any liability coverage, to injury, sickness, disease, death, or destruction (1) with respect to which an insured under the policy is also an insured under a nuclear energy liability policy issued by the Nuclear Energy Liability Insurance Association, Mutual Atomic Energy Liability Underwriters, or Nuclear Insurance Association of Canada or would be an insured under any such policy but for its termination upon exhaustion of its limit of liability; or (2) resulting from the hazardous properties of nuclear material and with respect to which any person or organization is required to maintain financial protection pursuant to the Atomic Energy Act of 1954 or any law amendatory thereof or the insured is (or had this policy not been issued would be) entitled to indemnity from the United States or any agency thereof under any agreement entered into by the United States, or any agency thereof, with any person or organization

(8) under any Medical Payments Coverage or any Supplementary Payments provision relating to immediate medical or surgical relief or to expenses incurred with respect to bodily injury, sickness, disease, or death resulting from the hazardous properties of nuclear material and arising out of the operation of a nuclear facility by any person or organization

(9) under any liability coverage, to injury, sickness, disease, death, or destruction resulting from the hazardous properties of nuclear material if (1) the nuclear material is at any nuclear facility owned or operated by or on behalf of an insured or has been discharged or dispersed therefrom; (2) the nuclear material is contained in spent fuel or waste at any time possessed, handled, used, processed, stored, transported, or disposed of by or on behalf of an insured; or (3) the injury, sickness, disease, death, or destruction arises out of the furnishing by an insured of services, materials, or parts for equipment in connection with the planning, construction, maintenance, operation, or use of any nuclear facility; if such facility is located in the United States, its territories or possessions, or Canada, this exclusion applies only to injury to or destruction of property at such nuclear facility

(10) under Coverage C, to loss attributable to nuclear reaction, nuclear radiation, or radioactive contamination or to any act or condition incident to any of the foregoing

As used in exclusions 7, 8, and 9, the following definitions apply: *Hazardous properties* include radioactive, toxic, or explosive properties. *Nuclear material* means source material, special nuclear material, or byproduct material. *Source material, special nuclear material, and byproduct material* have the meanings given them in the Atomic Energy Act of 1954 or in any law amendatory thereof. *Spent fuel* means any fuel element or fuel component (solid or liquid) that has been used or exposed to radiation in a nuclear reaction. *Disposable material* means material containing byproduct material and resulting from the operation by any person or organization of any nuclear facility included in the definition of nuclear facility under 1 or 2 below. *Nuclear facility* means

(1) any nuclear reactor

(2) any equipment or device designed or used for separating the isotopes of uranium or plutonium; processing or utilizing spent fuel; or handling, processing, or packaging waste

(3) any equipment or device designed or used for the processing, fabricating, or alloying of special nuclear material if at any time the total amount of such material in the custody of the insured at the premises where such equipment or device is located consists of or contains more than 25 grams of plutonium or uranium 233 (or any combination thereof) or more than 250 grams of uranium 235

(4) any structure, basin, excavation, premises, or place prepared or used for the storage or disposal of waste (includes the site on which any of the foregoing is located, all operation conducted on such site, and all premises used for such operations)

Nuclear reactor means any apparatus designed or used to sustain nuclear fission in a self-supporting chain reaction or to contain a critical mass of fissionable material. With respect to injury to or destruction of property, *injury* or *destruction* includes all forms of radioactive contamination of property.

d. **Conditions:** The following conditions, except conditions (3) through (12), apply to all coverages. Conditions (3) through (12) apply only to the coverage noted thereunder.

(1) **Premium:** The premium bases and rates for the hazards described in the Declarations are stated therein. Premium bases and rates for hazards not so described are those applicable in accordance with the requirements of the manuals used by the company. The term *contract cost* means the total cost of all work described in Item 6 of the Declaration. The term *rental cost* means the total cost to the Contractor for rental or work trains or other railroad equipment, including the remuneration of all employees of the insured while operating, attached to, or engaged thereon. The advance premium stated in the Declarations is an estimated premium only. Upon termination of this policy, the earned premium shall be computed in accordance with the Company's rules, rates, rating plans, premiums, and minimum premiums applicable to this insurance. If the earned premium thus computed exceeds the estimated advance premium paid, the Company shall look to the Contractor specified in the Declarations for any such excess. If less, the Company shall return to the Contractor the unearned portion paid. In no event shall payment or premium be an obligation of the named insured.

(2) **Inspection:** The named insured shall make available to the Company records of information relating to the subject matter of this insurance. The Company shall be permitted to inspect all operations in connection with the work described in Item 6 of the Declarations.

(3) **Limits of liability, Coverage A:** The limit of bodily injury liability stated in the Declarations as applicable to "each person" is the limit of the Company's liability for all damages (including damages for care and loss of services) arising out of bodily injury sustained by one person as the result of any one occurrence. The limit of such liability stated in the Declarations as applicable to "each occurrence" is (subject to the provision respecting each person) the total limit of the Company's liability for all such damage arising out of bodily injury sustained by two or more persons as the result of any one occurrence.

(4) **Limits of liability, Coverages B and C:** The limit of liability under Coverages B and C stated in the Declarations as applicable to "each occurrence" is the total limit of the Company's liability for all damages and all loss under Coverages B and C combined arising out of physical injury to, destruction of, or loss of all

property of one or more persons or organizations, including the loss or use of any property attributable to such injury or destruction under Coverage B, as the result of any one occurrence. Subject to the provision respecting "each occurrence," the limit of liability under Coverages B and C stated in the declaration as "aggregate" is the total limit of the Company's liability for all damages and all loss under Coverages B and C combined arising out of physical injury to, destruction of, or loss of property, including the loss or use of any property attributable to such injury or destruction under Coverage B.

Under Coverage C, the limit of the Company's liability for loss shall not exceed the actual cash value of the property, or if the loss is a part thereof, the actual cash value of such part, at time of loss, nor what it would then cost to repair or replace the property of such part thereof with other of like kind and quality.

(5) **Severability of interests, Coverages A and B:** The term *the insured* is used severally and not collectively. However, inclusion herein of more than one insured shall not operate to increase the limits of the Company's liability.

(6) **Notice:** In the event of an occurrence or loss, written notice containing particulars sufficient to identify the insured and also reasonably obtainable information with respect to the time, place, and circumstances thereof and the names and addresses of the injured and of able witnesses shall be given by or for the insured to the company or any of its authorized agents as soon as is practicable. If a claim is made or a suit is brought against the insured, he shall immediately forward to the Company every demand, notice, summons, or other process received by him or his representative.

(7) **Assistance and cooperation of the insured, Coverages A and B:** The insured shall cooperate with the Company and upon the Company's request attend hearings and trials and assist in making settlements, securing and giving evidence, obtaining the attendance of witnesses, and conducting suits. Except at his own cost, the insured shall not voluntarily make any payment, assume any obligations, or incur any expense other than for first aid to others that shall be imperative at the time of an accident.

(8) **Action against Company, Coverages A and B:** No action shall lie against the Company unless as a condition precedent thereto the insured shall have fully complied with all the terms of this policy, nor until the amount of the insured's obligation to pay shall have been finally determined either by judgment against the insured after actual trial or by written agreement of the insured, the claimant, and the Company. Any person or organization or the legal representative thereof who has secured such judgment or written agreement shall thereafter be entitled to recover under this policy to the extent of the insurance afforded by this policy. No person or organization shall have any right under this policy to join the Company as a part to any action against the insured to determine the insured's liability. Bankruptcy or insolvency of the insured or of the insured's estate shall not relieve the Company of any of its obligations hereunder.

(9) **Action against Company, Coverage C:** No action shall lie against the Company unless as a condition precedent thereto there shall have been full compliance with all the terms of this policy nor until 30 days after proof of loss is filed and the amount of loss is determined as provided in this policy.

(10) **Insured's duties in event of loss, Coverage C:** In the event of loss, the insured shall protect the property, whether or not the loss is covered by this policy. Any further loss attributable to the insured's failure to protect shall not be recoverable under this policy. Reasonable expenses incurred in affording such protection shall be deemed incurred at the company's request.

The insured shall also file with the Company, as soon as practicable after loss, his sworn proof of loss in such form and including such information as the Company may reasonably require and shall, upon the Company's request, exhibit the damaged property.

(11) **Appraisal, Coverage C:** If the insured and the Company fail to agree as to the amount of loss, either may demand an appraisal of the loss within 60 days after the proof of loss is filed. In such event the insured and the Company shall each select a competent appraiser, and the appraisers shall select a competent and disinterested umpire. An award in writing or any two shall determine the amount of loss. The insured and the Company shall each pay his chosen appraiser

and shall bear equally the other expenses of the appraisal and umpire. The Company shall not be held to have waived any of its rights by any act relating to appraisal.

(12) **Payment of loss, Coverage C:** The Company may pay for the loss in money, but there shall be no abandonment of the damaged property to the Company.

(13) **No benefit to bailee coverage:** The insurance afforded by this policy shall not enure directly or indirectly to the benefit of any carrier or bailee (other than the named insured) liable for loss to the property.

(14) **Subrogation:** In the event of any payment under this policy, the Company shall be subrogated to all of the insured's rights of recovery therefor against any person or organization. The insured shall execute and deliver instruments and papers and do whatever else is necessary to secure such rights. The insured shall do nothing after loss to prejudice such rights.

(15) **Application of insurance:** The insurance afforded by this policy is primary insurance. If the insured has other primary insurance against a loss covered by this policy, the Company shall not be liable under the policy for a greater proportion of such loss than the applicable limit of liability stated in the Contract bears to the total applicable limit of all valid and equitable insurance against such loss.

(16) **3-year policy:** A policy period of 3 years is comprised of three consecutive annual periods. Computation and adjustment of earned premium shall be made at the end of each annual period. Aggregate limits of liability as stated in this policy shall apply separately to each annual period.

(17) **Changes:** Notice to any agent of knowledge possessed by any agent or by any other person shall not affect a waiver or a change in any part of this policy or stop the Company from asserting any right under the terms except by endorsement issued to form a part of this policy signed by *_____ provided, however, changes may be made in the written portion of the declaration by *_____ when initialed by such *_____ or by endorsement issued to form a part of this policy signed by such

*_____. [*Insert titles of authorized company representatives.]

(18) **Assignment:** Assignment of interest under this policy shall not bind the Company until its consent is endorsed hereon.

(19) **Cancellation:** This policy may be cancelled by the named insured by mailing to the Company written notice stating when the cancellation shall become effective. This policy may be cancelled by the Company by mailing to the named insured, Contractor, and governmental authority at the respective addresses shown in this policy written notice stating when such cancellation shall be effective (not less than 30 days thereafter). The mailing of notice shall be sufficient proof of notice. The effective date and hour of cancellation stated in the notice shall become the end of the policy period. Delivery of such written notice either by the named insured or the Company shall be equivalent to mailing. If the named insured cancels, the earned premium shall be computed in accordance with the customary short rate table and procedure. If the Company cancels, the earned premium shall be computed pro rata. The premium may be adjusted either at the time cancellation is effected or as soon as practicable after the cancellation becomes effective, but payment or tender of unearned premium is not a condition of cancellation.

(20) **Declarations:** By acceptance of this policy, the named insured agrees that such statements in the Declarations as are made by him are his agreements and representations, that his policy is issued in reliance on the truth of such representations, and that this policy embodies all agreements existing between himself and the Company or any of its agents relating to this insurance.

e. **For a policy issued by one company:**

In witness whereof, the _____ Indemnity Company has caused this policy to be signed by its president and a secretary at _____ and countersigned on the Declarations page by a duly authorized agent of the Company.

(Facsimile of Signature) Secretary	(Facsimile of Signature) President

For a policy issued by two companies:

In witness whereof, the _____ Indemnity Company has caused this policy with respect to Coverages _____ and such other parts of the policy as are applicable thereto to be signed by its president and a secretary at _____ and countersigned on the Declarations page by a duly authorized agent of the Company.

(Facsimile of Signature) Secretary	(Facsimile of Signature) President

(d) **Submitting Copies of Insurance Policies:** Prior to beginning construction operations on or over the railway right of way, the Contractor shall submit to the Department evidence of the railway company's approval and a copy of the required insurance policies. The State will not be responsible for any claims from the Contractor resulting from delay in the acceptance of any of these policies by the railway company other than consideration of an extension of time. If the delay is caused by the failure of the Contractor or his insurer to file the required insurance policies promptly, an extension of time will not be granted.

(e) **Beginning Construction:** Preliminary contingent work or other work by the railway company may delay the starting or continuous prosecution of the work by the Contractor. The Contractor shall be satisfied as to the probable extent of such work and its effect on the operations prior to submitting a proposal. The State will not be responsible for any claims by the Contractor resulting from such delays except that an extension of time may be considered.

(f) **Arranging for Tests:**

1. **Railroad specifications:** When ordering materials that are to conform to railroad specifications, the Contractor shall notify the railway company, who will arrange for tests. The Contractor shall specify in each order that the materials are to be tested in accordance with the requirements of the railroad specifications and not those of the Department.

2. **Highway specifications:** When ordering materials that are to conform to highway specifications, the Contractor shall specify in each order that the materials are to be tested in accordance with the requirements of VDOT specifications.

107.09—Construction Over or Adjacent to Navigable Waters.

The Contractor shall conduct the work on navigable waters so as to ensure the least possible obstruction to navigation and that the existing navigable depths will not be impaired except as may be allowed by a permit issued by the U.S. Coast Guard. The Contractor shall also provide and maintain temporary navigation lights and signals required by U.S. Coast Guard regulations for the protection of navigation. When the Engineer determines that the work has reached a point where such action may be taken, the channel(s) through the structure shall be promptly cleared of falsework, piling, or other obstructions placed therein or caused by the construction of the structure to the satisfaction of the Coast Guard.

107.10—Barricades and Warning Signs.

The Contractor shall take all necessary precautions for the protection of the work and the safety of the public as described herein and in Sections 104.04, 107.07, and 512.

Highways closed to traffic shall be protected by barricades and other warning devices as required by the Engineer. Barricades and warning devices shall be illuminated where required during darkness and low visibility. The Contractor shall erect warning devices in advance of a location on the project where operations or obstructions may interfere with the use of the road by traffic and at all intermediate points where the new work crosses or coincides with an existing roadway. The Contractor shall maintain sign faces and reflective surfaces of warning devices in a clean and visible condition. Barricades, warning signs, lights, temporary signals, and other protective devices shall conform to the requirements of the *MUTCD*. The reflective surface of signs and safety devices furnished by the Contractor shall be fabricated using encapsulated lens reflective sheeting conforming to the requirements of Section 701.

107.11—Use of Explosives.

The Contractor shall be responsible for damage resulting from the use of explosives. Explosives shall be stored in a secure manner in compliance with federal, state, and local laws and ordinances.

The Contractor shall notify each property and utility owner having a building, structure, or other installation above or below ground in proximity to the site of the work of his intention to use explosives. Notice shall be given sufficiently in advance to enable the owners to take steps to protect their property. Notice shall not relieve the Contractor of responsibility for damage resulting from his blasting operations.

107.12—Protecting and Restoring Property and Landscape.

The Contractor shall preserve property and improvements along the lines of and adjacent to the work unless their removal or destruction is called for by the plans. The Contractor shall use suitable precautions to prevent damage to such property.

When the Contractor finds it necessary to enter on private property, he shall secure from the owner or lessee a written permit for such entry prior to moving thereon. An executed copy of this permit shall be furnished the Engineer.

The Contractor shall be responsible for damage or injury to property during the prosecution of the work resulting from any act, omission, neglect, or misconduct in the method of executing the work or attributable to defective work or materials. This responsibility shall not be released until final acceptance of the project.

When direct or indirect damage is done to property by or on account of any act, omission, neglect, or misconduct in the method of executing the work or in consequence of the nonexecution thereof on the part of the Contractor, the Contractor shall restore such property to a condition similar or equal to that existing before such damage was done by repairing, rebuilding, or restoring, as may be directed by the Engineer, or making settlement with the property owner. The Contractor shall secure from the owner a release from any claim against the Department without additional compensation therefor. A copy of this release shall be furnished the Engineer.

107.13—Responsibility for Damage Claims.

The Contractor shall indemnify and save harmless the State, the Board, and its officers, agents, and employees, as well as the city, town, county, or other municipality in which the work is performed and their officers, agents, and employees, from suits, actions, or claims brought for or on account of any injuries or damages received or sustained by any person, persons, or property resulting from or arising out of the work performed by the Contractor, or by or in consequence of any neglect in safeguarding the work, through the use of unacceptable materials in the construction or the improvement, or resulting from any act or omission, neglect, or misconduct of the Contractor; or by or on account of any claims or amounts recovered by infringement of any patent, trademark, or copyright. The Commissioner may retain as much of the monies due the Contractor under and by virtue of his Contract as the State considers necessary to ensure that a fund will be available to pay a settlement or judgment of such suits, actions, or claims. If no monies are due, the Contractor's surety will be held until all such claims and actions have been settled and suitable evidence to that effect has been furnished the Board. Any extension of time granted the Contractor in which to complete the Contract shall not relieve him or his surety of this responsibility.

It is not intended by any of the provisions of any part of the Contract to create the public or any member thereof as a third party beneficiary hereunder or to authorize anyone not a party to the Contract to maintain a suit for personal injuries or property damage pursuant to the terms or provisions of the Contract.

When any act, omission, or other action of the Contractor occurs that affects the health, safety, or welfare of the public, the Engineer will direct the Contractor to take prompt action to repair, replace, or restore the damage or injury within a time frame established by the Engineer. If the Contractor fails to make such repair, replacement, or restoration within the established time frame, the Engineer will have the damage or injury repaired, replaced, or restored and will deduct the cost of such repair, replacement, or restoration from monies due the Contractor.

107.14—Environmental Stipulations.

By signing the bid, the bidder shall have stipulated (1) that any facility to be used in the performance of the Contract (unless the Contract is exempt under the Clean Air Act as amended [42 U.S.C. 1857, et seq., as amended by P.L. 91-604], the Federal Water Pollution Control Act as amended [33 U.S.C. 1251 et seq. as amended by P.L. 92-500], and Executive Order 11738 and regulations in implementation thereof [40 C.F.R., Part 15]) is not listed on the EPA's List of Violating Facilities pursuant to 40 C.F.R. 15.20; and (2) that the Department will be promptly notified prior to the award of the Contract if the bidder receives any communication from the Director, Office of Federal Activities, EPA, indicating that a facility to be used for the Contract is under consideration to be listed on the EPA's List of Violating Facilities.

No separate payment will be made for the work or precautions described herein except where provided for as a specific item in the Contract or except where provision has been made for such payment in these specifications.

(a) **Erosion and Siltation:** The Contractor shall exercise every reasonable precaution, including temporary and permanent measures, throughout the duration of the project to control erosion and prevent or minimize siltation of rivers, streams, lakes, and impoundments. Siltation control measures shall be applied to erodible material exposed by any activity associated with construction, including but not limited to local material sources, stockpiles, disposal areas, and haul roads.

Temporary measures shall be coordinated with contract work to the extent practicable to ensure economical, effective, and continuous erosion and siltation control. Permanent erosion control measures and drainage facilities shall be installed as the work progresses.

The Contractor shall inspect erosion and siltation control devices and measures for deficiencies immediately after each rainfall and at least daily during prolonged rainfall. Deficiencies shall be corrected immediately. Failure on the part of the Contractor to maintain erosion and siltation control devices in a functioning condition may result in the Engineer notifying the Contractor in writing of specific deficiencies. If the Contractor fails to correct or take appropriate actions to remedy the specified deficiencies within 24 hours after receipt of such notification, the Department may require the Contractor to discontinue work in other areas and concentrate efforts toward rectifying the specified deficiencies or the Engineer may proceed to remedy specified deficiencies and deduct the entire cost of such work from monies due the Contractor.

(b) **Pollution:**

1. **Water:** The Contractor shall exercise every reasonable precaution throughout the duration of the project to prevent pollution of rivers, streams, and impoundments. Pollutants such as chemicals, fuels, lubricants, bitumens, raw sewage, paints, sedimentation, and other harmful material shall not be discharged into or alongside rivers, streams, or impoundments or into channels leading to them.

   Construction discharge water shall be filtered to remove deleterious materials prior to discharge into state waters. During specified spawning seasons, discharges and construction activities in spawning areas of state waters shall be restricted so as not to disturb or inhibit aquatic species that are indigenous to the waters. Neither water nor other effluence shall be discharged onto wetlands or breeding or nesting areas of migratory waterfowl. When used extensively in wetlands, heavy equipment shall be placed on mats. Temporary construction fills and mats in wetlands and flood plains shall be constructed of approved nonerodible materials and shall be removed by the Contractor to natural ground when the Engineer so directs.

   If the Contractor dumps, discharges, or spills any oil or chemical that reaches or has the potential to reach a waterway, he shall immediately notify all appropriate jurisdictional state and federal agencies in accordance with the requirements of Section 107.01 and shall take immediate actions to contain, remove, and properly dispose of the oil or chemical.

   Excavation material shall be disposed of in approved areas above the mean high water mark shown on the plans in a manner that will prevent the return of solid or suspended materials to state waters. If the mark is not shown on the plans, the mean high water mark shall be considered the elevation of the top of stream banks.

Constructing new bridge(s) and dismantling and removing existing bridge(s) shall be accomplished in a manner that will prevent the dumping or discharge of construction or disposable materials into rivers, streams, or impoundments.

Construction operations in rivers, streams, or impoundments shall be restricted to those areas where channel changes are shown on the plans and to those that must be entered for the construction of structures. Rivers, streams, and impoundments shall be cleared of falsework, piling, debris, or other obstructions placed therein or caused by construction operations.

The Contractor shall prevent stream constriction that would reduce stream flows below the minimum, as defined by the State Water Control Board, during construction operations.

If it is necessary to relocate an existing stream or drainage facility temporarily to facilitate construction, the Contractor shall design and provide temporary channels or culverts of adequate size to carry the normal flow of the stream or drainage facility. The Contractor shall submit a temporary relocation design to the Engineer for review and acceptance in sufficient time to allow for discussion and correction prior to beginning the work the design covers. Costs for the temporary relocation of the stream or drainage facility shall be included in the contract price for the related pipe or box culvert.

Temporary bridges or other structures shall be used wherever an appreciable number of stream crossings will be made.

2. **Air:** The Contractor shall comply with the provisions of Section 107.01 and the State Air Pollution Control Law and Rules of the State Air Pollution Control Board, including notifications required therein.

Burning shall be performed in accordance with applicable local laws and ordinances and under the constant surveillance of watchpersons. Care shall be taken so that the burning of materials does not destroy or damage property or cause excessive air pollution. The Contractor shall not burn rubber tires, asphalt, used crankcase oil, or other materials that produce dense smoke. Burning shall not be initiated when atmospheric conditions are such that smoke will create a hazard to the motoring public or airport operations. Provisions shall be made for flagging vehicular traffic if visibility is obstructed or impaired by smoke. At no time shall a fire be left unattended.

Asphalt mixing plants shall be designed, equipped, and operated so that the amount and quality of air pollutants emitted will conform to the Rules of the State Air Pollution Control Board.

Emission standards for asbestos incorporated in the EPA's National Emission Standards for Hazardous Air Pollutants apply to the demolition or renovation of any institutional, commercial, or industrial building, structure, facility, installation, or portion thereof that contains friable asbestos.

3. **Noise:** The Contractor's operations shall be performed so that exterior noise levels measured during a noise-sensitive activity shall be not more than 80 decibels. *Noise-sensitive activity* is any activity for which lowered noise levels are essential if the activity is to serve its intended purpose. Such activities include, but are not limited to, those associated with residences, hospitals, nursing homes, churches, schools, libraries, parks, and recreational areas.

   The Department may monitor construction-related noise. If construction noise levels exceed 80 decibels, the Contractor shall take corrective action before proceeding with operations. The Contractor shall be responsible for costs associated with the abatement of construction noise and the delay of operations attributable to noncompliance with these requirements.

   The Department may prohibit or restrict to certain portions of the project any work that produces objectionable noise between 10 P.M. and 6 A.M. If other hours are established by local ordinance, the local ordinance shall govern.

   Equipment shall in no way be altered so as to result in noise levels that are greater than those produced by the original equipment.

   When feasible, the Contractor shall establish haul routes that direct his vehicles away from developed areas and ensure that noise from hauling operations is kept to a minimum.

   These requirements are not applicable if the noise produced by sources other than the Contractor's operation at the point of reception is greater than the noise from the Contractor's operation at the same point.

(c) **Forests:** The Contractor shall take all reasonable precautions to prevent and suppress forest fires in any area involved in construction operations or occupied by him as a result of such operations. The Contractor shall cooperate with the proper authorities of the state and federal governments in reporting, preventing, and suppressing forest fires. Labor, tools, or equipment furnished by the Contractor upon the order of any forest

official issued under authority granted the official by law shall not be considered a part of the Contract. The Contractor shall negotiate with the proper forest official for compensation for such labor, tools, or equipment.

(d) **Archeological, Paleontological, and Rare Mineralogical Findings:** In the event of the discovery of prehistoric ruins, Indian or early settler sites, burial grounds, relics, fossils, meteorites, or other articles of archeological, paleontological, or rare mineralogical interest during the prosecution of work, the Contractor shall act immediately to suspend work at the site of the discovery and notify the Engineer. The Engineer will immediately notify the proper state authority charged with the responsibility of investigating and evaluating such finds. The Contractor shall cooperate and, upon request by the Engineer, assist in protecting, mapping, and removing the findings. Labor, tools, or equipment furnished by the Contractor for such work will be paid for in accordance with the requirements of Section 104.03. Findings shall become the property of the State unless they are located on federal lands, in which event they shall become the property of the U.S. government.

When such work delays the progress of the work, the Engineer will give consideration to adjustments in the contract time limit in accordance with the requirements of Section 108.09.

107.15—Opening Sections of Projects to Traffic.

When specified in the Contract or when directed by the Engineer, certain sections of the work may be opened to traffic. Such opening shall not constitute acceptance of the work or any part thereof or a waiver of any provision of the Contract.

On any section of the work opened by order of the Engineer where the Contract does not provide for traffic to be carried through the work and the Contractor has not been dilatory in prosecuting the work, the Contractor will not be required to assume any expense entailed in maintaining the road for traffic. Such expense will be borne by the Department or will be compensated for in accordance with the requirements of Section 109.05. Repair of slides and repair of damage attributable to traffic will be compensated for in accordance with the requirements of Section 109.05. The cost of all other repairs shall be borne by the Contractor. Slides shall be removed by the Contractor in accordance with the requirements of Section 303.

On any section of the work opened by order of the Engineer where the Contract does not provide for traffic to be carried through the work, any additional cost for the completion of other items of work that are occasioned because of the changed working conditions will be compensated in accordance with the requirements of Section 109.05.

If the Contractor is dilatory in completing the work, he shall not be relieved of the responsibility for maintenance during the period the section is opened to traffic prior to final acceptance. Any expense resulting from the opening of such portions under these circumstances, except slides, shall be borne by the Contractor. The Contractor shall conduct the remainder of the construction operations so as to cause the least obstruction to traffic.

107.16—Contractor's Responsibility for Work.

Until final acceptance of the work by the Engineer in accordance with the requirements of Section 105.15, the Contractor shall have charge and care thereof and shall take every precaution against damage to any part thereof by action of the elements or from any other cause. The Contractor shall rebuild, repair, restore, and make good damage to any portion of the work occasioned by any of the foregoing causes before final acceptance and shall bear the expense thereof. The Department may reimburse the Contractor for repair of damage to work attributable to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor.

In case of suspension of work, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the work, provide for erosion control and drainage, and erect any necessary temporary structures, signs, or other facilities at his own expense. During the suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings, and soddings furnished under the Contract and shall take adequate precautions to protect new tree growth and other important vegetation against damage.

107.17—Contractor's Responsibility for Utility Property and Services.

At points where the Contractor's operations are adjacent to the properties of any utility, including railroads, and damage to which might result in considerable expense, loss, or inconvenience, work shall not commence until arrangements necessary for the protection thereof have been completed.

The Contractor shall cooperate with owners of utility lines so that removal and adjustment operations may progress in a reasonable manner, duplication of adjustment work may be reduced to a minimum, and services rendered by those parties will not be unnecessarily interrupted.

If any utility service is interrupted as a result of accidental breakage or of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the authority in the restoration of service. If utility service is interrupted, repair work shall be continuous until service is restored. No work shall be undertaken around fire hydrants until provisions for continued

service have been approved by the local fire authority. When the Contractor's work operations require the disconnection of "in service" fire hydrants, the Contractor shall notify the locality's fire department or communication center at least 24 hours prior to disconnection. In addition, the Contractor shall notify the locality's fire department or communications center no later than 24 hours after reconnection of such hydrants. The Contractor shall be responsible for any damage to utilities that is attributable to his neglect or methods of performing the work.

Nothing in this section shall be construed to be in conflict with Section 107.12.

107.18—Furnishing Right of Way.

The Department will secure necessary rights of way and easements in advance of construction. The Department will not be responsible for any delay in the acquisition of a right of way other than consideration of an extension of time. Easements for temporary uses and detours requested by the Contractor and approved by the Department in lieu of a detour within the right of way or easement area shall be acquired by the Contractor without the Department being a party to the agreement.

107.19—Personal Liability of Public Officials.

In carrying out any of the provisions of these specifications or in exercising any power or authority granted to them by or within the scope of the Contract, there shall be no liability upon the Board, Commissioner, Engineer, or their authorized representatives, either personally or as officials of the State. In all such matters, they act solely as agents and representatives of the State.

107.20—No Waiver of Legal Rights.

The State shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after final acceptance of the work and payment therefor from showing (1) the true amount and character of the work performed and materials furnished by the Contractor, (2) that any such measurement, estimate, or certificate is untrue or incorrectly made, or (3) that the work or materials do not conform with the provisions of the Contract. The State shall not be precluded or estopped, notwithstanding any such measurement, estimate, or certificate, and payment in accordance therewith, from recovering from the Contractor or his surety, or both, such damage as it may sustain by reason of his failure to comply with the terms of the Contract. Neither the acceptance by the Department or any representative of the Department nor any payment for or acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Department shall operate as a waiver of any portion of the Contract or of any power herein reserved or of any right to damages. A

waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach.

SECTION 108—PROSECUTION AND PROGRESS OF WORK

108.01—Subcontracting.

No portion of the Contract shall be subcontracted or otherwise disposed of without the written consent of the Engineer.

The Contractor shall perform, with his own organization, work amounting to not less than 30 percent of the original contract value.

The Contractor shall not subcontract any part of the contract work having a contract value of $1 million or more to a Contractor who is not prequalified with the Department in accordance with the requirements of Section 102.01. Work having a contract value of less than $1 million shall not be subcontracted to any Contractor who is not prequalified or registered with the Department. This restriction does not apply to contract specialty items, consultants, manufacturers, suppliers, or haulers. Consent to subcontract or otherwise dispose of any portion of the contract work shall not relieve the Contractor of any responsibility for the fulfillment of the entire Contract.

108.02—Notice to Proceed.

The Engineer will issue a Notice to Proceed within 30 days after execution of the Contract by the Department. The contract time will start at the commencement of work or on the date specified in the Notice to Proceed, whichever is earlier. In no case shall work begin before the Contract is executed by the Department. The Contractor shall notify the Engineer at least 3 days prior to the date on which work will begin.

108.03—Prosecution of Work.

The Contractor shall begin work within 10 days of the date specified in the Notice to Proceed. Work shall be conducted in such a manner and with sufficient materials, equipment, tools, and labor as are necessary to ensure its completion in accordance with the plans and these specifications within the time limit specified in the Contract and these specifications. Once the Contractor has begun work, it shall be prosecuted continuously and to the fullest extent possible except for interruptions caused by weather or delays authorized or ordered by the Engineer. If approval is given to discontinue the work temporarily, the

Contractor shall notify the Engineer at least 24 hours in advance of resuming operations.

108.04—Critical Materials.

When the supply of critical materials becomes scarce because of the needs of national defense or industrial conditions beyond the control of the Department or Contractor, the provisions of this Section will become applicable to the Contract.

When all items of work involving noncritical materials have been completed by the Contractor or have progressed to a point where no further work is practicable prior to receipt of critical materials, a complete suspension of work will be granted by the Department. Requests for partial suspension orders because of delays attributable to nonreceipt of critical materials will be considered on the basis of merit in each case.

The Department reserves the right to substitute materials by means of an extra work order.

108.05—Limitation of Operations.

The Contractor shall conduct the work in a manner and sequence that will ensure its expeditious completion with the least interference to traffic and shall have due regard for the location of detours and provisions for handling traffic. The Contractor shall not open any work to the prejudice or detriment of work already started. The Engineer may require the Contractor to finish a section of work before work is started on any other section.

108.06—Gratuities.

Gifts, gratuities, or favors shall not be given or offered by the Contractor to personnel of the Department. A gift, gratuity, or favor of any nature whatsoever or offer of such by the Contractor shall be a violation of this provision.

The Contractor shall not employ any personnel of the Department for any services without the prior written consent of the Engineer.

If the Engineer determines that the Contractor or the Contractor's employees, representatives, or agents of any person acting in his behalf have violated this provision, the Contractor may, at the discretion of the Engineer, be disqualified from bidding on future contracts with the Department. Any implicated employees, agents, or representatives of the Contractor may be prohibited from working on any contract awarded by the Department. The decision of the

Engineer shall be binding on all parties. A Contractor so disqualified may be reinstated only by petition to and approval by the Board.

108.07—Character of Workers, Work Methods, and Equipment.

Workers shall have sufficient skill and experience to perform properly the work assigned to them. Workers engaged in special or skilled work shall have sufficient experience in such work and in the operation of equipment required to perform it properly and satisfactorily.

Any person employed by the Contractor or any subcontractor who, in the opinion of the Engineer, does not perform his work in a proper and skillful manner or is intemperate or disorderly shall, at the written request of the Engineer, be removed forthwith by the Contractor or subcontractor employing the person and shall not be employed again on any portion of the work without the approval of the Engineer. If the Contractor fails to remove the person or furnish suitable and sufficient personnel for proper prosecution of the work, the Engineer may withhold all monies that are or may become due the Contractor and may suspend the work until the Contractor has complied with the request or order.

Equipment shall be of sufficient size and in such mechanical condition as to meet the requirements of the work and produce a satisfactory quality of work. Equipment shall be such that no damage to the roadway, adjacent property, or other highways will result from its use. The Engineer may order the removal and require replacement of unsatisfactory equipment.

When methods and equipment to be used by the Contractor are not prescribed in the Contract, the Contractor is free to use methods or equipment approved by the Engineer that will accomplish the contract work in conformity with the requirements of the Contract.

When the Contract specifies that construction be performed by the use of particular methods and equipment, they shall be used unless others are authorized by the Engineer. If the Contractor desires to use a different method or type of equipment, he may request permission from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment he proposes to use and an explanation of the reasons for desiring to make the change. If permission is given, it will be on the condition that the Contractor shall be fully responsible for producing construction work in conformity with contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not conform to the requirements of the Contract, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove any deficient work and replace it with work of the specified quality or take such other corrective action as the Engineer may direct. No change will be made in the basis of payment for the construction items involved or the contract

time limit as the result of authorizing a change in methods or equipment under these provisions.

108.08—Progress Schedule.

The Contractor shall submit a progress schedule satisfactory to the Engineer that shows the proposed order of work and indicates the time required to complete the items of work. The schedule shall conform to the requirements of Section 103.06(e). The schedule may be used as the basis for establishing major construction operations and as a check on the progress of the work. The schedule shall, however, be subject to revision in accordance with the requirements of Section 105.08. Payment for material stockpiled or stored in accordance with the requirements of Section 109.08 will not be considered in determining the Contractor's rate of progress.

108.09—Determination and Extension of Contract Time Limit.

The contract time limit will be determined by the Department and specified in the Contract in calendar days or as a fixed date. No request for an extension of time will be considered that is based on any claim that the contract time limit as originally established was inadequate.

If the satisfactory fulfillment of the Contract with extensions and increases authorized in accordance with the requirements of Sections 104.02 and 104.03 requires the performance of work in greater quantities than those specified in the Contract, the contract time limit may be increased according to one of two options selected at the discretion of the Engineer: (1) the extra time allowances as agreed on and set forth in the extra work order that covers the additional work, or (2) the same ratio that the total cost of work actually performed shall bear to the total cost shown in the bid schedule.

With a fixed-date contract, when the Notice to Proceed is not issued within 45 days after the opening of bids, or the Contractor is unable to commence work because of any failure of the Department, or when the Contractor is delayed because of the fault of the Department, the Contractor may be given a time extension based on the number of days delayed beyond the 45 days. No time extension will be allowed for a delay in the issuance of the Notice of Proceed when the delay is the fault of the Contractor.

During prosecution of the work, the Contractor shall identify the causes for any delays attributable to conditions he deems to be beyond his control and shall identify the particular construction operations affected and the significant dates that encompass the periods of delay. The timely submission to the Engineer of such information is essential for the Department to make an adequate evaluation of any subsequent claim received from the Contractor for an extension of the contract time limit.

If the Contractor has not completed the work within the contract time limit or as extended in accordance with the requirements of this Section, he may make a written claim to the Engineer for an extension of time setting forth the reasons he believes will justify granting the claim. Such claims must be filed within 60 days after the final estimate is paid by the State. If the Engineer determines that the work was delayed because of conditions beyond the control of and without the fault of the Contractor, the Engineer may extend the time for completion as the conditions justify. The extended time shall then be in full force and effect the same as if it had been the original time for completion.

(a) **Calendar Days:** When the contract time limit is specified in calendar days, the time includes Sundays, holidays, and nonworking days. When the Engineer authorizes the suspension of work in whole or in part in accordance with the requirements of Section 108.10 and such suspension is not attributable to any fault or negligence on the part of the Contractor, the contract time limit will be adjusted. The contract time limit may be adjusted on a day-for-day basis when the work is wholly suspended and on a prorated basis when the work is partially suspended.

To determine the number of calendar days chargeable to the contract time limit for work performed between the effective dates of a partial suspension order, the total dollar value of the Contract will be divided by the number of days in the contract time limit. The result shall be the dollar value of one day's work. The dollar value of all work actually performed during a partial suspension period will be divided by the monetary value of one day's work. The result, in days, will be charged against the contract time limit. In no case will the number of days charged be greater than the total number of calendar days between the effective dates of a partial suspension order. In determining the dollar value of work actually performed during a partial suspension period, the dollar value of adjustments made for work performed prior to the issuance of a partial suspension order and the dollar value of mobilization and stockpiled materials during the period will be excluded.

(b) **Fixed Date:** When the contract time limit is specified as a fixed date, the Contractor shall take into consideration normal conditions considered unfavorable for the prosecution of the work and shall place sufficient workers and equipment on the project to complete the work in accordance with the contract time limit.

The Engineer may give consideration for extension of time when a delay occurs due to unforeseen causes beyond the control of and without the fault or negligence of the Contractor. However, consideration will not be given to extensions of time attributable to weather conditions or conditions resulting from weather.

If there is a delay in the progress of the work due to unforeseen causes described hereinbefore, and the delay extends the contract time limit into the period between November 30 of one year and April 1 of the following year and working conditions during such period are unsuitable for the completion of the work, then consideration may be given to granting an extension of time that will encompass a suitable period during which such work can be expeditiously and acceptably performed.

When the Engineer determines that an extension of contract time will be made in accordance with the requirements of Section 108.09, the daily dollar value to be used in computing time extensions resulting from monetary increases will be based on the number of days resulting from deducting 45 days from the number of days between the inclusive dates of the receipt of bids and the fixed completion date.

108.10—Suspension of Work Ordered by the Engineer.

If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation and/or contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment within 7 calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the cost and/or time required for the performance of the contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the contract is warranted.

No contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.

No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of this contract.

108.11—Failure To Complete on Time.

For each calendar day that any work remains incomplete after the contract time limit specified for the completion of the work, the Department will assess liquidated damages against the Contractor. Liquidated damages, assessed in accordance with the Schedule of Liquidated Damages (Table I-1), at the rate applicable to the Contract for each day of additional time consumed, subject to such adjustments as provided in accordance with the requirements of Section 108.09, will be deducted from any monies due the Contractor, not as a penalty but as liquidated damages.

108.12—Liquidated Damages.

The following Schedule of Liquidated Damages, representing the cost of administration, engineering, supervision, inspection, and other expenses, will be charged against the Contractor for each calendar day beyond the contract time in which the Contract remains in an incomplete state:

TABLE I-1
Schedule of Liquidated Damages

Original Contract Amount In Dollars		Daily Charge In Dollars
From More Than	To and Including	
0	50,000	120
50,000	100,000	250
100,000	500,000	450
500,000	1,000,000	1,050
1,000,000	2,000,000	1,400
2,000,000	4,000,000	1,600
4,000,000	8,000,000	1,800
8,000,000 +		2,800

108.13—Default of Contract.

The Contractor may be declared in default if he does *any* one of the following:

1. fails to begin the work under the Contract within 10 days of the date specified in the Notice to Proceed

2. fails to perform the work with sufficient workers and equipment or with sufficient materials to ensure prompt completion of the work

3. performs the work unsuitably or neglects or refuses to remove materials or perform anew work that is unacceptable

4. discontinues prosecution of the work

5. fails to resume work that has been discontinued within a reasonable time after notice to do so

6. becomes insolvent, is declared bankrupt, or commits any act of bankruptcy or insolvency

7. allows any final judgment to stand against him unsatisfied for a period of 10 days

8. makes an assignment for the benefit of creditors

9. fails for any other cause whatsoever to carry on the work or contractual obligations in an acceptable manner

If any of these conditions exists, the Engineer will give notice in writing to the Contractor and his surety of the delay, neglect, or default. If within 10 days after such notice the Contractor or his surety has not taken measures that will, in the judgment of the Engineer, ensure satisfactory progress of the work or give assurances satisfactory to the Engineer that the provisions of the Contract will be fully carried out and instructions complied with, the Commissioner may then, or at any time thereafter, declare the Contractor in default. Without violating the Contract, the Commissioner may call upon the Contractor's surety for the satisfactory and expeditious completion of all work under the Contract or may otherwise terminate the Contract in accordance with Section 108.14.

If the Contractor is declared in default, subsequent payments will be made to the surety and further negotiations will be conducted with the surety.

If the Contractor's surety fails or refuses to proceed with the work and make satisfactory progress thereon in accordance with the instructions of the Commissioner, the Commissioner will appropriate and use any or all materials and equipment on the project site that are suitable and acceptable and will enter into an agreement with others for the completion of the work, or he will use such other methods as he deems necessary to ensure the completion of the work.

Costs and charges incurred by the Department, including the cost of completing the work under the Contract, will be deducted from any monies due or that will become due the Contractor and his surety. If the expense incurred by the Department is less than the sum that would have been payable under the Contract if it had been completed by the Contractor, the Contractor and his surety will be entitled to receive the difference. If the expense exceeds the sum that would have been payable under the Contract, the Contractor and his surety shall be liable for and shall pay to the State the amount of the excess.

108.14—Termination of Contract.

(a) **Conditions for Termination:** The Department may terminate the Contract or any portion thereof because of *any* of the following conditions:

1. default

2. national emergency

3. action by the State, U.S. government, or court order

4. conditions beyond the control of the Department

(b) **Provisions of Termination:** Termination will be in accordance with the following:

1. Disturbed areas shall be promptly placed in an acceptable condition as directed by the Engineer. Payment for such work will be made at the contract unit prices or, in the absence of contract unit prices, in accordance with the requirements of Section 104.03.

2. Payment will be made for the actual number of units or items of work completed at the contract unit price, or as mutually agreed, for items of work partially completed. No claim for loss of anticipated profits will be considered, and the provisions of Section 104.02 will not apply.

3. Reimbursement for organizing the work when not specified in the Contract and moving equipment to and from the job will be considered where the volume of work completed is too small to compensate the Contractor for these expenses under the contract unit prices.

4. At the option of the Engineer, materials the Contractor obtains for the work that have been inspected, tested, and accepted by the Engineer and that have not been incorporated in the work may be purchased from the Contractor at actual costs as shown by receipted bills and actual cost records at such points of delivery as may be designated by the Engineer.

5. The termination of the Contract or a portion thereof shall not relieve the Contractor of his responsibilities for the completed work, nor shall it relieve his surety of its obligation for and concerning any just claims arising out of the work performed.

108.15—Termination of Contractor's Responsibilities.

The Contract will be considered complete upon final acceptance. The Contractor will be notified in writing of the final acceptance, and his responsibility will then cease except as set forth in his bond.

SECTION 109—MEASUREMENT AND PAYMENT

109.01—Measurement of Quantities.

Work specified in the Contract will be measured by the Engineer according to the International System of Units (SI). The methods of measurement and computations to be used to determine quantities of material furnished and work performed will be those generally recognized as conforming to good engineering practice.

Longitudinal measurements for surface computations will be made horizontally, and transverse measurements will be the surface measure shown on the plans or ordered in writing by the Engineer. Individual utility encroachment areas of 1 square meter or less will not be deducted from surface areas measured for payment.

Structures will be measured according to neat lines shown on the plans.

Items that are measured by the meter will be measured parallel to the base or foundation upon which they are placed.

Allowance will not be made for surfaces placed over a greater area than shown on the plans or for any material moved from outside the area of the cross section and lines shown on the plans.

When standard manufactured items are specified and are identified by weights or dimensions, such identification will be considered nominal. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

(a) **Measurement by Mass**: Materials that are measured or proportioned by mass shall be weighed on accurate scales. When material is paid for on a metric tonnage basis, personnel performing the massing shall be certified by the Engineer and shall be bonded to the Commonwealth of Virginia in the amount of $10,000 for the faithful observance and performance of the duties of the weighperson required herein. The bond shall be executed on a form having the exact wording as the Weighpersons Surety Bond Form furnished by the Department and shall

be submitted to the Department prior to the furnishing of the metric tonnage material. No payment will be made for materials delivered in excess of the legal load limits established for each truck.

The Contractor shall have the weighperson perform the following:

1. Post and furnish a weekly tare mass of each truck used and keep a record of them for 12 months.

2. Furnish a signed shipping ticket for each load that shows the date, truck number, load number, plant name, size and type of material, project, schedule or purchase order number, and the masses specified herein.

3. Maintain sufficient documentation so that the accumulative metric tonnage and distribution of each lot of material, by contract, can be readily identified.

4. Submit by the end of the next working day a summary of the number of loads and total masses for each type of material by contract.

Trucks used to haul material being paid for by mass shall display the truck uniform identification number and legal gross and legal net mass limits. These markings shall be no less than 50 millimeters high and permanently stenciled on each side of the truck with contrasting color and located as to be clearly visible when the vehicle is positioned on the scales and observed from normal position of the weighperson at the scale house.

Trucks used to haul material shall be equipped with a cover suitable to protect the material and to protect the traveling public.

The truck tare to be used in the massing operation shall be the mass of the empty truck determined with full tank(s) of fuel and the operator seated in the cab. The tare mass of trucks shall be recorded to the nearest 10 kilograms. At the option of the Contractor, a new tare may be determined for each load. When a new tare is obtained for each load, the requirement for full tank(s) of fuel will be waived.

Net rail shipment masses may be used for pay quantities when evidenced by railroad bills of lading. However, such masses will not be accepted for pay quantities of materials that subsequently pass through a stationary mixing plant.

Scales shall conform to the requirements for accuracy and sensitivity as set forth by the *National Institute of Standards and Technology Handbook No. 44 for Specification Tolerances and Requirements for Commercial and Weighing Devices.* Scales used in the massing of materials paid for

on a metric tonnage basis shall be approved and sealed in accordance with the requirements of the policies of the Bureau of Weights and Measures of the Department of Agriculture and Consumer Services, or other approved agencies, at least once every six months and upon being moved. Hopper and truck scales shall be serviced and tested by a scale service representative at least once every six months. Hopper scales shall be checked with a minimum 225 kilograms of test masses and truck scales shall be checked with a minimum 9,000 kilograms of test masses.

Copies of scale test reports shall be maintained on file at the scale location for at least 18 months, and copies of all scale service representative test reports shall be forwarded to the Department.

The quantity of materials paid for on a metric tonnage basis shall be determined on scales equipped with an automatic printer. Truck scale printers shall print the net mass and either the gross or tare mass of each load. Hopper scale printers shall conform to the requirements of Section 211.11 and shall print the net mass of each load. The shipping ticket shall also show the legal gross mass for material massed on truck scales and the legal net mass for material massed on hopper scales.

If the automatic printer becomes inoperative, the massing operation may continue for 48 hours provided satisfactory visual verification of masses can be made. The written permission of the Engineer will be required for the operation of scales after 48 hours.

If significant discrepancies are discovered in the printed mass, the ultimate mass for payment will be calculated on volume measurements of the materials in place and unit masses determined by the Engineer or by other methods deemed appropriate to protect the interests of the State.

(b) **Measurement by Cubic Meter**: Material that is measured by the cubic meter, loose measurement or vehicular measurement, shall be hauled in approved vehicles and measured therein at the point of delivery. Material measured in vehicles, except stream bed gravel, will be allowed at the rate of 2/3 the volume of the vehicle. The full volume of the vehicle will be allowed for stream bed gravel. Such vehicles may be of any size or type acceptable to the Engineer provided the body is of such shape that the actual contents can be readily and accurately determined. Unless all approved vehicles are of uniform capacity, each vehicle shall bear a plainly legible identification mark indicating the specific approved capacity. Each vehicle shall be loaded to at least its water level capacity.

When approved by the Engineer in writing, material specified to be measured by the cubic meter may be massed and such masses converted

to cubic meters for payment purposes. Factors for conversion from mass to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before they are used.

(c) **Measurement by Lump Sum**: When used as an item of payment, the term *lump sum* will mean full payment for completion of work described in the Contract. When a complete structure or structural unit (in effect, lump sum work) is specified as the unit of measurement, the unit will be construed to include necessary fittings and accessories. The quantities may be shown on the plans for items for which lump sum is the method of measurement. If shown, the quantities are approximate and are shown for estimating purposes only. Items that are to be measured as complete units will be counted by the Inspector in the presence of a representative of the Contractor.

(d) **Specific Items:**

1. **Concrete:** Concrete will be measured and computed by dividing the work into simple geometrical figures and adding their volumes.

2. **Excavation, embankment, and borrow**: In computing volumes of excavation, embankment, and borrow, methods having general acceptance in the engineering profession will be used. When the measurement is based on the cross-sectional area, the average end area method will be used.

3. **Asphalt:** Asphalt will be measured by the liter, volumetric measurement, based on a temperature of 15 °C using the following correction factors:

   a. 0.00063 per degree Celsius for petroleum oils having a specific gravity 15/15 °C above 0.966

   b. 0.00072 per degree Celsius for petroleum oils having a specific gravity 15/15 °C between 0.850 and 0.966

   c. 0.00045 per degree Celsius for emulsified asphalt

   Unless volume correction tables are available, the following formula shall be used in computing the volume of asphalt at temperatures other than 15 °C:

$$V^1 = V/K(T - 15) + 1$$

   where V = volume of asphalt to be corrected; V^1 = volume of asphalt at 15 °C; K = correction factor (coefficient of expansion); and T = temperature in degrees Celsius of asphalt to be corrected.

When asphalt is delivered by mass, the volume at 15 °C will be determined by dividing the net mass by mass per liter at 15 °C.

When specified in the Contract, asphalt will be measured by mass. Net certified scale masses, or masses based on certified volumes in the case of rail shipments, will be used as a basis of measurement, subject to correction when asphalt has been lost from the car or the distributor, disposed of, or otherwise not incorporated in the work.

When asphalt is shipped by truck or transport, net certified masses or volumes subjected to correction for loss or foaming may be used to compute quantities.

Only the quantity of asphalt actually placed in the work and accepted will be considered in determining the amount due the Contractor.

4. **Timber**: Timber will be measured in cubic meters actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the extreme length of each piece.

5. **Equipment rental:** Equipment rental will be measured by time in hours of actual working time and necessary traveling time of the equipment within the limits of the project or source of supply and the project except when another method of measurement is specified.

109.02—Plan Quantities.

When specified in the Contract, items will be measured and paid for on the basis of plan quantities. The quantities allowed for compensation will be those shown on the plans with deductions from or authorized additions to such quantities resulting from deviations from the plans. In the case of excavation, only excavation within the cross-section prism will be paid for on a plan quantity basis.

If the Contractor believes that any plan quantity is incorrect, he may solicit, at his own expense, the aid of a certified Professional Engineer to check the quantity or he may request the Department in writing to check computations of the quantity. Written requests for a quantity check by the Department shall be accompanied by calculations, drawings, or other evidence indicating why the plan quantity is believed to be in error. If any item of the Contract is found to be in error, payment will be made in accordance with the corrected plan quantity.

If the Department determines during construction that there is an error in the plan quantity, or that conditions vary from those anticipated in the design to the extent that an actual measurement of a plan quantity item is warranted, the

Department will make such measurement. Payment will then be based on the measured quantity in lieu of the plan quantity.

109.03—Scope of Payment.

Payments to the Contractor will be made for the quantities of contract items performed in accordance with the plans and the requirements of the specifications. If, upon completion of the construction, these quantities show either an increase or decrease from the quantities shown in the Contract, the contract unit prices shall prevail unless they have been modified by work orders.

Quantities appearing on the proposal are estimated quantities for the basic design shown on the plans. With the approval of the Department, the Contractor may furnish other design(s) that may involve changes in quantities or the use of different materials. However, payment will be made for plan quantities only and in the units of measure given in the proposal for the basic design unless the dimensions for the basic design would have had to have been changed by an authorized modification to conform to field conditions encountered. In this event, modified plan quantities will be used for pay quantities at contract unit prices for the items listed on the proposal.

The Contractor shall accept the compensation provided for in the Contract as full payment for the following:

1. furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work

2. performing all work contemplated under the Contract

3. all loss or damage arising from the nature of the work or from action of the elements or any other unforeseen difficulties that may be encountered during prosecution of the work and until its final acceptance

4. all risks of every description connected with the prosecution of the work

5. all expenses incurred in consequence of the suspension of the work as herein authorized

6. any infringement of patent, trademark, or copyright

7. the completion of the work in accordance with the requirements of the Contract

If the payment clause in the specifications relating to any unit price in the Contract requires that the unit price cover and be considered compensation for certain work or material essential to the item, the work or material will not be measured or paid for under any other item except as provided in Section 106.05.

The payment of any partial estimate or any retained percentage prior to final acceptance of the project as provided for in Section 105.15 shall in no way affect the obligation of the Contractor to repair or renew any defective parts of the construction or to be responsible for all damages attributable to such defects.

109.04—Compensation for Altered Quantities.

When the accepted quantities of work vary from the estimated quantities set forth in the Contract but such variance is within the percentage limits set forth in Section 104.02 whether or not there have been any changes in the plans, the Contractor shall accept as payment in full, so far as contract items are concerned, payment at the original contract unit prices for the accepted quantities of work performed. No allowance or other adjustment except as provided for in Section 104.02 will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting directly from either such alterations or unbalanced allocation among the contract items of overhead expense on the part of the Contractor and subsequent loss of expected reimbursements therefor or from any other cause except the payment for the actual quantity performed at the original contract unit price.

Alterations of plans or character of work involving extra work orders as provided for in Section 104.02 will be paid for in accordance with the requirements of Section 104.02. If prices cannot be agreed on, the Contractor shall proceed with the performance of the work on a force account basis in accordance with the requirements of Section 109.05.

109.05—Extra and Force Account Work.

Extra work performed in accordance with the requirements of Section 104.03 will be paid for at the unit prices or lump sum specified in the work order. In lieu of such agreement, the Department may require the Contractor to do such work on a force account basis to be compensated in the following manner:

(a) **Labor:** Unless otherwise approved, the Contractor will receive the rate of wage or scale as set forth in his most recent payroll for each classification of laborers, foremen, and superintendent(s) who are in direct charge of the specific operation. The time allowed for payment will be the number of hours such workers are actually engaged in the work. If overtime work is authorized, payment will be at the normal overtime rate set forth in the Contractor's most recent payroll. If workers performing the class of labor needed have not been employed on the project, mutually agreed on rates will be established. However, the rates shall be not less than those predetermined for the project, if applicable. An amount equal to 45 percent of the approved force account payroll will be included in the payment for labor to cover administrative

costs, profit, and benefits, and/or deductions normally paid by the Contractor.

(b) **Insurance and Tax:** The Contractor will receive an amount equal to 25 percent of the approved force account payroll exclusive of additives of administrative cost as full compensation for property damage and liability, workers' compensation insurance premiums, unemployment insurance contributions, and social security taxes of force account work.

(c) **Materials:** The Contractor will receive the actual cost of materials accepted by the Engineer that are delivered and used for the work including taxes, transportation, and handling charges paid by the Contractor, exclusive of labor and equipment rentals as herein set forth, to which 15 percent of the cost will be added for administration and profit. The Contractor shall make every reasonable effort to take advantage of trade discounts offered by material suppliers. Any discount received shall accrue to the Department. Salvageable temporary construction materials will be retained by the Department, or their appropriate salvage value shall be credited to the State, as agreed on by the Department.

(d) **Equipment:** The Contractor shall provide the Engineer a list of all equipment to be used in the work. For each piece of equipment, the list shall include the serial number; date of manufacture; location from which equipment will be transported; and, for rental equipment, the rental rate and name of the company from which it is rented. The Contractor will be paid hourly rental rates for pieces of machinery, equipment, and attachments necessary for prosecution of the work that are approved for use by the Engineer. Hourly rental rates will not exceed 1/176 of the monthly rates of the schedule shown in the *Rental Rate Blue Book* modified in accordance with the *Blue Book* rate adjustment tables that are current at the time the force account is authorized. Adjustment factors or rate modifications indicated on area maps in the *Blue Book* will not be considered when acceptable rates are determined. Hourly rental rates for equipment held in ready will be at 50 percent of the rate paid for equipment in use.

Payment will be made for the total hours the equipment is in use. When equipment is in use less than 40 hours for any given week and is held in ready, payment for held-in-ready time will be allowed for up to 40 hours, minus hours in use. Payment will not be made for the time that equipment is on the project in excess of 24 hours prior to its actual use in the force account work. An amount equal to the *Blue Book* estimated operating cost per hour will be paid for all hours the equipment is in use. This operating cost shall be full compensation for fuel, lubricants, repairs, greasing, fueling, oiling, small tools, and other incidentals. No compensation will be paid for the use of machinery or equipment not authorized by the Engineer.

The Contractor will be paid freight cost covering the moving of equipment to and from the specific force account operation provided such cost is supported by an invoice showing the actual cost to the Contractor. However, such payment will be limited to transportation from the nearest source of available equipment. If equipment is not returned to the nearest equipment storage lot but is moved to another location, the freight cost paid will not exceed the cost of return to the storage lot.

The rates for equipment not listed in the *Blue Book* schedule shall not exceed the hourly rate being paid for such equipment by the Contractor at the time of the force account authorization. In the absence of such rates, prevailing rates being paid in the area where the work is contemplated shall be used.

If the Contractor does not possess or have readily available equipment necessary for performing the force account work and such equipment is rented from a source other than a company that is an affiliate of the Contractor, payment will be based on actual invoice rates, to which 15 percent of the invoice cost will be added for administrative cost and profit. If the invoice rate does not include the furnishing of fuel, lubricants, repairs, and servicing, it will be converted to an hourly rate, and an amount equal to the *Blue Book* estimated operating cost per hour will be added for each hour the equipment is in use.

(e) **Miscellaneous:** No additional allowance will be made for attachments that are common accessories for equipment as defined in the *Blue Book*, general superintendents, timekeepers, secretaries, the use of small tools, or other costs for which no specific allowance is herein provided. The Contractor will receive compensation equal to the cost of the bond, special railroad insurance premiums, and other additional costs necessary for the specific force account work as determined by the Department. The Contractor shall supply documented evidence of such costs.

(f) **Compensation:** The compensation as set forth in this Section shall be accepted by the Contractor as payment in full for work performed on a force account basis. At the end of each day, the Contractor's representative and the Inspector shall compare and reconcile records of the cost of work done as ordered on a force account basis.

If all or a portion of the force account work is performed by an approved subcontractor, the Contractor will be paid 10 percent of the subcontract net force account costs before additives are applied to cover his profit and administrative cost. The amount resulting will not be subject to any further additives. The itemized statements of costs as required by (g) herein shall be submitted on a form that separates the subcontracted portions of the force account labor, materials, and equipment from the other force account costs.

(g) **Statements:** Payments will not be made for work performed on a force account basis until the Contractor has furnished the Engineer duplicate itemized statements of the cost of such work detailed as follows:

1. payroll indicating name, classification, date, daily hours, total hours, rate, and extension of each laborer, foreman, and superintendent

2. designation, dates, daily hours, total hours, rental rate, and extension for each unit of equipment

3. quantities of materials, prices, and extensions

4. transportation of materials

Statements shall be accompanied and supported by invoices for all materials used and transportation charges. However, if materials used on the force account work are not specifically purchased for such work but are taken from the Contractor's stock, then in lieu of the invoices, the Contractor shall furnish an affidavit certifying that such materials were taken from his stock; that the quantity claimed was actually used; and that the price, transportation, and handling claimed represented his actual cost.

109.06—Eliminated Items.

If any item in the Contract is determined to be unnecessary for the proper completion of the work contracted, the Department may, upon written notice to the Contractor, eliminate such item from the Contract. Payment will not be made for such item except that the Contractor will be compensated for the actual cost of any work performed for the installation of such item and the net cost of materials purchased, including freight and tax costs, as evidenced by invoice. No additional compensation will be made for overhead or anticipated profit.

109.07—Partial Payments.

Partial payments will be based on a monthly progress estimate consisting of approximate quantities and value of work performed as determined by the Engineer. When the method of measurement for a contract item is in units of each or lump sum, the value of work accomplished for partial payment will be determined on a pro rata basis. Partial payments will be made once each month for the work performed in accordance with the contract requirements except when the net receivable amount is less than $500. In this case, no partial payment will be made and the value of such work will be carried over to the next monthly progress estimate. The Contractor will be given the opportunity to review the monthly progress estimate prior to each partial payment. Upon final acceptance,

a semifinal estimate will be prepared and any additional partial payment will be vouchered for payment, regardless of the value.

The monthly progress estimates for contractors on the Department's prequalification list will be prepared in accordance with the following schedule:

1. **Contractor companies whose name begins with the letter *A* through *F*:** The monthly progress estimate will be prepared on the 4th day of each month, beginning on the first 4th day following the date of the Notice to Proceed, and on the same day of the succeeding months as the work progresses.

2. **Contractor companies whose name begins with the letter *G* through *P*:** The monthly progress estimate will be prepared on the 11th day of each month, beginning on the first 11th day following the date of the Notice to Proceed, and on the same day of the succeeding months as the work progresses.

3. **Contractor companies whose name begins with the letter *Q* through *Z*:** The monthly progress estimate will be prepared on the 20th day of each month, beginning on the first 20th day following the date of the Notice to Proceed, and on the same day of the succeeding months as the work progresses.

Monthly progress estimates for joint venture contracts will be prepared in accordance with the aforementioned schedule by using the name of the first Contractor, from left-to-right order, as it appears in the Contract.

Partial payments will be made for the work shown on the monthly progress estimate subject to the limitations established herein. If the Engineer determines that the Contractor has been overpaid, the Department will deduct such overpayments from any future payments due the Contractor.

The Department will deduct an amount equivalent to 5 percent of the monthly progress estimate and will retain such monies until final payment is made in accordance with the requirements of Section 109.09. The balance less all previous partial payments will be vouchered for payment. After 50 percent of the total contract value has been completed and 5 percent has been retained on this amount, the Department will make the remaining partial payments in full provided the Contractor is maintaining a satisfactory rate of progress. *Total contract value* will be considered to mean the original amount of the Contract except when the Contract is increased or decreased by more than 20 percent, in which case the adjusted total will be considered as the total contract value.

If the Contractor's progress falls more than 10 percent behind the latest approved progress schedule, the progress will be considered unsatisfactory and the normal

5 percent retainage will be withheld for each month the Contractor is behind the progress schedule by more than 10 percent.

When the dollar value of the work completed has reached 90 percent of the total dollar value indicated on the Contractor's latest approved progress schedule, the progress will be determined at the time of the monthly progress estimate by comparing the percentage of time used with the percentage of work completed. When the percentage of time used exceeds the percentage of work completed by more than 10 percent, the Contractor's progress will be considered unsatisfactory and the normal 5 percent retainage will be withheld for each month the percentage of time used exceeds the percentage of work completed by more than 10 percent.

When the Engineer determines that the Contractor's progress is considered satisfactory in accordance with these requirements, the remaining monthly progress estimate payments will be made in full. However, retainage previously withheld will not be released on subsequent monthly progress estimates.

For contracts without a payment bond, the Contractor shall submit a letter from each materials supplier and subcontractor involved to the Engineer that the Contractor has paid or made satisfactory arrangements for settling all bills for materials and subcontracted work that was paid on the previous month's progress estimate. The Department will use the source of supply letter and approved subletting request to verify that certifications have been received for work that was paid on the previous monthly estimate. The Contractor shall furnish these and other certificates as are required as a prerequisite to the issuance of payment for the current monthly estimate. The Department may withhold the payment of any partial or final estimate voucher or any sum(s) thereof from such vouchers if the Contractor fails to make payment promptly to all persons supplying equipment, tools, or materials; for any labor he uses in the prosecution of the contract work; or for any other cause as determined by the Engineer.

At the time the Contractor submits a bid, he will have the option to use the escrow account procedure for the use of funds retained by the Department by so indicating in the space provided on the proposal. If the Contractor elects to use the escrow account procedure, the Escrow Agreement Form included in the proposal and Contract shall be executed and submitted to the Department within 15 calendar days after notification. If the Escrow Agreement Form is not submitted, the Contractor shall forfeit such rights to the use of the escrow account procedure. In order to have retained funds paid to an escrow agent, the Contractor, the escrow agent, and the surety shall execute an Escrow Agreement Form and submit it to the Department for approval. The Contractor's escrow agent shall be a trust company, bank, or savings and loan institution with its principal office located in the State. The Escrow Agreement Form shall contain the complete address of the escrow agent and surety. The executed escrow agreement will be authority for the Department to pay the retained funds to the escrow agent. After approving the agreement, the Department will pay to the escrow agent the funds retained as provided herein. The escrow agent, in

accordance with the stipulations contained in the escrow agreement, may invest the funds paid into the escrow account and pay earnings on such investments to the Contractor or release the funds to the Contractor provided such funds are fully secured by approved securities.

Retained funds invested and securities held as collateral for retainage may be released only as and when directed by the Department. When the final estimate is released for voucher, the Department will direct the escrow agent to settle the escrow account by paying the Contractor or the Department monies due them as determined by the Department. The Department may recall retained funds and release them to the surety upon receipt of a written request from the Contractor or in the event of default.

109.08—Payment for Material on Hand.

When requested in writing by the Contractor, payment allowances may be made for material secured for use on the project. Such material payments will be for only those actual quantities identified in the Contract, approved work orders or otherwise documented as required to complete the project and shall be in accordance with the following terms and conditions:

(a) **Structural Units:** An allowance of 100 percent of the cost to the Contractor for structural steel materials for fabrication not to exceed 60 percent of the contract price may be made when such material is delivered to the fabricator and has been adequately identified for exclusive use on the project. An allowance of 100 percent of the cost to the Contractor for superstructure units, not to exceed 90 percent of the contract price, may be made when they have been fabricated. Prior to the granting of such allowances, the structural steel materials and fabricated units shall have been tested or certified and found acceptable to the Department and shall have been stored in accordance with the requirements specified herein. Allowances will be based on invoices, bills, or the estimated value as approved by the Engineer and will be subject to the retainage requirements of Section 109.07.

(b) **Other Materials:** For reinforcing steel, aggregate, pipe, guardrail, signs and sign assemblies, and other nonperishable material, an allowance of 100 percent of the cost to the Contractor for materials, not to exceed 90 percent of the contract price, may be made when such material is delivered and stockpiled or stored in accordance with the requirements specified herein. However, no allowance will be made for cement, seed, plants, fertilizer, and other perishable material. Prior to the granting of such allowances, the material shall have been tested and found acceptable to the Department. Allowances will be based on invoices, bills, or the estimated value of the material as approved by the Engineer and will be subject to the retainage provisions of Section 109.07.

(c) **Excluded Items:** No allowance will be made for fuels, form lumber, falsework, temporary structures, or other work that will not become an integral part of the finished construction.

(d) **Storage:** Material for which payment allowance is requested shall be stored in an approved manner in areas where damage is not likely to occur. If any of the stored materials are lost or become damaged, the Contractor shall repair or replace them. If payment allowance has been made prior to such damage or loss, the amount so allowed or a proportionate part thereof will be deducted from the next progress estimate payment and withheld until satisfactory repairs or replacement has been made.

When it is determined to be impractical to store materials within the limits of the project, the Engineer may approve storage on private property or, for structural units, on the manufacturer's or fabricator's yard. Requests for payment allowance for such material shall be accompanied by a release from the owner or tenant of such property or yard agreeing to permit the removal of the materials from the property without cost to the State.

(e) **Materials Inventory:** If the Contractor requests a payment allowance for properly stored material, he shall submit a certified and itemized inventory statement to the Engineer no earlier than 5 days and no later than 2 days prior to the progress estimate date. The statement shall be submitted on forms furnished by the Department and shall be accompanied by invoices or other documents that will verify the material's cost. Following the initial submission, the Contractor shall submit to the Engineer a monthly certified update of the itemized inventory statement within the same time frame. The updated inventory statement shall show additional materials received and stored with invoices or other documents and shall list materials removed from storage since the last certified inventory statement, with appropriate cost data reflecting the change in the inventory. If the Contractor fails to submit the monthly certified update within the specified time frame, the Engineer will deduct the full amount of the previous statement from the progress estimate.

At the conclusion of the project, the cost of material remaining in storage for which payment allowance has been made will be deducted from the progress estimate.

109.09—Final Payment.

When final acceptance has been duly made by the Engineer as provided for in Section 105.15, the Engineer will prepare the final statement of the quantities of the classes of work performed. Thereafter, the Contractor will be afforded

10 days in which to review the final estimate before payment. The time may be extended by mutual agreement, and the extension added to the 90-day criteria set forth hereinafter.

The Contractor shall certify to the Department that he has paid or made satisfactory arrangements for settling all bills for materials, labor, equipment, supplies, and other items entering into or used on the work and shall furnish other certificates as are required by the Department as a prerequisite to the issuance of final payment. However, the certification regarding payment will not be a prerequisite to the issuance of final payment on contracts that require a payment bond.

Upon review of the final estimate by the Contractor and approval by the Engineer, the Contractor will be paid the entire sum due after previous payments are deducted and other amounts are retained or deducted under the provisions of the Contract. Final payment will become due and the final estimate paid within 90 calendar days after final acceptance.

Upon written request from the Contractor, annual interest will be paid on the balance that has not been paid due to the fault of the Department within 90 calendar days after final acceptance except that monies in escrow will not be subject to such interest. The rate of interest will be the base rate on corporate loans (prime rate) at large U.S. money center commercial banks as reported daily in *The Wall Street Journal.* When a split rate is published, the lower of the two rates shall be used. However, in no event shall the rate of interest paid exceed the rate of interest established pursuant to Section 58.1-1812 of the Code of Virginia 1950, as amended, and the rate effective on the 91st day following final acceptance will be applicable throughout the period of time for which interest is paid. The period subject to payment of interest will begin on the 91st calendar day after final acceptance and will extend through the date of the payment of the final estimate.

Failure by the Contractor to provide required information and certifications will extend the 90-day period for final payment by the number of days equivalent to the delay attributable to the Contractor.

When the payment date is delayed beyond the 90-day period by the fault of the Contractor and monies are due the State, the Contractor will be assessed annual interest on the balance due the State for the time delay attributable to the Contractor. The rate of interest will be determined as specified hereinbefore.

Monies resulting from the final estimate and owed to the Department will become due and payable within 30 days of receipt by the Contractor or his escrow agent of a certified letter giving notification of the amount owed. The Contractor will be assessed annual interest at the rate determined as specified hereinbefore for any balance that remains unpaid after 37 days from receipt of the letter.

Prior partial estimates and payments shall be subject to correction in the final estimate and payment.

SECTION 110—MISCELLANEOUS PROVISIONS

110.01—Common Carrier Rates.

The common carrier rates and taxes thereon that are current on the date of the opening of bids shall be considered applicable to all items subject to transportation charges thereunder. If such rates or taxes are thereafter increased by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such increases, when evidenced by receipted common carrier bills, will be paid the Contractor by the Department. Requests for such payments shall be made not later than 60 days after final acceptance. If after the date of the opening of bids such rates or taxes are reduced by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such decreases, when evidenced by receipted common carrier bills, will be deducted by the Department from the monies due the Contractor on the work performed under the Contract.

The carrier rates for petroleum tank truck carriers, as defined in Sections 56-338.19 and 56-338.36 of the Code of Virginia, that are in effect on the date of the opening of bids for the project shall be considered effective for at least 1 year after that date. After 1 year from that date, the Department will pay the Contractor additional compensation equal to the cost of any carrier rate increases, subject to a maximum of 8 percent of the original carrier rate for any materials ordered, delivered, and actually incorporated into the work after the 1-year period. However, the Contractor shall advise the Engineer in writing of his intent to request additional compensation attributable to carrier rate changes at the time of occurrence and shall submit receipted carrier bills and all relative information concerning the original and current carrier rates as they pertain to the project. If carrier rates are decreased after the 1-year period, the Department will deduct from monies due the Contractor an amount equal to the cost of any carrier rate decreases, subject to a maximum of 8 percent of the original carrier rate, for any materials ordered, delivered, and actually incorporated into the work, based on receipted carrier bills that shall be furnished by the Contractor. On each succeeding year of the Contract, a maximum difference of 8 percent of the original rate will be considered for increases or decreases in compensation under these terms and conditions.

Except for the aforementioned carriers, additional compensation attributable to changes in hauling rates of other contract carriers will not be allowed.

110.02—Labor and Wages.

The Contractor shall comply with the provisions and requirements of the State's workers' compensation law and public statutes that regulate hours of employment on public work. Job orders placed with a State Employment Service shall indicate that employment preference will be given to veterans referred for employment. Advertisements in newspapers or other publications for project employees shall include the notation "Employment Preference to Veterans."

(a) **Predetermined Minimum Wages:** The provisions of laws requiring the payment of a minimum wage of a predetermined minimum wage scale for the various classes of laborers and mechanics, when such a scale is incorporated in the Contract, shall be expressly made a part of any Contract hereunder. The Contractor and his agents shall promptly comply with all such applicable provisions.

Any classification not listed and subsequently required shall be classified or reclassified in accordance with the wage determination. If other classifications are used, omission of classifications shall not be cause for additional compensation. The Contractor shall be responsible for determining local practices with regard to the application of the various classifications.

(b) **Labor Rate Forms:** The Contractor shall complete Form C-28, indicating by classification the total number of employees, excluding executive and administrative employees, employed on the project. The Contractor shall also indicate on the form the rate per hour for each classification. The Contractor shall submit an original and two copies of the form prior to the due date of the second estimate for payment and for each 90-day period thereafter until the work specified in the Contract has been completed.

If at the time of final acceptance the period since the last labor report is 30 days or more, the Contractor shall furnish an additional labor report as outlined herein prior to payment of the final estimate.

110.03—Equal Employment Opportunity.

The Contractor shall comply with the applicable provisions of presidential executive orders and the rules, regulations, and orders of the President's Committee on Equal Employment Opportunity.

The Contractor shall maintain the following records and reports as required by the contract EEO provisions:

1. record of all applicants for employment
2. new hires by race, work classification, hourly rate, and date employed
3. minority and nonminority employees employed in each work classification
4. changes in work classifications
5. employees enrolled in approved training programs and the status of each
6. minority subcontractor or subcontractors with meaningful minority group representation
7. copies of Form C-57 submitted by subcontractors

If the Contract has a pay item for trainees, the Contractor shall submit semiannual training reports in accordance with the instructions shown on the forms furnished by the Department. If the Contractor fails to submit such reports in accordance with the instructions, his monthly progress estimate for payment may be delayed.

The Contractor shall cooperate with the Department in carrying out EEO obligations and in the Department's review of activities under the Contract. The Contractor shall comply with the specific EEO requirements specified herein and shall include these requirements in every subcontract of $10,000 or more with such modification of language as may be necessary to make them binding on the subcontractor.

(a) **EEO Policy:** The Contractor shall accept as operating policy the following statement:

It is the policy of this Company to assure that applicants are employed and that employees are treated during employment without regard to their race, religion, sex, color, or national origin. Such action shall include employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship or on-the-job training.

(b) **EEO Officer:** The Contractor shall designate and make known to the Department an EEO Officer who can effectively administer and promote an active contractor EEO program and who shall be assigned adequate authority and responsibility to do so.

(c) **Dissemination of Policy:**

1. Members of the Contractor's staff who are authorized to hire, supervise, promote, and discharge employees or recommend such

action or are substantially involved in such action shall be made fully cognizant of and shall implement the Contractor's EEO policy and contractual responsibilities to provide equal employment opportunity in each grade and classification of employment. The following actions shall be taken as a minimum:

a. Periodic meetings of supervisory and personnel office employees shall be conducted before the start of work and at least once every 6 months thereafter, at which time the Contractor's EEO policy and its implementation shall be reviewed and explained. The meetings shall be conducted by the EEO Officer or another knowledgeable company official.

b. New supervisory or personnel office employees shall be given a thorough indoctrination by the EEO Officer or another knowledgeable company official covering all major aspects of the Contractor's EEO obligations within 30 days following their reporting for duty with the Contractor.

c. The EEO Officer or appropriate company official shall instruct employees engaged in the direct recruitment of employees for the project relative to the methods followed by the Contractor in locating and hiring minority group employees.

2. In order to make the Contractor's EEO policy known to all employees, prospective employees, and potential sources of employees such as schools, employment agencies, labor unions where appropriate, and college placement officers, the Contractor shall take the following actions:

a. Notices and posters setting forth the Contractor's EEO policy shall be placed in areas readily accessible to employees, applicants for employment, and potential employees.

b. The Contractor's EEO policy and the procedures to implement such policy shall be brought to the attention of employees by means of meetings, employee handbooks, or other appropriate means.

(d) **Recruitment:**

1. When advertising for employees, the Contractor shall include in all advertisements for employees the notation "An Equal Opportunity Employer" and shall insert all such advertisements in newspapers or other publications having a large circulation among

minority groups in the area from which the project work force would normally be derived.

2. Unless precluded by a valid bargaining agreement, the Contractor shall conduct systematic and direct recruitment through public and private employee referral sources likely to yield qualified minority group applicants, including, but not limited to, state employment agencies, schools, colleges, and minority group organizations. The Contractor shall identify sources of potential minority group employees and shall establish procedures with such sources whereby minority group applicants may be referred to him for employment consideration.

3. The Contractor shall encourage his employees to refer minority group applicants for employment by posting appropriate notices or bulletins in areas accessible to all employees. In addition, information and procedures with regard to referring minority group applicants shall be discussed with employees.

(e) **Personnel Actions:** Wages, working conditions, and employee benefits shall be established and administered, and personnel action of any type shall be taken without regard to race, color, religion, sex, or national origin.

1. The Contractor shall conduct periodic inspections of project sites to ensure that working conditions and employee facilities do not indicate discriminatory treatment of personnel.

2. The Contractor shall periodically evaluate the spread of wages paid within each classification to determine whether there is evidence of discriminatory wage practices.

3. The Contractor shall periodically review selected personnel actions in depth to determine whether there is evidence of discrimination. Where evidence is found, the Contractor shall promptly take corrective action. If the review indicates that the discrimination may extend beyond the actions reviewed, corrective action shall include all affected persons.

4. The Contractor shall investigate all complaints of alleged discrimination made to him in connection with obligations under the Contract, attempt to resolve such complaints, and take appropriate corrective action. If the investigation indicates that the discrimination may affect persons other than the complainant, corrective action shall include those persons. Upon completion of each investigation, the Contractor shall inform every complainant of all avenues of appeal.

(f) **Training:**

1. The Contractor shall assist in locating, qualifying, and increasing the skills of minority group and women employees and applicants for employment.

2. Consistent with work force requirements and as permissible under federal and state regulations, the Contractor shall make full use of training programs, i.e., apprenticeship and on-the-job training programs for the geographical area of contract performance. Where feasible, 25 percent of apprentices or trainees in each occupation shall be in their first year of apprenticeship or training.

3. The Contractor shall advise employees and applicants for employment of available training programs and the entrance requirements for each.

4. The Contractor shall periodically review the training and promotion potential of minority group employees and shall encourage eligible employees to apply for such training and promotion.

5. If the Contract does not provide a separate pay item for trainees, the cost associated with the training specified herein shall be included in the price bid for other items in the Contract.

6. If the Contract provides a pay item for trainees, training shall be in accordance with the requirements of Section 518.

(g) **Unions:** If the Contractor relies in whole or in part on unions as a source of employees, best efforts shall be made to obtain the cooperation of such unions to increase opportunities for minority groups and women in the unions and to effect referrals by such unions of minority and women employees. Actions by the Contractor, either directly or through his Contractor's Association acting as agent, shall include the following procedures:

1. In cooperation with the unions, best efforts shall be used to develop joint training programs aimed toward qualifying more minority group members and women for membership in the unions and to increase the skills of minority group employees and women so that they may qualify for higher-paying employment.

2. Best efforts shall be used to incorporate an EEO clause into union agreements to the end that unions will be contractually bound to refer applicants without regard to race, color, religion, sex, or national origin.

3. Information shall be obtained concerning referral practices and policies of the labor union except that to the extent the information is within the exclusive possession of the union. If the labor union refuses to furnish the information to the Contractor, the Contractor shall so certify to the Department and shall set forth what efforts he made to obtain the information.

4. If a union is unable to provide the Contractor with a reasonable flow of minority and women referrals within the time limit set forth in the union agreement, the Contractor shall, through his recruitment procedures, fill the employment vacancies without regard to race, color, religion, sex, or national origin, making full efforts to obtain qualified or qualifiable minority group persons and women. If union referral practice prevents the Contractor from meeting the EEO requirements, the Contractor shall immediately notify the Department.

(h) **Subcontracting:** The Contractor shall use best efforts to use minority group subcontractors or subcontractors with meaningful minority group and female representation among their employees. Contractors shall obtain lists of MBE, DBE, and WBE construction firms from the Department. If MBE, DBE, or WBE goals are established in the proposal, the Contractor shall comply with the requirements of Section 110.04.

The Contractor shall use best efforts to ensure subcontractor compliance with his EEO obligations.

(i) **Records and Reports:** The Contractor shall keep such records as are necessary to determine compliance with his EEO obligations. The records shall be designed to indicate the following:

1. the number of minority and nonminority group members and women employed in each work classification on the project

2. the progress and efforts being made in cooperation with unions to increase employment opportunities for minorities and women if unions are used as a source of the work force

3. the progress and efforts being made in locating, hiring, training, qualifying, and upgrading minority and female employees

4. the progress and efforts being made in securing the services of minority group subcontractors or subcontractors with meaningful minority group and female representation among their employees

Records shall be retained for a period of 3 years following completion of the contract work and shall be available at reasonable times and places for inspection by authorized representatives of the Department.

Each month for the first 3 months after construction begins and every month of July thereafter for the duration of the project, Form C-57 shall be completed to indicate the number of minority, nonminority, and female employees currently engaged in each work classification shown on the form. The completed Form C-57 shall be submitted within 3 weeks after the reporting period. Failure to do so may result in delay of approval of the Contractor's monthly progress estimate for payment.

110.04—Use of Minority Business Enterprises.

It is the policy of the Department that MBEs shall have the maximum opportunity to participate in the performance of the Contract. The Contractor shall ensure that MBEs have such opportunity, including participation in any subsequent subcontracts. The Contractor shall take all necessary and reasonable steps to ensure that MBEs have the maximum opportunity to compete for and perform work on the Contract.

MBE shall mean a small business concern, as defined pursuant to Section 3 of the Small Business Act and implementing regulations, that is owned and controlled by one or more minorities or women. *Owned and controlled* means that at least 51 percent of the business is owned by one or more minorities or women or, in the case of a publicly owned business, at least 51 percent of the stock is owned by one or more minorities or women and the management and daily business operations are controlled by one or more such individuals.

Minority shall mean a person who is a citizen or lawful permanent resident of the United States and is a bona fide member of a minority group, or so regarded by that particular minority community, and who is:

1. black (a person having origins in any of the black racial groups of Africa)

2. Hispanic (a person of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race)

3. Portuguese (a person of Portuguese, Brazilian, or other Portuguese culture or origin, regardless of race)

4. Asian American (a person having origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands)

5. American Indian or Alaskan Native (a person having origins in any of the original peoples of North America)

6. a member of another group, or other individual, found to be economically and socially disadvantaged by the Small Business Administration under 8(a) of the Small Business Act as amended (15 U.S.C. 637[a])

The Department will furnish each prequalified Contractor a list of certified MBEs. This list shall not be construed as an endorsement of the quality or performance of the business.

The Contractor shall designate and make known to the Department a liaison officer who is assigned the responsibility of effectively administering and promoting an active program for use of MBEs.

The performance of work for the purpose of this specification shall be interpreted to include, but not necessarily be limited to, subcontracting; furnishing materials, supplies, and services; and leasing equipment.

The Contractor shall furnish and require each subcontractor to furnish information relative to all MBE involvement on the project for each month during the life of the Contract in which participation occurs and verification is available. The information shall be indicated on Form C-63 and certified on Form C-63A or by copies of cancelled checks with appropriate identifying notations. Failure to provide the Department the forms by the Contractor's estimate date may result in delay of approval of the Contractor's monthly progress estimate for payment.

If specific goals for participation by MBEs have been established for the Contract, such goals will be indicated in the proposal on Form C-61. Goals for MBEs will not apply if the bidder is a certified MBE, and goals for WBEs will not apply if the bidder is a certified WBE. Each bidder shall comply with the requirements of Section 102.01. If the bidder is an MBE that is owned and controlled by a minority female(s), participation may be applied toward either the minority goal or the female goal but not to both.

The bidder shall meet or exceed goals established or shall have made a reasonable good faith effort to meet them. Such effort shall be documented and include, but not be limited to, the following:

1. advertisement for MBE interest in the project in general circulation media, trade association publications, and minority focus media. Advertisement shall be made in no fewer than the number of publications specified on Form C-61.

2. written notification to no fewer than the respective number of MBEs specified on Form C-61 advising that their interest in the project is solicited. Such notification shall be made to MBEs on the Department's list of Certified MBEs that is current at the time of the Notice of Advertisement.

Any agreement between a bidder and an MBE whereby the MBE promises not to provide quotations for performance of work to other bidders is prohibited.

The bidder shall indicate in the appropriate spaces provided on Form C-61 the percentage participation that will be attained or exceeded during the life of the Contract and shall submit the completed form with his bid.

Within 10 days after the opening of bids in accordance with the requirements of Section 102.12, the apparent low bidder, as read at the bid opening, shall submit to the Department a fully executed Form C-61A indicating how the applicable goals will be achieved.

If the apparent low bidder as read at the bid opening is unable to meet the goals established by the Department in the proposal after expending reasonable good faith efforts as described herein, a description of the efforts shall be submitted on a fully executed Form C-61A within 10 days after the opening of bids in accordance with the requirements of Section 102.12. The following documentation shall be attached: (1) copies of the advertisements placed; (2) copies of correspondence with each MBE from which bids were solicited; and (3) reasons for failure to use each MBE with whom there was contact.

The signatures on Form C-61A shall be those of authorized representatives of the bidder as shown on Form C-37 and C-38A or authorized by letter from the bidder.

If it is determined subsequent to the bid opening that the apparent low bidder has changed, the new apparent low bidder will be advised by letter and shall submit the information required herein within 10 days after the date of the letter.

The Department reserves the right not to award the Contract to any apparent low bidder who fails to meet the goals established by the Department and who is unable to demonstrate reasonable good faith efforts to meet such goals as described herein or who fails to submit the required information within the specified 10 days.

If an MBE through no fault of the Contractor is unable or unwilling to fulfill his agreement with the Contractor, the Contractor shall immediately notify the Department. If the Department, after review of the facts, relieves the Contractor of the responsibility to use any proposed MBE, the Contractor shall immediately use reasonable good faith to obtain a substitute MBE to perform an equal or greater dollar value of the work. The substitute MBE's name, description of the work, and dollar value of the work shall be submitted to the Department prior to the MBE beginning the work.

The Contractor is encouraged to use the services of banks owned or controlled by minorities or women. However, use of such services will not be credited toward attainment of the goals established for the Contract. The Department

has on file, and will make available on request, the known names and addresses of minority and female-owned banks in the State.

The Department will monitor the Contractor's MBE involvement during the life of the Contract. The level of achievement attained by the Contractor in meeting or exceeding the goals established in the Contract, or his efforts if no goals are established, will be a relevant factor in determining the Contractor's performance rating for future prequalification.

If specific goals for participation by MBEs have not been established for the Contract and the Contractor intends to subcontract a portion of the work on the project, the Contractor shall seek out and consider MBEs as potential subcontractors. The Contractor shall contact MBEs to solicit their interest, capability, and prices and shall retain on file the proper documentation to substantiate such contacts.

By signing the bid, the bidder certifies the following on the work proposed to be subcontracted and shown on the Contractors Proposal to Subcontract Form: (1) that he has taken affirmative action to seek out and consider MBEs as potential subcontractors; and (2) that, if awarded the project, the same affirmative action required under (1) will be taken for any work proposed to be subcontracted and not shown on the Contractor's Proposal to Subcontract Form.

110.05—Construction Safety and Health Standards.

It is a condition of the Contract, and shall be made a condition of each subcontract entered into pursuant to the Contract, that the Contractor and any subcontractor shall not require any worker employed in performance of the Contract to work in surroundings or under working conditions that are unsanitary, hazardous, or dangerous to their health or safety, as determined under construction safety and health standards promulgated by the U.S. Secretary of Labor in accordance with the requirements of Section 107 of the Contract Work Hours and Safety Standards Act.

The Contractor shall comply with the Virginia Occupational Safety and Health Standards adopted under Section 40.1-22 of the Code of Virginia and the duties imposed under Section 40.1-51.1 of the Code. Any violation of the requirements or duties that is brought to the attention of the Contractor by the Engineer or any other person shall be immediately abated.

110.06—Bulletin Boards and Posting Official Notices.

Except for maintenance contracts, the Contractor shall furnish, erect, and maintain at least two bulletin boards having dimensions of at least 1,200 millimeters in width and 900 millimeters in height at locations readily accessible to all personnel concerned with the project. The boards shall be erected

immediately upon initiation of the contract work and shall be maintained until the completion of such work, at which time they shall be removed from the project. Each bulletin board shall be equipped with a removable glass or plastic cover that when in place will protect posters from weather or damage. The Contractor shall promptly post official notices on the bulletin boards. The costs for such work shall be included in the price bid for other contract items.

110.07—Certification of Nonsegregated Facilities.

The Certification of Nonsegregated Facilities, as required by the May 9, 1967, Order of the Secretary of Labor (32 F.R. 7439, May 19, 1967) on Elimination of Segregated Facilities for highway construction contracts exceeding $10,000 that are not exempt from the provisions of the equal opportunity clause, requires that bidders neither maintain nor provide facilities for employment that are segregated on a basis of race, creed, color, or national origin, whether such facilities are segregated by directive or on a de facto basis. If the Contract exceeds $10,000 and is not exempt from the provisions of the equal opportunity clause, the bidder by signing the bid will be deemed to have signed and agreed to the provisions of the certification. If the Contract exceeds $10,000 and is not exempt from the provisions of the equal opportunity clause, the Contractor shall forward the following notice to prospective subcontractors for construction contracts and material suppliers where the subcontracts or material supply agreements exceed $10,000 and are not exempt from the provisions of the equal opportunity clause:

NOTICE TO PROSPECTIVE SUBCONTRACTORS AND MATERIAL SUPPLIERS OF REQUIREMENT FOR CERTIFICATION OF NONSEGREGATED FACILITIES

1. Subcontractors and material suppliers are cautioned as follows: By signing the subcontract or entering into a material supply agreement, the subcontractor or material supplier will be deemed to have signed and agreed to the provisions of the Certification of Nonsegregated Facilities, as required by the May 9, 1967, Order of the Secretary of Labor (32 F.R. 7439, May 19, 1967) on Elimination of Segregated Facilities, prior to the award of the subcontract or consummation of a material supply agreement if such subcontract or agreement exceeds $10,000 and is not exempt from the provisions of the equal opportunity clause. This certification provides that the subcontractor or material supplier does not maintain, or provide for his employees, facilities that are segregated on the basis of race, creed, color, or national origin, whether such facilities are segregated by directive or on a de facto basis. The certification also provides that the subcontractor or material supplier will not maintain such segregated facilities.

2. Subcontractors or material suppliers receiving subcontract awards or material supply agreements exceeding $10,000, which are not exempt from the provisions of the equal opportunity clause, will be required to provide for the forwarding of this notice to prospective subcontractors for construction contracts and material suppliers where the subcontracts or material supply agreements exceed $10,000 and are not exempt from the provisions of the equal opportunity clause.

Division II

MATERIALS

SECTION 200—GENERAL

200.01—Description.

These specifications cover general sampling and testing procedures, certifications for aggregate acceptance, and technicians and batchers for asphalt and hydraulic cement concrete.

200.02—Conformance with Specifications.

Materials shall conform to these specifications in accordance with the requirements of Section 106.06. Whenever a reference to a material is followed by a reference to a specification, the material shall conform to the referenced specification.

Material that is required to conform to these specifications shall not be used until it has been approved by the Engineer.

Where maximum and minimum limits are given for a characteristic of a material, material whose specified characteristic approximates the mean value shall be furnished. The specified limits shall not be exceeded.

When a material is fabricated of or treated with another material or when any combination of materials is assembled to form a product, the failure of any component to comply with the applicable specification shall be sufficient cause for rejection of the whole unless the combination of components will produce a product satisfactory to the Engineer.

If the Contractor desires to substitute another material for that specified, he shall submit proof that the substitute material is equal in all respects to the material specified. Proof shall be in the form of specifications for the proposed substitution that may be readily compared with the specifications for the original material.

200.03—General Sampling and Testing Procedures.

Materials shall be tested in accordance with the requirements of standard AASHTO, ASTM, or federal methods or methods devised by the Department as specified in the applicable specifications or as approved by the Engineer. At the discretion of the Engineer, the Contractor may furnish a certification of conformity from the manufacturer in lieu of testing.

The Engineer reserves the right to retest any material that has previously been tested or accepted on certification and reject that material if it is found to be defective.

The Department has developed test methods for the evaluation of certain materials or their properties. These test methods are identified by the prefix *VTM* (Virginia Test Method) followed by a number that will identify the specific VTM to be used. Copies of the Department's test methods may be obtained from the Materials Division, VDOT.

Sampling of materials shall be performed in accordance with the standard methods of the Department. When required, samples submitted to the Department's laboratory shall be accompanied by an MSDS. Failure by the Contractor to submit an MSDS will be cause for rejection of the material.

When a material is to be tested prior to delivery to the project, the Contractor shall furnish complete identification of the material and its specific intended use in the proposed construction, including references to the plans or specifications calling for the material.

Material will be inspected at the original or intermediate source of supply whenever it is economically advantageous to the Department. This inspection does not relieve the Contractor of the responsibility to furnish materials that conform to the specifications. The Department's representative shall have ready access to all parts of any processing plant furnishing material for a project. Access for sampling and inspecting materials or plant equipment shall include secure, sturdy platforms conforming to local, state, and federal safety regulations.

The Department may discontinue the use of a plant laboratory for acceptance testing in the event of a mechanical malfunction of the laboratory equipment and in cases of emergency involving plant inspection personnel. In such event, acceptance testing will be performed at the district or central office laboratory until the malfunction or emergency has been satisfactorily corrected or resolved.

200.04—Acceptance Procedures for Aggregates.

Aggregates conforming to the requirements of Section 207 (for Type I) and Section 208 will be accepted under a quality assurance program that uses statistical concepts. Aggregate materials shall conform to such requirements prior to the addition of admixtures.

Acceptance procedures for other aggregates shall be in accordance with the requirements of an approved production control plan conforming to the policies of the Department with regard to sampling and testing. Shipments of aggregates accepted under such a production control plan shall be accompanied by the following certification:

Aggregate Certification

Aggregate shipped under this certification has been tested and conforms to the requirements of VDOT.

_____

Signature and Title

The certification may be printed or stamped on the delivery ticket or affixed by a gummed label thereto. The certification shall be signed by an authorized representative of the aggregate supplier and given to the Engineer upon delivery of the aggregate.

The 2.00 millimeter sieve shall be the dividing sieve for soils, select material, aggregate subbase material, and aggregate base material. The 2.36 millimeter sieve shall be the dividing sieve for asphalt concrete aggregates. That portion of the total aggregate retained on the sieves is defined as coarse aggregate, and that portion passing the sieves is defined as fine aggregate. Soundness tests will be performed in accordance with the requirements of AASHTO T104 without regard to these definitions of fine and coarse aggregate. Fine and coarse aggregates for hydraulic cement concrete are distinguishable by their conformity to the series of grading requirements in Section 202 and Section 203, respectively.

The term *nonpolishing aggregate* shall mean aggregate that the Department has determined will result in a surface of acceptable skid resistance when it is used and exposed as part of a wearing surface. The Department reserves the right to evaluate and determine the acceptability of polishing characteristics of aggregate proposed for use in pavement surfaces.

200.05—Handling and Storing Aggregates.

Stockpiles of aggregate shall be constructed on areas that are hard, well drained, and denuded of vegetation. The different sizes and kinds of aggregates shall be kept separate during handling and storage and until batched. Care shall be taken to prevent segregation of coarse and fine particles during handling and storing.

Aggregates placed directly on the ground shall not be removed from the stockpiles within 300 millimeters of the ground until final cleanup, and then only clean aggregate shall be used.

200.06—Technician and Batcher Certification.

Certification for technicians and batchers will be awarded by the Department upon a candidate's satisfactory completion of an examination.

(a) **Central Mix Aggregate Technician:** A Central Mix Aggregate Technician designs and makes necessary adjustments in job mixtures at the plant based on analysis of the specified material. The technician also samples materials and conducts any tests necessary to put the plant into operation and produce a mixture in accordance with the applicable specifications.

(b) **Asphalt Concrete Plant Technician:** An Asphalt Concrete Plant Technician designs and makes necessary adjustments in asphalt concrete mixtures at the mixing plant. The technician also samples material and conducts any tests necessary to put the plant into operation and ensure production of a mixture conforming to these specifications.

(c) **Hydraulic Cement Concrete Plant Technician:** A Hydraulic Cement Concrete Plant Technician performs necessary adjustments in the proportioning of material used to produce the specified concrete mixtures.

(d) **Hydraulic Cement Concrete Batcher:** A Hydraulic Cement Concrete Batcher performs the batching operation. The batcher implements adjustments only at the direction of a certified Concrete Plant Technician unless the batcher's certification authorizes otherwise.

(e) **Asphalt Paving Technician:** An Asphalt Paving Technician inspects asphalt concrete placement and surface treatment in accordance with the requirements of Sections 315 and 313.

(f) **Concrete Field Technician:** A Concrete Field Technician provides quality control of placement operations for hydraulic cement concrete in accordance with the requirements of Sections 316, 404, 405, 410, 412, 415, 502, 504, 505, 506, and 509.

SECTION 201—MINERAL FILLER

201.01—Description.

These specifications cover inorganic material such as lime or fly ash, usually of very fine grading, added to soil or asphalt to produce a desired effect.

201.02—Detail Requirements.

Mineral filler shall conform to the requirements of AASHTO M17. Tests will be performed in accordance with the requirements of AASHTO T37.

SECTION 202—FINE AGGREGATE

202.01—Description.

These specifications cover material for use as fine aggregate in hydraulic cement concrete, mortar, asphalt concrete, and asphalt surface treatments.

202.02—Materials.

Fine aggregate is classified herein in accordance with its occurrence or method of manufacture as natural sand or stone sand. Natural sand shall consist of grains of hard, sound material, predominantly quartz, occurring in natural deposits or in loosely bound deposits, such as sandstone conglomerate. Stone sand shall consist of sound crushed particles of approved Grade A stone, essentially free from flat or elongated pieces, with sharp edges and corners removed.

Fine aggregates for use in hydraulic cement concrete that are obtained from more than one source shall not be used alternately or mixed without the consent of the Engineer.

202.03—Detail Requirements.

(a) **Grading:** Grading shall conform to the requirements of Table II-1. Tests will be performed in accordance with the requirements of AASHTO T27.

(b) **Soundness:** Soundness shall conform to the requirements of Table II-2. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.

TABLE II-1
Fine Aggregate

Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Mass)								
Grading	**9.5 mm**	**4.75 mm**	**2.36 mm**	**1.18 mm**	**600 μm**	**300 μm**	**150 μm**	**75 μm**
A	Min. 100	97±3	90±10	67±18	42±17	17±9	Max. 10	
B	Min. 100	97±3					Max. 10	
C		Min. 100	97±3				Max. 25	
F	Min. 100	92±8	80±2	62±22	30±19	Max. 26	Max. 10	Max. 7
G	Min. 100	70±30		50±35		Max. 26	Max. 10	Max. 5

TABLE II-2
Soundness

Use	**Max. Soundness Loss (%)**	
	Magnesium Sulphate (5 Cycles)	**Freeze and Thaw (20 Cycles)**
Hydraulic cement concrete	18	8
Asphalt concrete surfaces and surface treatments	25	15
Asphalt concrete bases	30	15

(c) **Organic Impurities:** When fine aggregate is to be used in hydraulic cement concrete, the percentage of organic impurities shall conform to the requirements of AASHTO T21; however, material producing a darker color than that specified in AASHTO T21 may be accepted in accordance with the requirements of AASHTO M6.

(d) **Void Content:** Void content will be tested in accordance with the requirements of VTM-5.

(e) **Deleterious Material:** The amount of deleterious material in sands shall be not more than the following:

Material	% by Mass	AASHTO Test Method
Clay lumps	0.25	T112
Shale, mica, coated grains, soft or flaky particles	1.0	T113
Organic material	0	T21
Total material passing 75 µm sieve by washing[1]		T11 and T27
For use in concrete subject to abrasion	3	
For other concrete	5	

[1]In the case of stone sand, if the material passing the 75 µm sieve is dust of fracture, essentially free from clay or shale, the percentages shown for use in concrete subject to abrasion and in other concrete may be increased to 5.0% and 7.0%, respectively.

SECTION 203—COARSE AGGREGATE

203.01—Description.

These specifications cover material for use as coarse aggregate in hydraulic cement concrete, asphalt concrete, asphalt surface treatments, and drainage.

203.02—Materials.

Coarse aggregate shall consist of crushed stone, crushed slag, or crushed or uncrushed gravel with clean, hard, tough, and durable pieces free from

adherent coatings and deleterious amounts of friable, thin, elongated, or laminated pieces; soluble salts; or organic materials.

(a) **Crushed hydraulic cement concrete** will be permitted for use as a coarse aggregate provided it conforms to the physical requirements specified herein and shows no adverse chemical reaction. Crushed hydraulic cement concrete will not be permitted in the following: (1) reinforced cement concrete, (2) in combination with other materials in contact with geotextile fabric when such fabric is used as a drainage item, and (3) in backfill or bedding for perforated pipe.

(b) **Crushed gravel** shall consist of particles of which at least 80 percent by mass shall have at least one face fractured by artificial crushing. Tests will be performed in accordance with the requirements of VTM-15.

(c) **Blast furnace slag** shall be relatively free from foreign minerals and glassy or spongy pieces. It shall have a dry rodded unit mass of at least 1.12 megagrams per cubic meter for size No. 68 and smaller, and at least 1.04 megagrams per cubic meter for larger sizes. Tests will be performed in accordance with the requirements of AASHTO T19. When used in asphalt surface treatments, blast furnace slag shall not contain more than 10 percent nonporous material and shall have an absorption of at least 3 percent. Tests will be performed in accordance with the requirements of AASHTO T85.

203.03—Detail Requirements.

(a) **Grading:** Open graded aggregates shall conform to the requirements of Table II-3. Tests will be performed in accordance with the requirements of AASHTO T27.

(b) **Soundness:** Soundness shall conform to the requirements of Table II-4. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.

TABLE II-3

Sizes of Open Graded Coarse Aggregates

Va. Size No.	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Mass)														
	100 mm	90 mm	75 mm	63 mm	50 mm	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	300 µm	150 µm
1	Min. 100	95 ± 5		43 ± 17		Max. 15		Max 5							
2			Min. 100	95 ± 5		43 ± 17		Max 15	Max. 5						
3				Min. 100	90-100	35-70	0-15		Max. 5						
357					Min. 100		60 ± 20		20 ± 10		Max. 5				
5						Min. 100	95 ± 5	58 ± 17	Max. 15	Max. 5					
56						Min. 100	95 ± 5	58 ± 17	25 ± 10	Max. 15	Max. 5				
57						Min. 100	95 ± 5		43 ± 17		Max. 7	Max. 3			
68							Min. 100	95 ± 5		48 ± 17	Max. 20	Max. 8	Max. 5		
7								Min. 100	95 ± 5	57 ± 17	Max. 15	Max. 5			
78								Min. 100	95 ± 5	60 ± 20	Max. 20	Max. 8	Max. 5		
8									Min. 100	92 ± 8	25 ± 15	Max. 8	Max. 5		
8P									Min. 100	75 ± 100	5-30	Max. 5			
9										Min. 100	92 ± 8	25 ± 15	Max. 10	Max. 5	
10										Min. 100	92 ± 8				20 ± 10

TABLE II-4
Soundness

Use	Max. Soundness Loss (%)	
	Magnesium Sulphate (5 Cycles)	Freeze and Thaw (20 Cycles)
Hydraulic cement concrete	12	5
Asphalt surface courses	15	6
Asphalt and aggregate bases	20	7
Select material (Type I) and subbase	30	12

(c) **Abrasion Loss:** Abrasion loss shall conform to the requirements of Table II-5. Tests will be performed in accordance with the requirements of AASHTO T96 on aggregate with a grading the most nearly identical with the grading to be used in the work.

TABLE II-5
Abrasion

Use	Max. Los Angeles Abrasion Loss (%)	
	100 Rev.	500 Rev.
Grade A stone	9	40
Grade B stone	12	45
Grade C stone	14	50
Slag	12	45
Gravel	12	45

(d) **Deleterious Material:** The amount of deleterious material shall be not more than the following:

Material	% by Mass	AASHTO Test Method
Coal and lignite	0.25	T113
Clay lumps	0.25	T112
Material passing 75 μm sieve by washing[1]	1.00	T11

[1]When the material passing the 75 μm sieve by washing is dust of fracture, the percentage of deleterious material may be increased to 1.50%.

SECTION 204—STONE FOR MASONRY, RIPRAP, POROUS BACKFILL, AND GABIONS

204.01—Description.

These specifications cover aggregate materials used to protect ground slopes from erosion or wave action and those used for drainage, generally behind a backwall or abutment.

204.02—Detail Requirements.

(a) **Stone for rubble or mortar rubble masonry** shall be sound, durable, and free from seams, cracks, and other structural defects and shall be minimum Grade C stone free from rounded, worn, or weathered surfaces.

(b) **Stone for riprap and bedding** shall be sound, durable, and free from seams, cracks, and other structural defects. Riprap stone and bedding exposed to the wave action of water shall be of igneous or metamorphic origin. Riprap bedding shall be crushed stone, minimum Grade B.

(c) **Porous backfill** shall be aggregate size No. 78 or No. 8, minimum Grade B.

(d) **Gabion stone** shall be durable and free from seams and cracks. Weathered stone shall not be used. Stone shall have a mass of between 2 and 15 kilograms except that approximately 5 percent of the individual stones may have a mass of less than 2 or more than 15 kilograms. At least 50 percent of the stone shall have a mass greater than 5 kilograms.

SECTION 205—CRUSHER RUN AGGREGATE

205.01—Description.

These specifications cover crushed aggregate used for backfilling and bedding pipe and box culverts, maintaining traffic, and repairing and constructing all-weather private access pavements.

205.02—Materials.

Crusher run aggregate shall be crushed from stone, slag, or gravel and shall contain all of the sizes produced when the original aggregate is reduced through

a series of crushers to the maximum size specified. It shall be essentially free from deleterious substances in accordance with the requirements of Section 203.

(a) **Crushed hydraulic cement concrete** will be permitted for use as crusher run aggregate provided it conforms to the physical requirements of Section 203 and shows no adverse chemical reaction. It shall not be used in a subsurface drainage application in combination with perforated pipe or as a base material where geotextile fabric is to be used.

(b) **Crushed gravel** shall consist of particles of which at least 90 percent by mass of material retained on the 2.00 millimeter sieve shall have at least one face fractured by artificial crushing. Tests will be performed in accordance with the requirements of VTM-15.

205.03—Detail Requirements.

(a) **Grading:** Grading shall conform to the following when tested in accordance with the requirements of AASHTO T27:

	% by Mass of Materials Passing Sieve					
Size No.	**63 mm**	**50 mm**	**37.5 mm**	**25.0 mm**	**19.0 mm**	**4.75 mm**
24	Min. 100	95 ± 5				32 ± 18
25			Min. 100	95 ± 5		32 ± 18
26				Min. 100	95 ± 5	38 ± 22

(b) **Atterberg Limits:** The liquid limit shall be not more than 25. The plasticity index shall be not more than 3. Tests will be performed in accordance with the requirements of VTM-7.

(c) **Soundness Loss:** Soundness loss shall conform to the requirements of Table II-4 for aggregate bases. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.

(d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent. Tests will be performed in accordance with the requirements of AASHTO T96.

SECTION 206—LIGHTWEIGHT AGGREGATE

206.01—Description.

These specifications cover lightweight aggregate used in hydraulic cement concrete and asphalt surface treatment.

206.02—Detail Requirements.

Lightweight aggregate shall consist of clay, shale, or slate expanded through a sintering or rotary kiln.

(a) **Lightweight aggregate used in hydraulic cement concrete** shall conform to the requirements of AASHTO M195.

(b) **Lightweight aggregate used for asphalt surface treatment** shall conform to the requirements of AASHTO M195 except that Sections 3, 6, and 8 will not apply. Grading shall conform to the requirements of Table II-3 except that the maximum percentage by mass of material passing the 2.36 millimeter sieve shall be 16 percent and passing the 1.18 millimeter sieve shall be 9 percent.

SECTION 207—SELECT MATERIAL

207.01—Description.

These specifications cover nonplastic material obtained from roadway cuts, borrow areas, or commercial sources used as foundation for subbase, shoulder surfacing, fill, backfill, or other specific purposes.

207.02—Detail Requirements.

Select material shall consist of approved local or commercial materials free from roots, muck, and debris.

(a) **Grading:**

1. **Type I:** Grading for Type I shall conform to the job-mix formula selected from within the design range specified in Table II-6, subject to the applicable tolerances specified in Table II-7, when tested in accordance with the requirements of VTM-25.

TABLE II-6
Design Range: Select Material, Type I

% by Mass of Material Passing				
75 mm Sieve	**50 mm Sieve**	**2.00 mm Sieve**	**425 µm Sieve**	**75 µm Sieve**
100	95-100	25-55	16-30	4-14

TABLE II-7
Process (P) and Range (R) Tolerance: Select Material, Type I

	Tolerance on Each Laboratory Sieve (%)									
	75 mm		50 mm		2.00 mm		425 µm		75 µm	
No. Test	P	R	P	R	P	R	P	R	P	R
1	0.0		±4.0		±15.0		±10.0		±6.0	
2	0.0	0.0	±3.0	5.0	±10.5	18.5	±7.0	13.0	±4.0	8.5
3	0.0	0.0	±2.5	5.5	±8.5	22.0	±5.5	15.0	±3.5	10.0
4	0.0	0.0	±2.0	6.0	±7.5	23.5	±5.0	16.5	±3.0	10.5
8	0.0	0.0	±1.5	7.0	±5.5	26.5	±3.0	18.5	±2.0	12.0

2. **Type II and Type III:** Grading for Types II and III shall conform to the following when tested in accordance with the requirements of VTM-25:

Percent by Mass of Material Passing Sieve

Type	75 mm	50 mm	75 µm
II		Min. 100	Max. 25
II[1]	Min. 100		Max. 20

[1]A maximum of 25% of material retained on the 75 µm sieve will be allowed for Type III if the liquid limit is less than 25 and the plasticity index is less than 6.

(b) **Atterberg Limits:**

1. **Type I:** The mean of the Atterberg limits shall conform to the requirements in Table II-8 when tested in accordance with the requirements of VTM-7.

TABLE II-8
Atterberg Limits: Select Material Type I

No. Tests	Max. Liquid Limit	Max. Plasticity Index
1	25.0	6.0
2	23.9	5.4
3	23.2	5.1
4	23.0	5.0
8	22.4	4.7

2. **Types II and III:** Atterberg limits shall conform to the following when tested in accordance with the requirements of VTM-7:

Type	Max. Liquid Limit	Max. Plasticity Index
II	30	9
III	30	9

(c) **CBR:** Tests for CBR will be performed in accordance with the requirements of VTM-8 for conformance to the specified value.

(d) **Soundness:** Soundness for Type 1 shall conform to the requirements of Table II-4. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.

207.03—Job-Mix Formula for Select Material, Type I.

The Contractor shall submit or shall have the supplier submit a job-mix formula for the Engineer's approval prior to starting work. The formula shall establish a single percentage of aggregate passing each required sieve size denoted in Table II-6 and shall be in effect until a modification is approved by the Engineer. If unsatisfactory results or other changed conditions make it necessary, the Contractor shall prepare and submit a new formula for the Engineer's approval.

207.04—Mixing.

The Contractor shall provide a laboratory as specified in Section 106.07. Select material shall be produced at optimum moisture ±2 percentage points.

The Contractor shall have a certified Central Mix Aggregate Technician present at the plant during initial setup and subsequent production.

207.05—Acceptance of Select Material, Type I.

Sampling and testing for determination of grading and Atterberg limits shall be performed by the Contractor. The Contractor shall provide the Department copies of test results on forms furnished by the Department and shall maintain appropriate current quality control charts. The Department will perform independent monitor tests. If there is a statistically significant difference between the two sets of results, an investigation will be made to determine the reason for the difference. If it is determined that the material does not conform to the requirements of the Contract, the material will be rejected or a payment adjustment will be made in accordance with the requirements of Section 207.07 herein.

Determination of grading and Atterberg limits will be based on a mean of the results of tests performed on four samples taken in a stratified random manner

for each 2,000 metric ton lot. Lots of 4,000 metric tons may be used when the normal daily production of the source from which the material is being obtained is more than 2,000 metric tons. If visual examination reveals that the material is obviously contaminated or segregated, the material will be rejected without additional sampling or testing. If it is necessary to determine the grading and Atterberg limits of the material in an individual location, one sample taken from the material in question will be tested and the results will be compared to the job-mix formula with the tolerances specified in Tables II-7 and II-8 for one test. The results obtained will apply only to the material in question.

A lot will be considered acceptable for grading if the mean of the results falls within the allowed deviation from the job-mix formula and the difference between the maximum and minimum results does not exceed the range values specified in Table II-7.

A lot will be considered acceptable for Atterberg limits if the mean of the test results is less than the maximum allowed for the liquid limit and plasticity index values specified in Table II-8.

If the liquid limit exceeds 30 or the plasticity index exceeds 9 on any individual sample, that portion of the lot from which the sample was taken will be considered a separate part of the lot and shall be removed from the road.

If the Contract requires less than 2,000 metric tons of material, the amount of material necessary to complete the last lot is less than 2,000 metric tons (or 4,000 metric tons, if applicable), the job-mix formula is modified within a lot, or a portion of the lot is rejected on the basis of individual test results, the mean results of the tests on the samples taken will be compared to the job-mix formula with the applicable process tolerances specified in Tables II-7 and II-8 for the number of tests performed.

207.06—Referee System for Select Material, Type I.

If the test results obtained for one of the four samples or the mean of the four samples tested to evaluate a particular lot is questionable, the referee system as defined in Section 208.07 will be applied except that the final mean results will be compared to the job-mix formula with the tolerances given in Tables II-7 and II-8 for the mean of eight tests.

207.07—Payment Adjustment System for Select Material, Type I.

If a lot of material does not conform to the acceptance requirements stated herein, adjustment points, determined as follows, will be applied for each 1 percent or part thereof that the grading or Atterberg limits are outside the job-mix formula with the tolerances given in Tables II-7 and II-8.

Sieve	Adjustment Points Process	Range
75 mm	1	1
50 mm	1	1
2.00 mm	1	1
425 μm	3	3
75 μm	5	5

Atterberg Limits	Adjustment Points
Liquid limit	3
Plasticity index	7

If the total adjustment (excluding the range adjustment) for the lot is more than 25 points, the failing material shall be removed from the road. If the total adjustment (excluding the range adjustment) is 25 points or less and the Contractor does not elect to remove and replace the material, the contract unit price for the material will be reduced by 1 percent for each adjustment point. The total adjustment will be applied to the tonnage represented by the sample(s).

SECTION 208—SUBBASE AND AGGREGATE BASE MATERIAL

208.01—Description.

These specifications cover material used to form a foundation for base or surface pavement.

208.02—Materials.

(a) **Subbase material** shall consist of mixtures of natural or crushed gravel, crushed stone or slag, and natural or crushed sand; with or without soil mortar.

(b) **Aggregate base material** will be designated as Type I or Type II as follows: **Type I** shall consist of crushed stone, crushed slag, or crushed gravel, with or without soil mortar or other admixtures. Crushed gravel shall consist of particles of which at least 90 percent by mass of the material retained on the 2.00 millimeter sieve shall have at least one face fractured by artificial crushing. **Type II** shall consist of gravel, stone, or slag screenings; fine aggregate and crushed coarse aggregate; sand-clay-gravel mixtures; or any combination of these materials; with or without soil mortar or other admixtures.

TABLE II-9
Design Range for Dense Graded Aggregates

Size No.	Amounts Finer Than Each Laboratory Sieve (Square Openings*) (% by Mass)					
	50 mm	25.0 mm	9.5 mm	2.00 mm	425 μm	75 μm
21A	100	94-100	63-72	32-41	14-24	6-12
21B	100	85-95	50-69	20-36	9-19	4-7
22		100	62-78	39-56	23-32	8-12

* In millimeters, except where otherwise indicated.

208.03—Detail Requirements.

(a) **Grading:** Grading shall conform to the requirements of the job-mix formula selected from within the design range specified in Table II-9, subject to the applicable tolerances specified in Table II-10 when tested in accordance with the requirements of VTM-25.

TABLE II-10
Process Tolerances for Each Laboratory Sieve (%)

No. Tests	Top Size	25.0 mm	19.0 mm	9.5 mm	2.00 mm	425 µm	75 µm
1	0.0	±10.0	±14.0	±19.0	±14.0	±8.0	±4.0
2	0.0	±7.1	±10.0	±13.6	±10.0	±5.7	±2.9
3	0.0	±5.6	±7.8	±10.6	±7.8	±4.4	±2.2
4	0.0	±5.0	±7.0	±9.5	±7.0	±4.0	±2.0
8	0.0	±3.6	±5.0	±6.8	±5.0	±2.9	±1.4

(b) **Atterberg Limits:** Atterberg limits shall conform to the requirements of Table II-11 when tested in accordance with the requirements of VTM-7.

TABLE II-11
Atterberg Limits

	Max. Liquid Limit	Max. Plasticity Index	
No. Tests	Subbase and Aggregate Base Type I and II	Subbase Sizes No. 21A, and 22 and Aggregate BaseType II	Aggregate Base Type I and Subbase Size No. 19
1	25.0	6.0	3.0
2	23.9	5.4	2.4
3	23.2	5.1	2.1
4	23.0	5.0	2.0
8	22.4	4.7	1.7

(c) **Soundness:** Soundness shall conform to the requirements of Table II-4 when tested in accordance with the requirements of AASHTO T103 or T104.

(d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent when tested in accordance with the requirements of AASHTO T96.

(e) **Optimum Moisture:** Material shall be produced at optimum moisture ±2 percentage points.

(f) **Admixtures:** Admixtures shall conform to the applicable specifications.

208.04—Job-Mix Formula.

The Contractor shall submit, or shall have the source of supply submit, for the Engineer's approval, a job-mix formula for each mixture to be supplied for the project prior to starting work. The formula shall be within the design range specified in Table II-9. If unsatisfactory results or other conditions make it necessary, the Contractor shall prepare and submit a new job-mix formula for approval.

208.05—Mixing.

Subbase or aggregate base materials shall be mixed in an approved central mixing plant of a pugmill or other mechanical type. Materials shall be blended prior to or during mechanical mixing in a manner than will ensure conformance to the specified requirements.

Preparation of subbase and aggregate base material will be subject to inspection at the plant. The Contractor shall provide a laboratory as specified in Section 106.07.

During the initial setup and subsequent production, the Contractor shall have a certified Central Mix Aggregate Technician present at the plant.

208.06—Acceptance.

The Contractor shall provide the quality assurance necessary for the Engineer to determine conformance to the required grading and Atterberg limits of subbase and aggregate base material.

Sampling and testing for determination of grading and Atterberg limits shall be performed by the Contractor. The Contractor shall provide copies of test results to the Department on forms furnished by the Department and shall maintain appropriate current quality control charts. The Department will perform independent monitor tests at a laboratory of its choice. If there is a statistically significant difference in the two sets of results, an investigation will be made to determine the reason for the difference. If it is determined that the material does not conform to the requirements of the Contract, the material will be rejected or a payment adjustment will be made in accordance with the requirements of Section 208.08.

Determination of grading and Atterberg limits will be based on a mean of the results of tests performed on four samples taken in a stratified random manner from each 2,000 metric ton lot. Lots of 4,000 metric tons may be used when the normal daily production of the source from which the material being obtained is more than 2,000 metric tons. Samples shall be obtained from the approximate center of randomly selected quadrants of truckloads of material. Any statistically acceptable method of randomization may be used to determine the time and location of the stratified random sample to be taken. The Department shall be advised of the method to be used prior to the beginning of production.

A lot will be considered acceptable for grading if the mean of the test results is within the deviation from the job-mix formula specified in Table II-10.

A lot will be considered acceptable for Atterberg limits if the mean of the test results is less than the maximum for the liquid limit and plasticity index specified in Table II-11.

If the liquid limit exceeds 30 or the plasticity index exceeds 6 for Type I base material or No. 19 subbase material; or the plasticity index exceeds 9 for Type II base material or subbase materials No. 20, 21, 21A, 21B, or 22 on any individual sample; that portion of the lot from which the sample was taken will be considered a separate part of the lot and shall be removed from the road.

If either the amount of material in the lot is less than 2,000 metric tons (4,000 metric tons if applicable), the job-mix formula is modified within a lot, or a portion of the lot is rejected on the basis of individual test results, the mean test results of the samples taken will be compared to the job-mix formula with the tolerances given in Tables II-10 and II-11 for the number of tests performed.

If a visual examination reveals that material in any load is obviously contaminated or segregated, the load will be rejected without additional sampling or testing of the lot. If it is necessary to determine grading or Atterberg limits of material in an individual load, one sample (taken from the load) will be tested and the results compared to the job-mix formula with the tolerances given in Tables II-10 and II-11 for one test. Results obtained in the testing of a specific individual load will apply only to the load in question.

208.07—Referee System.

If the test results obtained for one of the four samples taken to evaluate a particular lot are questionable, the Contractor may request that the results of the questionable sample be disregarded. The Contractor shall then perform tests on five additional samples taken from randomly selected locations in the roadway

where the lot was placed. If the Engineer determines that one of the four test results is questionable, the Department will perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. The test results of the three original (unquestioned) samples will be averaged with the tests results of the five road samples, and the mean of the test values obtained for the eight samples will be compared to the job-mix formula with the tolerances specified in Tables II-10 and II-11 for the mean of eight tests.

If the Contractor questions the mean of the four original test results obtained for a particular lot, he may request approval to perform additional testing of that lot. If the Contractor requests further tests, he shall sample and test the material in accordance with procedures approved by the Department. If the Engineer determines that the mean of the four original test results is questionable, the Department will perform additional testing of that lot. The test results of the original four samples will be averaged with the test results of the four additional samples taken from randomly selected locations in the roadway where the lot was placed, and the mean of test values obtained for the eight samples will be compared to the job-mix formula with the tolerances specified in Tables II-10 and II-11 for the mean result of eight tests.

If the mean of the test values obtained for the eight samples conforms to the requirements for the mean of the results of eight tests, the material will be considered acceptable; if the mean does not conform, the lot will be adjusted in accordance with the payment adjustment rate specified in Section 208.08.

The provisions of this section will not be applicable to mixtures containing cement or other admixtures that alter the characteristics of the material.

208.08—Payment Adjustment System.

If a lot of material does not conform to the acceptance requirements of Section 208.06, payment adjustment points will be determined as follows:

Sieve No.	Adjustment Points for Each 1% Grading Is Outside Tolerance Permitted in Table II-10
50 mm	1
25.0 mm	1
19.0 mm	1
9.5 mm	1
2.00 mm	1
425 µm	3
75 µm	5

Atterberg Limits	Adjustment Points for Each 1% Atterberg Limits Exceed Maximum Permitted in Table II-11
Liquid limit	3
Plasticity index	7

If the total adjustment for the lot is more than 25 points, the failing material shall be removed from the road. If the total adjustment is 25 points or less and the Contractor does not elect to remove and replace the material, the unit price for the material will be reduced by 1 percent for each adjustment point. The adjustment will be applied to the tonnage represented by the sample(s).

The Contractor shall control the variability of his product in order to furnish a consistent, well-graded mixture. When the quantity of any one type of material furnished for a project exceeds 1,000 metric tons, the variability of the total quantity furnished will be determined on the basis of the standard deviation for each sieve size. If the standard deviation is within the limits specified in Table II-12, the contract unit price for the material will be adjusted as indicated hereinafter. Standard deviation computations will not be made separately on more than two job mixtures for the same type of material.

The contract unit price will be reduced by 0.5 percent for each adjustment point applied for standard deviation.

The disposition of material having standard deviations larger than those given in Table II-12 will be as determined by the Engineer.

TABLE II-12
Standard Deviation

	No. of Payment Adjustment Points for Each Sieve Size		
Sieve Size	1 Adjustment Point for Each Sieve Size	2 Adjustment Points for Each Sieve Size	3 Adjustment Points for Each Sieve Size
50.0 mm	0.6-1.5	1.6-2.5	2.6-3.5
25.0 mm	4.6-5.5	5.6-6.5	6.6-7.5
19.0 mm	5.6-6.5	6.6-7.5	7.6-8.5
9.5 mm	7.1-8.0	8.1-9.0	9.1-10.0
2.00 mm	5.6-6.5	6.6-7.5	7.5-8.5
425 µm	3.6-4.5	4.6-5.5	5.6-6.5
75 µm	3.1-4.0	4.1-5.0	5.1-6.0

SECTION 209—OPEN GRADED SHOULDER MATERIAL

209.01—Description.

These specifications cover the requirements for open graded material used on roadway shoulders where designated.

209.02—Detail Requirements.

Open graded shoulder material shall be aggregate material No. 18 and shall consist of mixtures of natural or crushed gravel, crushed stone, or sand; without soil mortar.

(a) **Grading:** Grading shall conform to the following when tested in accordance with the requirements of VTM-25:

Percent by Mass of Material Passing Sieve					
50.0 mm	**25.0 mm**	**19.0 mm**	**2.00 mm**	**425 μm**	**75 μm**
100	90 ± 10	55 ± 15	20 ± 10	8 ± 5	3 ± 3

(b) **Atterberg Limits:** Material shall be nonplastic, and the liquid limit shall be not more that 25 when tested in accordance with the requirements of VTM-7.

(c) **Soundness:** Soundness shall conform to the requirements of Table II-7 for subbase material when tested in accordance with the requirements of AASHTO T103 or T104.

(d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent when tested in accordance with the requirements of AASHTO T96.

209.03—Mixing.

Pugmill mixing will not be required for aggregate shoulder material No. 18. The Contractor shall provide a laboratory as specified in Section 106.07.

SECTION 210—ASPHALT MATERIALS

210.01—Description.

These specifications cover asphalt material consisting of asphalt, asphalt cement, asphalt cutback, or asphalt emulsion as defined in ASTM D8.

210.02—Materials.

Asphalt material shall be homogeneous and shall conform to the following:

1. Rapid curing and medium curing liquid asphalts used as surface treatments shall contain a heat-stable additive conforming to the requirements of Section 211.

2. Liquid asphalt material will be tested for coating ability in accordance with the requirements of AASHTO T182, with the following modifications:

   a. Material that can coat 95 percent of a shady dolomite will be classified Type I.

   b. Material that can coat 95 percent of a siliceous gravel wetted with 2 percent water by mass will be classified Type II.

3. Rapid curing cutback asphalts shall conform to the requirements of AASHTO M81.

4. Medium curing cutback asphalts shall conform to the requirements of AASHTO M82.

5. Cements shall be viscosity graded conforming to AASHTO M226, Table 2, except that the loss on heating shall be not greater than 1.0 for AC-5, 0.8 for AC-20, and 0.5 for all other grades.

6. Emulsions shall conform to the requirements of AASHTO M208 and shall be Type I as specified in 2.a. herein except that CRS-2 shall be Type II as specified in 2.b. herein. CRS-1h shall conform to the requirements of AASHTO M208 for CRS-1 except that the penetration shall be 40 to 110. Emulsions will be sampled and tested in accordance with the requirements of AASHTO T59 except that viscosity will be tested in accordance with the requirements of VTM-64.

210.03—Detail Requirements.

(a) **Shipping:** Shipments of asphalt material shall be made in transporting media that are free from contamination. Tank trucks or trailers shall be equipped with a sampling device approved by the Engineer. The device shall be made of pipe and a gate valve or petcock of size DN15 to DN25. The device shall be built into the tank or the recirculating or discharge line so that a sample can be drawn during circulation or discharge.

(b) **Storing:** Asphalt material to be stored shall be placed in storage tanks that are free from contamination.

210.04—Payment Adjustment System.

If the material represented by any one sample does not conform to the requirements herein and the material is a pay item, the contract unit price for the item will be reduced by 4 percent for each property that does not conform to the specifications for the quantity represented by the sample that was used on the project. Unused material represented by the failing sample will be rejected.

If the material represented by a failing sample was not a pay item, the material will be considered unacceptable and shall be subject to the requirements of Sections 105.13 and 106.10.

SECTION 211—ASPHALT CONCRETE

211.01—Description.

Asphalt concrete shall consist of a combination of mineral aggregate and asphalt material mixed mechanically in a plant specifically designed for such purpose.

Asphalt concrete shall conform to the requirements for the type designated.

211.02—Materials.

(a) **Asphalt materials** shall conform to the requirements of Section 210.

(b) **Coarse aggregate** shall be Grade A or B, conforming to the requirements of Section 203 for quality.

(c) **Fine aggregate** shall conform to the requirements of Section 202 and shall have a minimum sand equivalent value of 30 when tested in accordance with the requirements of AASHTO T176.

(d) **Fine or coarse aggregates** that tend to polish under traffic will not be permitted in any surface exposed to traffic except in areas where the posted speed is 24 kilometers per hour or less, and as permitted elsewhere in these specifications.

(e) **Mineral filler** shall conform to the requirements of Section 201.

(f) **Aggregate for asphalt concrete** shall be provided in sufficient sizes to produce a uniform mixture. The Contractor shall indicate the separate approximate sizes of aggregate to be used on the proposed job-mix formula.

Where segregation or nonuniformity is evidenced in the finished pavement, the Engineer reserves the right to require the Contractor to discontinue the use of crusher run or aggregate blends and to furnish separate sizes of open graded aggregate material.

(g) **An antistripping agent** shall be used in all asphalt mixes. It may be hydrated lime in accordance with Section 211.01(h) or an approved chemical additive from the Department's approved list found in the Material Division's *Manual of Instructions*.

The mixture shall produce a tensile strength ratio (TSR) value not less than 0.85 for the design and production tests. The TSR shall be determined in accordance with VTM-62. Design tests shall use the same materials that are to be used in the production mix and shall be conducted in a Department-approved laboratory.

The Contractor may use either at least 1.0 percent lime in accordance with Section 211.02 (h), an approved chemical additive at the manufacturer's recommended dosage, or a combination of both.

When a chemical additive is used, it shall be added to the asphalt cement prior to introduction into the mix. Any chemical additive or particular concentration of chemical additive found to be harmful to the asphalt material, or which changes the viscosity of the original asphalt cement more than 400 poises or the penetration more than -4 or +10, shall be changed to obtain compliance with these values

(h) **Hydrated lime** shall conform to the requirements of ASTM C977. Hydrated lime shall be added at a rate of not less than one percent by mass of the total dry aggregate.

A separate bin or tank and feeder system shall be provided to store and accurately proportion the lime into the aggregate in either dry or slurry form. The lime and aggregate shall be mixed by pugmill or other approved means to achieve a uniform lime coating of the aggregate prior to entering the drier. In the event lime is added in dry form, the aggregate shall contain at least 3 percent free moisture. The stockpiling of lime treated aggregate will not be permitted.

The feeder system shall be controlled by a proportioning device that shall be accurate to within plus or minus 10 percent of the specified amount. The proportioning device shall have a convenient and accurate means of calibration and shall be interlocked with the aggregate feed or mass determining system so as to maintain the correct proportion. A flow indicator or sensor shall be provided and interlocked with the plant controls such that production of the mixture will be interrupted if there is a stoppage of the lime feed.

The method of introducing and mixing the lime and aggregate shall be subject to approval by the Engineer prior to beginning production.

(i) **Reclaimed asphalt pavement material** may be used as a component material of asphalt mixtures in conformance with the following:

1. Reclaimed asphalt pavement material shall not exceed 25 percent by mass of the total aggregate, unless otherwise approved in writing by the Engineer.

2. The final asphalt mixture shall conform to the requirements for the type specified.

3. During the production process, reclaimed asphalt pavement material shall not be allowed to contact open flame.

4. Reclaimed asphalt pavement material shall be handled, hauled, and stored in a manner that will minimize contamination. Further, the material shall be stockpiled and used in such manner that variable asphalt contents and asphalt penetration values will not adversely affect the consistency of the mixture.

5. Reclaimed asphalt pavement shall be processed in such a manner as to ensure that the maximum top size introduced into the mix shall be 50 millimeters. The Engineer may require smaller sized particles be introduced into the mix if the reclaimed particles are not broken down or uniformly distributed throughout the mixture during heating and mixing.

211.03—Job-Mix Formula.

The Contractor shall submit or have the supplier submit for the Engineer's approval a job-mix formula for each mixture to be supplied. The job-mix formula shall be within the design range specified. The job-mix formula shall establish a single percentage of aggregate passing each required sieve, a single percentage of asphalt material to be added to the aggregate, and a single temperature at which the mixture is to be produced. Each approved job-mix formula shall remain in effect for the current and subsequent construction seasons, provided the results of tests performed on material currently being produced consistently meet the requirements of the job-mix for grading, asphalt content, and temperature as well as field Marshall requirements.

(a) In conjunction with the submittal of a job-mix formula, the Contractor shall submit complete Marshall design test data prepared by an approved testing laboratory for mixes to be used in surface, intermediate, and base courses.

(b) The Marshall design test data shall include but not be limited to the following information:

1. Grading data for each aggregate component of the mixture shown as percent passing for sieves 50 mm, 37.5 mm, 25.0 mm, 19.0 mm, 12.5 mm, 9.5 mm, 4.75 mm, 2.36 mm, 600 µm, 300 µm, 150 µm, and 75 µm. The grading shall be reported to the nearest 1.0 percent except the 75 µm sieve shall be reported to the nearest 0.1 percent.

2. The percentage of each aggregate component as compared to the total aggregate in the asphalt mixture.

3. The aggregate grading in the asphalt mixture as determined by extracting the asphalt from a laboratory prepared sample. The laboratory sample shall be batched on the basis of component percentages as indicated in (b)2. and at the proposed job-mix asphalt content. The extraction shall be in accordance with the requirements of VTM-36. Sieves noted in (b)1. shall be reported, beginning with the top size for that mix.

4. The following volumetric properties of the compacted mixture (calculated on the basis of the mixture's maximum specific gravity determined by AASHTO T-209 and the bulk specific gravity of the specimens determined by AASHTO T-166, Method A) for each asphalt content tested. Properties shall be determined and reported in accordance with the requirements of VTM-58.

a. Voids in total mix (VTM)
b. Voids in mineral aggregate (VMA)
c. Voids filled with asphalt (VFA)

5. The value of the maximum specific gravity of the asphalt mixture used in (b)4. shall be reported to three decimal places.

6. The stability and flow of the compacted asphalt mixture as determined by VTM-57 for each asphalt content tested.

7. At least four different asphalt contents shall be evaluated for the properties noted in (b)4. and (b)6. and the results plotted on graphs furnished by the Department. The asphalt contents evaluated shall approximate the proposed job-mix asphalt content and contents approximately 0.5 percent above and below this value.

(c) The Marshall design test data shall be plotted on graphs furnished by the Department and shall show that the proposed job-mix formula conforms to the requirements of the mix type.

(d) A determination will be made that any new asphalt concrete mixture being produced conforms to the job-mix formula approved by the Department. The Department will test the mixture using samples removed from production. The following tests will be run to determine the properties listed:

Asphalt content	VTM-36
Gradation	AASHTO T30
Marshall properties	VTM-58

In the event the Department determines that the mixture being produced does not conform to the approved job-mix formula, the Contractor shall immediately cease paving with that mixture.

Subsequent paving operations, using either a revised or other job-mix formula that has not been verified as described herein, shall be limited to a test run of 100 to 300 metric tons of mixture if such material is to be placed in Department work. No further paving for the Department is to occur until the acceptability of the mixture being produced has been verified using the 100 to 300 metric ton test run constraint.

Asphalt concrete mixtures used in surface and intermediate courses shall conform to the following requirements when tested in accordance with the requirements of VTM-57 and VTM-58:

TABLE II-13
Mix Design Criteria

Mix Type[1]	VTM (%)	VFA (%)	Min. VMA (%)	Minimum Stability (N)	Flow (mm)	AC Viscosity Grade	Marshall Blow
SM-1	4-8	65-80	17	4500	2.00-4.00	AC-20	50
SM-2A	3-6	65-80	15	5500	2.00-4.00	AC-20	50
SM-2B	3-6	65-80	15	7000	2.00-4.00	AC-20	75
SM-2C	3-6	65-80	15	7000	2.00-4.00	AC-30	75
SM-3A	3-6	65-80	14	7000	2.00-4.00	AC-20	50
SM-3B	3-6	65-80	14	7000	2.00-4.00	AC-20	75
SM-3C	3-6	65-80	14	8000	2.00-4.00	AC-30	75
IM-1A	3-6	65-80	14	7000	2.00-4.00	AC-20	50
IM-1B	3-6	65-80	14	7000	2.00-4.00	AC-20	75
BM-1				2000		AC-20	50
BM-2	3-6	65-80	13	13500	6.00 max	AC-20	75
BM-3	3-6	65-80	12	13500	6.00 max	AC-20	75

Maximum F/A ratio shall be 1.2:1 on all surface and intermediate mixtures.

Maximum F/A ratio shall be 1.4:1 on all base mixtures.

Minimum F/A ratio shall be 0.6:1 on all surface and intermediate mixtures.

Asphalt content shall be selected at the midpoint of the VTM range.

Base mixes shall have a minimum asphalt content of 4.0 percent determined by the Marshall Design as specified herein.

[1] SM = surface mix; IM = intermediate mix; BM = base mix.

The Engineer reserves the right to require adjustments in the job-mix formula based upon a plot of aggregate grading and the maximum density line on a 0.45 power graph where such plot indicates gap grading.

211.04—Asphalt Concrete Mixtures.

Asphalt concrete mixture shall conform to the requirements of Table II-13 and the following:

(a) **Type SM-1** asphalt concrete shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof, combined with asphalt cement.

At least 20 percent Grade A sand conforming to the requirements of Section 202 shall be used.

(b) **Type SM-2A, SM-2B and SM-2C** asphalt concrete shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof, combined with asphalt cement.

For mixtures SM-2B and SM-2C, at least 10 percent sand conforming to the requirements of Section 202 for Grading A, F, G, or a combination thereof shall be used. Natural sand shall not exceed 20 percent.

No more than 5 percent of the aggregate retained on the 4.75 millimeter sieve and no more than 20 percent of the total aggregate may be polish susceptible.

(c) **Type SM-3A, SM-3B and SM-3C** asphalt concrete shall consist of crushed stone, crushed slag or crushed gravel and fine aggregate, slag, or crushed screenings, or combination thereof combined with asphalt cement.

For mixtures SM-3B and SM-3C, at least 10 percent sand conforming to the requirements of Section 202 for Grading A, F, G, or a combination thereof shall be used. Natural sand shall not exceed 20 percent.

No more than 5 percent of the aggregate retained on the 4.75 millimeter sieve shall be polish susceptible. All material passing the 4.75 millimeter sieve may be polish susceptible.

(d) **Type IM-1A and IM-1B** asphalt concrete shall consist of crushed stone, crushed slag or crushed gravel and fine aggregate, slag, or stone screenings, or combination thereof combined with asphalt cement.

(e) **Type BM-1** asphalt concrete shall consist of local pit material. Addition of mineral filler, not to exceed 5 percent, or other aggregates will be permitted to conform to specification requirements.

(f) **Type BM-2 and BM-3** asphalt concrete shall consist of coarse aggregate (crushed stone, crushed slag, or crushed gravel); fine

aggregate (slag, stone screenings, gravel screenings, or combination thereof); combined with asphalt cement.

(g) **Type C** asphalt concrete (curb mix) shall consist of a blend of No.78 crushed aggregate, No. 10 crushed aggregate, fine aggregate, mineral filler and a powdered asphalt or other approved material; combined with 6.0 - 9.0 percent asphalt cement, viscosity grade AC-20.

(h) **Type P** asphalt patch material shall consist of open graded crushed stone and Grading A fine aggregate (15 percent minimum) combined with MC-400 cut-back asphalt. The job mix shall have a residual asphalt cement content of 4.5 - 6.5 percent. Production tolerance of residual asphalt cement shall be ±0.5 percent The aggregate gradation shall not exceed the design range noted in Table II-14.

An antistripping additive from the Department's approved product list shall be added to the cut-back asphalt at a rate of 1 percent by mass.

Tall oil pitch or equal shall be added to the cut-back asphalt at a rate of 2 percent by mass. The mixture shall have a minimum stockpile life of six months. Additional tall oil, up to 5 percent by mass, may be added to extend stockpile life.

Note: Tall oil may be substituted for the tall oil pitch.

The asphalt content will be approved by the Engineer prior to production.

The aggregate moisture content shall not exceed 0.5 percent. If necessary, the aggregate shall be allowed to cool until the temperature is not less than 52 °C or more than 80 °C before mixing with cut-back asphalt, unless otherwise specified by the Engineer.

(i) **Type SM-2, SM-3, IM-1, BM-2 and BM-3** asphalt mixtures may be designated (M) for modified, (S) for stabilized, or (M) or (S) for Contractor's option.

1. **Type (M)** asphalt mixtures shall consist of SM-2A, SM-3A, IM-1A, BM-2, or BM-3 mixes incorporating a modified asphalt cement meeting the following criteria:

Penetration, 25 °C, 100 g, 5 sec	Min. 40, max. 75
Viscosity, 60 °C, poises	Min. 6000
Softening point, R & B, C	Min. 60°
Flash point, C	Min. 232°
Solubility, %	Min. 99
RTFOT residue, elastic	
Recovery, 25 °C, %	Min. 50
Penetration, 4 °C, 200 g, 60 sec	Min. 13

Modified mixtures shall be designated with an (M) following the standard mix designations SM-3A(M), IM-1A(M), BM-2(M), and BM-3(M). B and C mixes shall not be modified.

2. **Type (S)** mixes shall consist of SM-2A, SM-3A, IM-1A, BM-2, and BM-3 mixes incorporating a stabilizing additive from the Department's approved list. These mixes shall be designated with an (S) following the standard mix designations SM-2A(S), SM-3A(S), IM-1A(S), SM-2(S), and SM-3(S). The minimum required additive shall be as specified on the approved list.

211.05—Testing.

The Contractor shall provide the quality assurance necessary for the Department to determine conformance with the required grading, asphalt content, and temperature properties for asphalt concrete.

The Contractor shall have a certified Asphalt Concrete Technician present at the plant during initial set-up and subsequent production and shall utilize such Technician for sampling, testing, designing, and adjusting mixes as necessary. The certified Asphalt Concrete Technician is that person who is capable of designing and making necessary adjustments in the asphalt concrete mixes at the mixing plant. The Technician shall be capable of sampling the material and conducting any tests necessary to put the plant into operation and to produce a mixture within the requirements of these specifications. Certification will be awarded by the Department upon satisfactory completion of an examination.

The Contractor shall maintain all records and test results associated with the material production and shall maintain appropriate current quality control charts. All test results and control charts shall be available for review by the Engineer.

The Contractor shall execute a quality control plan of process inspections and tests, including the determination of Marshall properties. The results of the Marshall tests shall be used, along with the results of other quality control efforts, to control the quality of the mixture being produced.

The Contractor shall perform at least one field Marshall test per day per mix or per 1000 metric tons per mix if more than 1000 metric tons of a mix is produced per day. In the event less than 300 metric tons of asphalt mixture is produced under a single job mix formula in a day, field Marshall testing will not be required. This tonnage shall be added to subsequent production. When the accumulated tonnage exceeds 300 metric tons, minimum testing frequency shall apply. Field Marshall test results shall be plotted and displayed in control chart form in the plant immediately following the completion of each individual test. The tests shall determine asphalt content in percent (nearest 0.1 percent), VTM in percent (nearest 0.1 percent), VMA in percent (nearest 0.1 percent), and VFA in percent (nearest 1.0 percent).

TABLE II-14

Design Range: Asphalt Concrete Mixtures

	% by Mass Passing Square Mesh Sieves										
Type	**50 mm**	**37.5 mm**	**25.0 mm**	**19.0 mm**	**12.5 mm**	**9.5 mm**	**4.75 mm**	**2.36 mm**	**600 μm**	**300 μm**	**75 μm**
SM-1					100	94-100	65-85		20-40	9-25	4-8
SM-2 A-B-C				100	97-100	82-94	48-62		18-24		4-7
SM-3 A-B-C			100	97-10	72-86		40-58		14-24		3-6
IM-1 A-B			100-97	72-86		40-58		14-24		3-6	
BM-1			100	85-98			60-80			20-30	1-6
BM-2		100	97-100	75-90		54-74		30-38			3-6
BM-3	100	97-100	70-86		46-64		26-44		8-18		2-5
C					100	92-100	70-75	50-60	28-36	15-20	7-9
P					100	95-100	35-50	Max 20	Max 10		Max 3

Legend: SM = Surface Mixture; IM = Intermediate Mixture; BM = Base Mixture; C = Curb Mixture; P = Patching Mixture.

211.06—Tests.

The Department may sample materials entering into the composition of the asphalt concrete, sample the mixture, or sample the completed pavement. The Contractor shall cooperate with the Engineer in obtaining these samples. When samples are obtained from the pavement, the resulting voids shall be filled and refinished by the Contractor without additional compensation.

The asphalt cement, when extracted and recovered in accordance with the requirements of AASHTO T170, shall have a recovered penetration at 25 °C of not less than 35 and a ductility at 25 °C of not less than 40 centimeters.

211.07—Plant Inspection.

The preparation of asphalt concrete mixtures will be accepted by a quality assurance plan. The Contractor shall provide a laboratory as specified in Section 106.07.

211.08—Acceptance.

Acceptance shall be made under the Department's quality assurance program, which includes the testing of production samples by the Contractor and monitor samples by the Department. Sampling and testing for the determination of grading, asphalt cement content, and temperature shall be performed by the Contractor, and the Department will perform independent monitor checks at a laboratory of its discretion. The Contractor shall provide copies of such test results to the Department on forms furnished by the Department. In the event the Contractor's test results indicate that the mixture conforms to the gradation, asphalt cement content, and mix temperature requirements, the mixture will be acceptable for these properties; however, nothing herein shall be construed as waiving the requirements of Sections 106.06, 200.02, and 200.03 or relieving the Contractor of the obligation to furnish and install a finished functional product that conforms to the requirements of the Contract. In the event a statistical comparative analysis of the Contractor's test results and the Department's monitor tests indicate a statistically significant difference in the results and either of the results indicate that the material does not conform to the grading and asphalt cement content requirements, an investigation will be made to determine the reason for the difference. In the event it is determined from the investigation that the material does not conform to the requirements of the Contract, price adjustments will be made in accordance with Section 211.09.

Acceptance for gradation and asphalt cement content will be based upon a mean of the results of four tests performed on samples taken in a stratified random manner from each 2,000 metric ton lot (4,000 metric ton lots may be used when the normal daily production of the source from which the material

is being obtained is in excess of 2,000 metric tons). Unless otherwise approved, samples shall be obtained from the approximate center of randomly selected quadrants of truck loads of material. Any statistically acceptable method of randomization may be used to determine the time and location of the stratified random sample to be taken; however, the Department shall be advised of the method to be used prior to beginning production.

A lot will be considered to be acceptable for gradation and asphalt content if the mean of the test results obtained is within the tolerance allowed from the job-mix formula, as shown in Table II-15.

The temperature of the mixture at the plant shall be controlled to provide load to load uniformity during changing weather conditions and surface temperatures; however, the maximum temperature of the mixture shall not exceed 162 °C. The temperature of the mixture at the time of placement in the road shall be not less than 120 °C.

In the event the job-mix formula is modified within a lot, the mean test results of the samples taken will be compared to the applicable process tolerance shown in Table II-15.

TABLE II-15
Process Tolerance on Each Laboratory Sieve and Asphalt Content (%)

No. Tests	Top Size	3.75 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	600 µm	300 µm	75 µm	AC[1]
1	0.0	±8.0	±8.0	±8.0	±8.0	±8.0	±8.0	±8.0	±6.0	±5.0	±2.0	±.60
2	0.0	±5.7	±5.7	±5.7	±5.7	±5.7	±5.7	±5.7	±4.3	±3.6	±1.4	±.43
3	0.0	±4.4	±4.4	±4.4	±4.4	±4.4	±4.4	±4.4	±3.3	±2.8	±1.1	±.33
4	0.0	±4.0	±4.0	±4.0	±4.0	±4.0	±4.0	±4.0	±3.0	±2.5	±1.0	±.30
8	0.0	±2.8	±2.8	±2.8	±2.8	±2.8	±2.8	±2.8	±2.1	±1.8	±0.7	±.21

[1]Asphalt content will be measured as extractable asphalt.

Field Marshall tests will be performed by the Department in accordance with the requirements of VTM-58 during the production of the approved job-mixes designed by the Marshall method. Should any field Marshall test fail to meet the limits specified in Section 211.03(c) the Department may require that production be stopped until necessary corrective action is taken by the Contractor.

Should visual examination by the Engineer reveal that the material in any load, or portion of the paved roadway, is obviously contaminated or segregated, that load, or portion of the paved roadway, will be rejected without additional sampling or testing of the lot. In the event it is necessary to determine the gradation or asphalt content of the material in any load, or portion of the paved roadway, samples will be taken and tested, and the results compared to the requirements of the approved job-mix formula. The results obtained in the testing will apply only to the material in question.

211.09—Adjustment System.

In the event a lot of material does not conform to the acceptance requirements of Section 211.08, adjustment points will be determined as follows:

Sieve	Adjustment Points for Each 1% That the Gradation Is Outside the Process Tolerance Permitted in Table II-14
50 mm	1
37.5 mm	1
25.0 mm	1
19.0 mm	1
12.5 mm	1
9.5 mm	1
4.75 mm	1
2.36 mm	1
600 µm	2
300 µm	2
75 µm	3

One adjustment will be applied for each 0.1 percent that the material is out of the process tolerance for asphalt content.

In the event the total adjustment for a lot is greater than 25 points, the failing material shall be removed from the road. In the event the total adjustment is 25 points or less and the Contractor does not elect to remove and replace the material, the unit price for the material will be reduced 1 percent of the unit price bid for each adjustment point. The adjustment will be applied to the tonnage represented by the sample or samples. In the event adjustment points are applied against 3 successive lots, plant adjustment shall be made prior to continuing production.

The Contractor shall control the variability of his product in order to furnish a uniform mix. When the quantity of any one type of material furnished to a project exceeds 4000 metric tons, the variability of the total quantity furnished

will be determined on the basis of the standard deviation for each sieve size and the asphalt content. In the event the standard deviation is within the ranges shown in Table II-16, the unit bid price for the material will be adjusted as indicated hereinafter. Adjustments for standard deviation computations will not be made on more than two job-mixes for the same type of material.

The unit bid price will be reduced by 0.5 percent for each adjustment point applied for the standard deviation.

The disposition of material having standard deviations larger than those shown in Table II-16 will be determined by the Engineer.

211.10—Referee System.

(a) In the event the test results obtained from one of the four samples taken to evaluate a particular lot appear to be questionable, the Contractor may request in writing that the results of the questionable sample be disregarded. The Contractor shall then perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. In the event the Engineer determines that one of the four tests results appears to be questionable, the Department will perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. The test results of the three original (unquestioned) samples will be averaged with test results of the five road samples and the mean of the test values obtained for the eight total samples will be compared to the requirements for the mean of eight tests as shown in Table II-15.

(b) In the event the Contractor questions the mean of the four original test results obtained for a particular lot, the Contractor may request in writing approval to perform additional testing of that lot. In the event the Engineer determines that the mean of the four original test results is questionable, the Department will perform additional testing of that lot. The test results of the original four samples will be averaged with the test results of the four additional samples taken from randomly selected locations in the roadway where the lot was placed, and the mean of test values obtained for the eight total samples will be compared to the requirements for the mean result of eight tests as shown in Table II-15.

If the Contractor requests additional tests, as described in (a) or (b) herein, the Contractor shall sample and test the material in accordance with Department-approved procedures. The Engineer reserves the right to observe the sampling and testing.

In the event the mean of the test values obtained for the eight total samples conforms to the requirements for the mean results of eight tests, the material will be considered acceptable. In the event the mean of the test values obtained for the eight samples does not conform to the requirements for the mean result of eight tests, the lot will be adjusted in accordance with the adjustment rate specified in Section 211.09.

Samples of the size shown herein shall be saw cut by the Contractor, without the use of liquids, for testing by the Department.

Application Rate	Minimum Sample Size
75 kg/m^2	200 by 200 mm
100 kg/m^2	185 by 185 mm
125 kg/m^2	165 by 165 mm
175 kg/m^2	130 by 130 mm

TABLE II-16
Standard Deviation

Sieve & AC[1]	Standard Deviation 1 Adjustment Point For Each Sieve Size & AC	2 Adjustment Points For Each Sieve Size & AC	3 Adjustment Points For Each Sieve Size & AC
12.5 mm	3.8-4.7	4.8-5.7	5.8-6.7
9.5 mm	3.8-4.7	4.8-5.7	5.8-6.7
4.25 mm	3.8-4.7	4.8-5.7	5.8-6.7
2.36 mm	3.0-3.9	4.0-4.9	5.0-5.9
600 µm	2.2-3.1	3.2-4.1	4.2-5.1
300 µm	1.5-2.4	2.5-3.4	3.5-4.4
75 µm	1.1-2.0	2.1-3.0	3.1-4.0
AC	0.27-0.36	0.37-0.46	0.47-0.56

[1]AC = Asphalt content.

211.11—Handling and Storing Aggregates.

Aggregates shall be handled, hauled, and stored in a manner that will minimize segregation and avoid contamination. Aggregates shall be stockpiled in the vicinity of the plant and on ground that is denuded of vegetation, hard and well drained, or otherwise prepared to protect the aggregate from contamination. Placing aggregate directly from the crusher bins into the cold feed may be permitted, provided the material is consistent in gradation. When different size aggregates are stockpiled, the stockpiles shall be positively separated.

211.12—Asphalt Concrete Mixing Plant.

Plants used for the preparation of asphalt concrete mixtures shall conform to the following requirements:

(a) **Plant Scales:** Scales shall be approved in accordance with the requirements of Section 109.01.

(b) **Drier:** The plant shall include a drier or driers that continuously agitate the aggregate during the heating and drying process. The aggregate shall be dried to a point at which the moisture content of the completed mixture does not exceed 1 percent as determined from samples taken at the point of discharge from the mixing operation.

(c) **Feeder for Drier:** The plant shall be equipped with accurate mechanical means for uniformly feeding the aggregate into the drier so that uniform production and uniform temperature will be obtained. Where different size aggregates are required to meet grading specifications, they must be proportioned by feeding into the cold elevator through a multiple compartment feeder bin (one bin for each size used) equipped with positive action gates that can be securely locked to maintain desired proportioning.

(d) **Bins:** When bins are used, adequate and convenient facilities shall be provided to make possible the sampling of representative aggregate material for each bin. Each compartment shall be provided with an overflow pipe of such size and at such location to prevent contamination of the aggregate in adjacent compartments and shall be provided with individual outlet gates that, when closed, will allow no leakage.

(e) **Thermometric Equipment:** The plant shall be equipped with an approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate or the completed mix if the drier drum mixing plant is used.

An approved thermometric device shall be fixed in the asphalt feed line at a suitable location near the charging valve at the mixer unit.

All thermometric devices shall be maintained in good working condition and shall be subject to checking by the laboratory thermometer. Any instruments that do not operate or register properly shall be removed, repaired, or replaced.

(f) **Pollution control:** Pollution control shall conform to the requirements of Section 107.14.

(g) **Equipment for Preparation of Asphalt Material:** Tanks for the storage of asphalt material shall be equipped with a heating system capable of heating and holding the material at the required temperatures. The heating system shall be designed to heat the contents of the tank by means of steam, electricity, or other approved means so that no flame is in contact with the heating surface of the tank. The circulating system for the asphalt material shall be designed to assure proper and continuous circulation during the operating period and to minimize oxidation. All pipe lines shall be steam jacketed or insulated to prevent undue loss of heat. Storage facilities for asphalt material shall be sufficient for at least one day's operation or an equivalent means of supply shall be provided that will assure continuous operation. Provisions shall be made for measuring and sampling storage tanks. When asphalt material is proportioned by volume, the temperature of the asphalt material in storage shall be maintained uniform (±10 °C) during operation of the plant by means of an approved automatic temperature control device.

(h) **Asphalt Control:** Asphalt material shall be accurately proportioned by volume or mass. When volumetric methods are used, measurements shall be made by means of approved meters or pumps, calibrated for accuracy. The section of the asphalt line between the charging valve and the spray bar shall be provided with an outlet valve for checking the meter.

When proportioned by mass, the asphalt material shall have its mass determined on approved scales. Dial scales shall have a capacity of not more than 15 percent of the capacity of the mixer. The value of the minimum graduation shall be not greater than 1 kilogram.

Except when a drier-drum mixing plant is used, the asphalt material bucket, its valves, and its spray bar shall be steam jacketed or heated by other approved means. The bucket shall have a capacity of at least 115 percent of the mass of the asphalt material required in any mixture and shall be supported by fulcrums.

The asphalt shall be delivered to the mixer in uniform, multiple streams for the full width of the mixer.

(i) **Proportioning Aggregates:** Mineral filler and any bag house fines the Contractor uses shall be metered or introduced by means of an approved device for uniform proportioning by mass or by volume.

The mass determining hopper shall be of sufficient size to hold the maximum required mass of aggregate for one batch without hand raking or running over. Sufficient clearance between the mass determining hopper and supporting devices shall be provided to prevent accumulation of foreign materials.

The discharge gate of the mass determining hopper shall be situated in such a manner that the aggregates will not segregate when dumped into the mixer. Gates on the bins and mass determining hopper shall be constructed to prevent leakage when closed.

(j) **Drum Mixer:** The aggregate shall be proportioned by a positive mass determining control at the cold aggregate feed by use of a belt scale that will automatically regulate the supply of material being fed and permit instant correction of variations in load. The cold feed flow shall be automatically coupled with the asphalt flow to maintain the required proportions.

(k) **Batch Mixer:** The batch mixer shall be of a twin pugmill or other approved type, steam jacketed or heated by other approved means, and capable of producing uniform mixtures within the specified tolerances. It shall be equipped with a sufficient number of paddles or blades, operated at such speeds as to produce a properly and uniformly mixed batch. The number and arrangement of the mixer paddles shall be subject to the approval of the Engineer. Badly worn or defective blades shall not be used in mixing operations.

The mixer shall be provided with an approved time lock that will lock the discharge gate after the aggregates and asphalt have been placed in the mixer and will not release the gate until the specified time has elapsed.

Batch type mixing plants used to produce asphalt concrete shall be equipped with approved automatic proportioning devices. Such devices shall include equipment for accurately proportioning batches of the various components of the mixture by mass or volume in the proper sequence and for controlling the sequence and timing of mixing operations. The automated system shall be designed to interrupt and stop the batching operation at any time batch quantities are not satisfied for each of the materials. A means shall be provided for observing the mass determination of each material during the batching operation.

The aggregate may be proportioned by cold feed controls in lieu of plant screens provided the cold aggregate feed meets the requirements specified in Section 211.12(j).

Should the automatic proportioning devices become inoperative, the plant may be allowed to batch and mix asphalt materials for a period of not more than 48 hours from the time the breakdown occurs provided alternate proportioning facilities are approved by the Engineer. Written permission of the Engineer will be required for

operation without automatic proportioning facilities for periods longer than 48 hours.

(l) **Continuous Mixing Plant:** A continuous mixing plant shall include a means for accurately proportioning each size of aggregate by either mass or volume. When gradation control is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each respective bin compartment. The orifice shall be rectangular, with one dimension adjustable by positive mechanical means, and shall be provided with a lock. Indicators shall be provided to show the individual gate opening in millimeters. The plant shall be equipped with a satisfactory revolution counter.

The plant shall include a means for calibrating gate openings by mass. The materials fed out of the bins through individual orifices shall be bypassed to a suitable test box, with each component material confined in a separate section. The plant shall be equipped to conveniently handle test samples having masses up to 100 kilograms per bin, and accurate platform scales shall be provided for this purpose.

Positive interlocking control shall be provided between the flow of aggregate from the bins and the flow of asphalt material from the meter or other proportioning device. This shall be accomplished by approved interlocking devices or other approved positive means.

Accurate control of the asphalt material shall be obtained by determining mass, metering, or volumetric measurement.

The aggregate may be proportioned by cold feed controls in lieu of plant screens provided the cold aggregate feed meets the requirements specified in Section 211.12(j).

The plant shall include a continuous mixer of an approved type that is steam jacketed or heated by other approved means. The paddles shall be of an adjustable type for angular position on the shafts and reversible to retard the flow of the mixture.

There shall be interlock cutoff circuits to interrupt and to stop the proportioning and mixing operations when the aggregate level in the plant or the asphalt material in storage falls below that necessary to produce the specified mixture.

(m) **Trucks, Truck Scales, and Automatic Printer System:** These shall conform to the requirements of Section 109.01.

211.13—Preparation of Mixture.

The asphalt and aggregate shall be introduced into the mixer at a temperature that will produce a mixture within the requirements of the job-mix formula; however, in no case shall the temperature of the asphalt material exceed 175 °C at the time of introduction into the mixer.

After the required amounts of aggregate and asphalt material have been introduced into the mixer, the materials shall be mixed until a uniform coating of asphalt and a thorough distribution of the aggregate throughout the mixture are secured within the requirements of the Ross count procedure described in AASHTO T195. Wet mixing time, based on the procedures of AASHTO T195, shall be determined by the Contractor at the beginning of production and approved by the Engineer for each individual plant or mixer and for each type of aggregate used; however, in no case shall the wet mixing time be less than 20 seconds. The wet mixing time is the interval of time between the start of introduction of the asphalt material into the mixer and the opening of the discharge gate. A wet mixing time that will result in fully coating a minimum of 95 percent of the coarse particles, based on the average of the 3 samples, and provided that none of the 3 samples result in fully coating less than 92 percent of the coarse particles, shall be the minimum wet mixing time requirement. A dry mixing time of up to 15 seconds may be required by the Engineer to accomplish the degree of aggregate distribution necessary to obtain complete and uniform coating of the aggregate with asphalt.

During production of asphalt concrete, normal acceptance samples will be used to determine F/A. If the average F/A of four tests (representing the lot), exceeds the specified F/A ratio, the Contractor shall cease production until changes have been made to comply with the approved mix design requirements.

211.14—Storage System.

In the event the Contractor elects to use a storage system, the system shall be capable of conveying the mix from the plant to the storage bins and storing the mix without a loss in temperature, segregation, or oxidation of the mix. Storage time shall be limited by the ability of the bins to maintain the mix within the quality requirements specified herein with a maximum time limit not to exceed 10 days. Material may be stored in bins for no more than 24 hours without an approved heating system.

The conveyor system may be a continuous type or skip bucket type. Continuous type conveyors shall be enclosed so that the mix temperature is maintained.

The storage bins shall be designed in such a manner as to prevent segregation of the mix during discharge from the conveyor into the bins and shall be equipped

with discharge gates that will not cause segregation of the mix while loading the mix into the trucks.

Approval for the use of storage bins may be withdrawn by the Engineer in the event there is an excessive amount of heat loss, segregation, or oxidation of the mix.

SECTION 212—JOINT MATERIALS

212.01—Description.

These specifications cover resilient products made from various materials that are designed to accommodate the movement of rigid structures, such as component parts of hydraulic cement concrete, and seal the joint from intrusion of water or incompressibles.

212.02—Detail Requirements.

(a) **Hot-poured joint sealer** shall be heated in accordance with the manufacturer's recommendations.

1. **Asphalt sealer** shall conform to the requirements of FS SS-S-1401 or AASHTO M173, with the following modifications:

   a. The temperature of the air bath during the bond test shall be -29° ± 1.6 °C.

   b. Asphalt sealer shall have a ductility of at least 400 millimeters at 25 °C when tested in accordance with the requirements of AASHTO T51.

   c. Material shall not have a flow of more than 10 millimeters.

   d. Hot-poured asphalt joint sealer shall be used only for longitudinal joints or crack sealing in concrete pavements.

2. **Elastomeric joint sealer** shall conform to the requirements of ASTM D3406 and shall be used only for longitudinal joints.

(b) **Silicone sealants** shall be furnished in a one-part silicone formulation. The sealant shall be compatible with the surface to which it is applied. Acid cure sealants are not acceptable for use on hydraulic cement concrete.

Silicone sealants will be identified in the following manner:

Class A: A low modulus non-sag silicone for use in sealing horizontal and vertical joints in hydraulic concrete pavements and structures. Tooling is required.

Class B: A very low modulus self-leveling silicone used to seal horizontal joints in hydraulic cement concrete pavements and structures. Tooling is not normally required.

Class C: An ultra low modulus self-leveling silicone used to seal horizontal joints in hydraulic cement concrete pavements and structures. It can also be used to seal the joints between hydraulic cement concrete pavement and asphaltic concrete shoulders. Tooling is not normally required.

Silicone sealants shall conform to the following physical requirements:

Properties	Test Method	Sealant Class		
		A	B	C
Tensile stress at 150% strain (Max. kPa) (Note 1)	ASTM C1135	310	275	100
Shore durometer hardness (0° and 25° ± 3 °C) (Note 1)	ASTM D-2240	"A" 10-25	"00" 40-80	"00" 20-80
Bond to concrete mortar (Min. kPa) (Note 1) (Note 3)	VTM-90	340	275	240
Tack free time (skin-over) (Max. minutes) (Note 2)	VTM-90 (Note 4)	180	180	180
Extrusion rate (Min. grams/minute)	VTM-90	75	90	100
Non-volatile (Min. %)	VTM-90	90	90	90
Specific gravity	ASTM D-792 (Method A)	1.1-1.5	1.1-1.5	1.1-1.5
Shelf life (from date of shipment)		6 months		
Movement capability and adhesion (Note 1)	VTM-90	No adhesive or cohesive failure after 10 cycles at -18 °C		
Ozone and UV resistance (Note 1)	ASTM C793-75	No chalking, cracking, or bond loss after 5,000 hours		

Note 1: The cure time for these specimens shall be 21 days for Class A and 28 days for Classes B and C. Specimens shall be cured at 25° ± 1.6 °C percent relative humidity.

Note 2: At conditions of 25° ± 1.6 °C and 50 ± 5 percent relative humidity.

Note 3: Class C silicone shall also attain its bond strength requirement to asphalt concrete.

Note 4: In cases of dispute, ASTM D-2377 shall be used as a referee test. The exposure period under Section 7, Procedure, shall be the tack free time requirement of this specification.

Bond breakers shall be chemically inert and resistant to petroleum products, solvents, and primers. The bond breaker shall not stain or adhere to the sealant. Bond breakers shall be either a backer rod or tape identified and used in accordance with the following:

1. **Backer rods:**

Type L: A closed-cell expanded polyethylene foam backer rod. This backer rod may be used with Class A silicone only and is suitable for roadway and structure joints.

Type M: A closed-cell polyolefin foam backer rod that has a closed-cell skin over an open-cell core. This backer rod may be used with all three types of sealants and is suitable for use in roadway and structure joints.

Backer rods shall conform to the following requirements:

Density (ASTM D-1622)	Min. 30 kg/m^3
Tensile strength (ASTM D-1623)	Min. 170 kPa
Water absorption (ASTM C-509)	Max. 0.5% by volume

2. **Bond breaking tapes:**

Type N: Bond breaking tape shall be made from extruded polyethylene and shall have a pressure-sensitive adhesive on one side. Bond breaking tapes may be used with all three types of sealants but are suitable for structure joints only.

Bond breaking tapes shall be no less than 125 micrometers.

The manufacturer of the joint sealant shall furnish certified test results on each lot of sealant furnished to a project. The certified test results must include all test results except the bond to concrete mortar and shore durometer hardness at -18 °C.

Only those silicone sealants that appear on the latest approved products listing published by the Department's Materials Division will be permitted for use.

Silicone sealants submitted for initial approval and conforming to the material requirements of this specification will not be approved until field evaluations are made. The material shall be installed in roadway or bridge joints and shall go through two winters without failure before being approved. After approval, material will be placed on the Department's approved products list.

Even though a sealant or bond breaker has been evaluated and approved, failure to perform adequately in actual use will be just cause for rejection.

(c) **Preformed asphalt joint filler** shall conform to the requirements of AASHTO M213.

(d) **Expanded rubber joint filler** shall conform to the requirements of ASTM D1056.

(e) **Preformed neoprene (polychloroprene) seals** shall conform to the requirements of ASTM D1056, Grade 2B3 (Mod). Modification requires that material be manufactured from neoprene.

(f) **PVC and PE joint fillers** shall conform to the requirements of ASTM D1667. Grades VE-43 BL to VE-45 BL shall be furnished. Adhesives for use with this material shall be as recommended by the manufacturer.

(g) **Sponge rubber joint filler** shall conform to the requirements of AASHTO M153, Type I. When used in conjunction with bridge bearings, the load required to compress the test specimen to 50 percent of its thickness before the test shall be not more than 700 kilopascals.

(h) **Gaskets for pipe** shall conform to the following: Rubber gaskets for ductile iron pipe and fittings shall conform to the requirements of AWWA C111; for concrete sewer pipe shall conform to the requirements of ASTM C443; and for other pipe shall conform to the requirements of AASHTO M198, Type A, and Section 237.

Preformed plastic gaskets shall conform to the requirements of AASHTO M198, Type B.

(i) **Preformed elastomeric joint sealer** shall be a vulcanized elastomeric compound in which noncrystallizing neoprene is used as the sole polymer. Sealer shall be resilient and resistant to heat, oil, and ozone.

The seal shall conform to the following as evidenced by samples cut from the finished product:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	Min. 14 MPa
Elongation at break	ASTM D412	Min. 250%
Hardness (durometer, Shore A)	ASTM D2240	55 ± 5
Oven aging (70 hr/100 °C)		
Tensile strength (change)	ASTM D573	Max. -30%
Elongation (change)		Max. -40%
Hardness (points change)		Max. +10
Ozone resistance (20% strain, 100 MPa in air, 300 hr/40 °C) (wipe with solvent to remove surface contamination)	ASTM D1149	No cracks
High temperature recovery (72 hr/100 °C under 50% deflection)	VTM-3	85% (no web adhesion or cracks)
Low temperature recovery (72 hr/-10 °C under 50% deflection)	VTM-3	87%
Low temperature recovery (22 hr/-29 °C under 50% deflection)	VTM-3	82%

When tested at a temperature of 21° ± 3 °C, the seal shall also conform to the following:

Use	Deflection Based on Nominal Width (%)	Pressure (kPa)
Pavement	20	Min. 20
	50	Max. 100
Structure	20	Min. 25
	50	Max. 275

After aging at 100 °C for 70 hours at 50 percent deflection, the seal shall conform to the following:

Use	Deflection Based on Nominal Width (%)	Pressure (kPa)
Pavement	20	Min. 7
	50	Max. 100
Structure	20	Min. 10
	50	Max. 275

Lubricant adhesive shall be a one-component polyurethane compound with an aromatic hydrocarbon solvent and shall conform to the physical properties of ASTM D4070.

Lubricant for pavement seals shall conform to the requirements of ASTM D2835.

(j) **Elastomeric Expansion Dam and Tooth Expansion Joint:** The elastomeric sheet gland material shall be virgin ethylene propylene diene monomer (EPDM) or virgin polychloroprene. The elastomeric material shall have the following physical properties:

Property	Test Procedures	Physical Properties
Tensile strength	ASTM D412	Min. 10 MPa
Elongation at break	ASTM D412	Min. 175%
Low temperature brittleness	ASTM D746	Not brittle at 40 °C
Oil deterioration (no requirement for EPDM material): Volume increase after 70 hr immersion in ASTM No. 3 oil at 100 °C	ASTM D471	Max. 120%
Ozone resistance: Exposure to 100 MPa ozone in air for 70 hr at 40 °C under 20% strain	ASTM D1149	No cracks
Hardness, durometer A	ASTM D2240	50-60

The elastomeric strip seal gland material shall be preformed non-reinforced polychloroprene and shall have the following properties:

Property	Test Procedures	Physical Properties
Tensile strength	ASTM D412	Min. 14 MPa
Elongation at break	ASTM D412	Min. 250%
Hardness, durometer A, points	ASTM D2240 (Modified)[A,C]	60 ± 5
Oven aging, 70 hr at (100 °C)	ASTM D573	
Tensile strength, loss,		Max. 20%
Elongation, loss		Max. 20%
Hardness, durometer A, points	ASTM D2240 (Modified)[A,C]	0 to +10
Oil swell, ASTM No. 3 oil, 70 hr at 100 °C, mass change	ASTM D471	Max. 45%
Ozone resistance 20% strain, 300 MPa in air, 70 hr at 40 °C	ASTM D1149 (Modified)[B]	No cracks
Low temperature stiffening, 7 days at -10 °C Hardness, durometer A, points change	ASTM D2240 (Modified)[A,C]	0 to +15
Compression set, 70 hr at 100 °C	ASTM D395 Method B (Modified)[A]	Max. 40%

[A] The term "modified" in the table relates to the specimen preparation. The use of the strip seal as the specimen source requires that more plies than specified in either of the modified test procedures be used. Such specimen modification shall be agreed upon by the purchaser and producer or supplier prior to testing.

[B] Test in accordance with Procedure A of D518.

[C] The hardness test shall be made with the durometer in a durometer stand as recommended in Method D2240.

The steel portion of expansion dams shall conform to the requirements of ASTM A709M, Grade 250.

Deformed reinforcing steel bars shall conform to the requirements of ASTM A615M, Grade 400.

Lubricant adhesive shall be a one-part moisture curing polyurethane compound conforming to the requirements of ASTM D4070.

Fabric reinforcement shall be nonwicking woven polyester material.

Bolts, nuts, and washers shall conform to the requirements of ASTM A276, Type 304 Stainless Steel.

Flathead screws shall conform to the requirements of ASTM F 738, Type 304 Stainless Steel.

Stud anchors shall conform to the requirements of Section 226.02(e).

Special conditions such as doglegs, tees, and crosses in the elastomeric strip seal gland shall be shop fabricated in a mold under heat and pressure.

(k) **Pressure relief joint material** shall conform to the requirements of ASTM D3204.

(l) **Waterstops** shall conform to the following:

1. **Metal:** Sheet copper shall conform to the requirements of Section 230.

2. **Nonmetallic waterstops:** Nonmetallic waterstops shall be manufactured from neoprene or PVC. Manufacturer's shop splices shall be fully vulcanized.

   a. **Neoprene waterstops** shall be manufactured from a vulcanized elastomeric compound containing neoprene as the sole elastomer and shall conform to the following:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	Min. 14 MPa
Elongation at break	ASTM D412	Min. 300%
Ozone resistance (20% strain, 100 hr at 40 °C)	ASTM D1149 (except 100 ±20 MPa)	No cracks
Oil swell (ASTM No. 3 oil, 70 hr at 100 °C, volume change)	ASTM D471	Max. 80%

After accelerated aging in accordance with the requirements of ASTM D573 for 70 hours at 100 °C, the elastomer shall not show a change in tensile strength of more than 15 percent or a change in the elongation at break of more than 40 percent.

b. **PVC waterstops** shall be manufactured from PVC conforming to U.S. Corps of Engineers Specification CRD-C 572 and shall conform to the ozone resistance as required for neoprene waterstops. A certificate certifying compliance with the performance requirements specified under paragraph 6 of CRD-C 572 shall be furnished with the test sample supplied.

(m) **Traffic loop sealant material** shall be an epoxy-resin system, a polyester system, or rubberized asphalt designed specifically to conform to the physical properties for sealing traffic loop pavement cuts. The system shall bond to either hydraulic cement concrete or asphalt concrete, be unaffected by environmental conditions, and have a dielectric strength sufficient to allow the traffic loop to operate as intended. The viscosity of the mixture shall be such that the mixture is easily pourable into the saw slot and sufficiently flowable to encase the electrical wiring.

1. **The epoxy-resin system** shall be a two-component material conforming to the following based on the epoxy without sand, except for the cure time requirement:

Property	Test Procedures	Physical Requirements
Pot life at 25 °C	ASTM C881, Para. 11.2	Min. 12 minutes
Initial cure time at 25 °C with sand		Max. 60 minutes
Hardness, Shore D	ASTM D2240	25 to 65
Elongation	ASTM D638	Min. 50%
Water absorption (24 hr)	ASTM D570	Max. 0.5%
3% NaCl absorption (24 hr)	ASTM D570	Max. 0.5%
ASTM No. 3 oil absorption (24 hr)	ASTM D570	Max. 0.1%
Gasoline absorption (24 hr)	ASTM D570	Max. 1.0%

The sand used in the epoxy-resin system shall conform to the following grading requirements:

Sieve No.	% Passing
1.18 mm	100
600 µm	95 ± 5
150 µm	Max. 10
75 µm	Max. 3

2. **The polyester system** shall be a two-component material conforming to the following:

Property	Test Procedures	Physical Requirements
Pot life at 25 °C	ASTM C881, Para. 11.2	Min. 12 minutes
Initial cure time at 25 °C		Max. 45 minutes
Hardness, Shore D	ASTM D2240	25-65
Elongation	ASTM D638	Min. 15%
Water absorption (24 hr)	ASTM D570	Max. 0.2%
3% NaCl absorption (24 hr)	ASTM D570	Max. 0.2%
ASTM No. 3 oil absorption (24 hr)	ASTM D570	Max. 0.02%
Gasoline absorption (24 hr)	ASTM D570	Max. 0.8%

3. **Rubberized asphalt** (two-component) shall conform to the following:

Property	Test Procedures	Physical Requirements
Pot life at 25 °C		Min. 25 minutes
Initial cure time at 25 °C		Max. 60 minutes
Hardness, Shore A	ASTM D2240	Max. 20
Flow at 60 °C (5 hr)	ASTM D1851	No flow
Bond at -18 °C (3 cycles)	ASTM D1851	Min. 50% of original width
Water absorption (72 hr)		Max. 0.1%
ASTM No. 3 oil absorption (24 hr)		Max. 0.1%

SECTION 213—DAMP-PROOFING AND WATER-PROOFING MATERIALS

213.01—Description.

These specifications cover materials, generally asphalt based, that are intended to prevent or delay the passage of water, usually through a section of hydraulic cement concrete.

213.02—Detail Requirements.

(a) **Asphalt** shall conform to the requirements of ASTM D312, Type II. Where vertical or near vertical surfaces are encountered, asphalt shall conform to the requirements of ASTM D312, Type IV. Primer shall conform to the requirements of AASHTO M116.

(b) **Fabric** shall conform to the requirements of AASHTO M117. When cotton fabric is used, it shall be saturated with asphalt. Glass fiber shall conform to the requirements of ASTM D1668.

(c) **Joint sealers** for horizontal joints shall be an asphalt cement, viscosity grade AC-40, conforming to the requirements of Section 210. Sealers for vertical joints shall have fiber added, 20 percent by mass. Fiber and asphalt shall be mixed by the manufacturer to ensure a uniform mixture.

(d) **Membrane** shall conform to one of the following systems:

1. **System A:**

   a. **Primer:** The primer shall be reduced in a volatile solvent and shall be of suitable consistency for application by brush, roller, or spray without further dilution. The primer base shall be compatible with the membrane and shall be designated by the membrane manufacturer.

   b. **Membrane:** The membrane shall be a laminate formed with suitably plasticized coal tar and reinforced with nonwoven synthetic fibers or glass fibers. It shall be free from blemishes, discontinuities, or other defects. The membrane shall be supplied in rolls conforming to the following requirements:

Thickness (min.)	1.63 mm	
Pliability: 180° bend over 25-mm mandrel at -12 °C	No cracks	ASTM D146
Softening point	105 °C to 125 °C	ASTM D36 Modified
Mass (kg/m^2 min.)	2.2	

2. **System B:**

a. **Primer:** The primer shall be of a base compatible with the membrane and recommended by the membrane manufacturer. It shall be reduced in a volatile solvent for application by brush or roller without further dilution.

b. **Membrane:** The membrane shall be laminate of rubberized asphalt and reinforced with synthetic fibers or mesh. It shall be uniformly manufactured and free from blemishes, discontinuities, or other defects. The membrane shall be supplied in rolls having a nominal width of 900 milimeters or other widths as approved by the Engineer, and shall conform to the following requirements:

Thickness (min.)	1.63 mm	
Tensile strength (min.)	730 kN/m width	ASTM D882, Method A
Puncture resistance (mesh)	90 kg	ASTM D154
Pliability: 180° bend over 25-mm mandrel at -12 °C	No cracks	ASTM D146
Water vapor permeability	.10	ASTM E96, Method B

c. **Mastic:** The mastic shall be a cold-applied rubberized asphalt composition as designated by the manufacturer of the membrane.

3. **System C:**

a. **Primer:** The primer shall be of a synthetic rubber and resin base compatible with the membrane as recommended by the membrane manufacturer. It shall be reduced in a volatile organic solvent and shall be of suitable consistency for application by brush or roller with dilution.

b. **Membrane:** The membrane shall be a laminate of suitable plasticized asphalt, reinforced with open weave fiber glass mesh, and having a thin polyester top surface film. It shall be uniformly manufactured and free from blemishes, discontinuities, or other defects. The membrane shall conform to the following requirements:

Thickness	1.50 ± .025 mm	
Pliability: 180° bend over 25-mm mandrel at -12 °C	No cracks	ASTM D146
Softening point	Min. 115 °C	ASTM D36 Modified
Needle penetration 5 sec at 100 g	40 to 50 at 25 °C	ASTM D5
Mass per square meter	1.4 to 1.7 kg	

4. **System D:**

a. **Membrane:** The membrane shall be a liquid elastomeric membrane conforming to the following requirements:

Penetration	Max. 1.20 cm after 48 hr	ASTM D3583
Flow	No flow, 72 hr at 70 °C	ASTM D3583
Bond	6 mm separation, 3 cycles, -18 °C	ASTM D3583
Resilience	Min. 60 after 48 hr at 25 °C	ASTM D3583
Elongation	Min. 500%, 13 mm per minute at 25 °C	ASTM D3583
Pliability	No cracks when slowly bent at -12 °C over a 25-mm mandrel	ASTM D146

b. **Protective covering** shall be Type II asphalt roll roofing conforming to ASTM D224, except that it shall be manufactured without talc, mica, or dust on one side. Minor amounts of talc, mica, or dust deposited due to rolling for shipment will not be cause for rejection.

5. **System E:**

a. **Primer:** The surface conditioner shall be a cut-back type solvent conforming to ASTM D41, mixed in a ratio of one part primer to three parts white gasoline.

b. **Membrane:** The waterproof membrane shall be a single component, hot-applied, clay extended rubberized asphalt that, after cooling, shall form a monolithic flexible surface averaging 3 millimeters (125 mils) in thickness continuously bonded to the concrete substrate and shall conform to the following requirements:

Penetration	Max. 35 cm at 0 °C Max. 100 cm at 25 °C Max. 220 cm at 49 °C	ASTM D1191
Flow	None at 49 °C Max. .5 cm at 60 °C	ASTM D1191
Water vapor transmission	.10 gr. at 25 °C .016 gr. at 49 °C	ASTM E96
Water resistance	No blistering No emulsification No deterioration	ASTM D2939
Low temperature flexibility and adhesion	No delamination, cracking, or adhesion failure	Bend 3-mm thick membrane on aluminum 90° over 6-mm mandrel at -9 °C

6. **Protective covering** shall be 25-kilogram asphalt roll roofing without talc, mica, or dust on one side conforming to ASTM D224, Type II, except provisions pertaining to roofing applications are waived. The sheets shall be free from visible external defects such as holes, ragged or untrue edges, breaks, protuberances, or indentations.

SECTION 214—HYDRAULIC CEMENT

214.01—Description.

These specifications cover cements that harden when mixed with water. The various types have special characteristics to be used as denoted in other parts of these specifications.

214.02—Detail Requirements.

(a) **Blended hydraulic cement** shall conform to the requirements of AASHTO M240, Type I-P.

(b) **Portland cements** shall conform to the requirements of AASHTO M85 except as follows:

1. The SO_3 content as specified in ASTM C150 will be permitted provided the supporting data specified in ASTM C150 are submitted to the Department for review and acceptance prior to use of the material.

2. Neither Type I nor Type II cement shall contain more than 1.0 percent alkalies (% Na_2O + % $0.658K_2O$).

3. When Type II cement is used, a maximum of 65 percent C_3S will be permitted provided the combined amount of C_3S and C_3A is not more than 73 percent.

4. When Type III modified cement is used, the C_3A content of the cement shall be not more than 8 percent.

5. The SiO_2 content shall be at least 20 percent.

SECTION 215—HYDRAULIC CEMENT CONCRETE ADMIXTURES

215.01—Description.

These specifications cover materials that are chemical or organic elements that may be added to a concrete mixture, when permitted elsewhere in these specifications, to achieve some desired effect.

215.02—Materials.

(a) **Air-entraining admixtures** shall conform to the requirements of AASHTO M154.

(b) **Water-reducing and retarding admixtures** shall conform to the requirements of AASHTO M194, Type D, and shall be free from water-soluble chlorides.

Use of water-reducing and retarding admixtures that have not been tested for compatibility with the brand, type, source, and quantity of cement proposed for use will not be permitted until tests have been performed in accordance with the requirements of VTM 16 and the test results conform to the requirements of Table I therein.

(c) **Water-reducing admixtures** shall conform to the requirements of AASHTO M194, Type A, and shall be free from water-soluble chlorides.

(d) **Accelerating admixtures** shall conform to the requirements of AASHTO M194, Type C or E.

(e) **High-range water-reducing and high-range water-reducing and retarding admixtures** shall conform to the requirements of AASHTO M194, Type F or G, and shall be free from water-soluble chlorides.

(f) **Calcium chloride** shall conform to the requirements of AASHTO M144, Type S, Grade 3, Class A.

(g) **Fly ash** shall conform to the requirements of Section 241.

(h) **Granulated iron blast-furnace slag** shall conform to the requirements of ASTM C989, Grade 100 or 120.

(i) **Silica fume** shall conform to the requirements of AASHTO M307.

(j) **Corrosion inhibitor** shall be calcium nitrite solution with 30 percent solids or other approved material.

215.03—Detail Requirements.

Approved admixture(s) shall be used in concrete in the proportions recommended by the manufacturer to obtain the optimum effect where seasonal, atmospheric, or job conditions dictate its use.

Only admixtures (a) through (e) that appear on the Department's approved list shall be used. Initial approval will be based on independent laboratory data submitted by the manufacturer. Following initial approval of concrete admixtures, the manufacturer shall annually certify to the Engineer in writing that the material currently being furnished is identical in both composition and chemical concentrations with the material for which the laboratory tests were performed. If the Contractor proposes to use an admixture that differs in concentration from the acceptance sample, a certificate will be required from the manufacturer stating that the material is essentially the same in chemical composition as the approved mixture.

When placing concrete by pumping is authorized, the use of pump-aid admixtures approved by the Department will be allowed provided they are used in accordance with the manufacturer's recommendations.

SECTION 216—WATER FOR USE WITH CEMENT OR LIME

216.01—Description.

These specifications cover water for use in mixing with cement or lime.

216.02—Detail Requirements.

Water shall be clean, clear, and free from oil, acid, salt, alkali, organic matter, or other deleterious substances.

Water that has been approved for drinking purposes may be accepted without testing for use in hydraulic cement concrete, cement, or lime stabilization. Water from other sources and pumping methods shall be approved by the Engineer before use.

The acidity or alkalinity of water will be determined colorimetrically or electrometrically. Water shall have a pH between 4.5 and 8.5. When subjected to the mortar test in accordance with the requirements of AASHTO T26, water shall produce a mortar having a compressive strength of at least 90 percent of a mortar of the same design using distilled water.

Wash water from hydraulic cement concrete mixer operations will be permitted to be reused in the concrete mixture provided it is metered and is 25 percent

or less of the total water. A uniform amount of wash water shall be used in consecutive batches, with subsequent admixture rates adjusted accordingly to produce a workable concrete conforming to the specifications. Wash water shall conform to the acceptance criteria of ASTM C94, Tables 1 and 2.

SECTION 217—HYDRAULIC CEMENT CONCRETE

217.01—Description.

These specifications cover materials, design criteria, and mixing and testing procedures for hydraulic cement concrete.

217.02—Materials.

Hydraulic cement concrete shall consist of hydraulic cement, fine aggregate, coarse aggregate, water, and admixture(s) mixed in the approved proportions for the various classes of concrete by one of the methods designated hereinafter.

The Contractor shall be responsible for the quality control and condition of materials during handling, blending, and mixing operations and for the initial determination and necessary adjustments in the proportioning of materials used to produce the concrete.

(a) **Cement** shall conform to the requirements of Section 214 and shall be Type II with a maximum alkali content of 0.40 percent or Type I-P, unless otherwise permitted herein or otherwise specified in the Contract. Fly ash or granulated iron blast-furnace slag shall not be added to concrete when Type I-P cement is used. Fly ash, granulated iron blast-furnace slag, silica fume, or other approved mineral admixtures shall be used with Types I, II (if above 0.40 percent alkali content), or III cements as specified herein.

Types I, II, or III cements may be used with latex modified portland cement concrete.

Fly ash, Type F, shall replace 15 percent by mass of the design cement and have an additional 5 percent by mass of the design cement content added, which will be considered cementitious material. Additional fly ash will be considered aggregate.

Granulated iron blast-furnace slag shall replace from 35 percent to 50 percent by mass of the design cement content.

Silica fume shall replace a minimum of 7 percent by mass of the design cement content.

Other mineral admixtures shall be used in accordance with the requirements shown on the approved list of mineral admixtures.

(b) **Formulated latex modifier** shall be a nontoxic, film-forming, polymeric emulsion of which 90 percent of the nonvolatiles are styrenebutadiene polymers. It shall be homogeneous and uniform in composition and free from chlorides. Latex modifier shall conform to the chemical and physical properties specified hereinafter when tested in accordance with the requirements of FHWA's Report No. RD-78-35. Initial approval of the modifier will be based on an analysis of the results of tests performed by an independent laboratory. After initial acceptance, material will be accepted upon certification subject to periodic testing. A copy of the initial test report shall be submitted to the Department and shall show the following chemical and physical properties:

Property	Value
Butadiene content (%)	30-40
Solids (%)	46-53
pH	8.5-12
Coagulum (%)	Max. 0.10
Surface tension	Max. 500 Pa./ m
Particle size:	
Mean nm	140-250
Median nm	140-250
Distribution	Unimodal
95% range nm	Max. 200
Freeze-thaw stability (% coagulum after 2 cycles)	Max. 0.10
Concrete slump	Greater than standard
Concrete air content	Max. 9%
Time for 50% slump loss	±25% standard
Concrete compressive strength (24 hr and 28 days)	Min. 75% standard
Compressive strength loss (28-42 days)	Max. 20%
Concrete flexural strength (24 hr and 28 days)	Greater than standard

Flexural strength loss (28-42 days)	Max. 25%
Bond strength/slant shear (% monolithic latex concrete cylinder)	Min. 45
Deicer scaling (50 cycles)	
Median grading	Max. 3
Worst rated	Below 5
Chloride permeability (95% absorbed)	
2-13 mm (% Cl^-)	Max. 0.320
13-25 mm (% Cl^-)	Max. 0.064

Values for viscosity and density spectrographs of the solid portion and volatile portion shall be provided in the report.

(c) **Fine aggregate** shall conform to the requirements of Section 202 for Grading A.

(d) **Coarse aggregate** shall be stone, air-cooled blast-furnace slag, or gravel conforming to the requirements of Section 203 for the class of concrete being produced.

(e) **Water** shall conform to the requirements of Section 216.

(f) **Admixtures** shall conform to the requirements of Section 215.

(g) **White portland cement concrete** shall conform to the requirements herein except as follows:

1. **Cement** shall be white portland cement conforming to the requirements of Section 214 for Type I portland cement except that it shall not contain more than 0.55 percent by mass of Fe_2O_3.

2. **Fine aggregate** shall consist of clean, hard, durable, uncoated particles of quartz composed of at least 95 percent silica; shall be free from lumps of clay, soft or flaky material, loam, organic material, or other deleterious material; and shall conform to the requirements of Section 202. It shall not contain more than 3 percent inorganic silt by actual dry mass when tested in accordance with the requirements of AASHTO T11. Stone sands that produce an acceptable white concrete may also be used.

3. **Coarse aggregate** shall be crushed stone or crushed or uncrushed gravel conforming to the requirements of Section 203.

(h) **Fly ash** shall conform to the requirements of Section 241.

(i) **Granulated iron blast-furnace slag** shall conform to the requirements of Section 215.

(j) **Concrete to which a high-range water reducer is to be added** shall conform to the requirements of Table II-17. Concrete shall be mixed 70 to 100 revolutions at mixing speed.

(k) **Silica fume** shall conform to the requirements of Section 215.

217.03—Handling and Storing Materials.

(a) **Aggregate** shall be kept separated by size until batched. Aggregates shall be clean and shall be maintained in at least a saturated, surface-dry condition.

Fine aggregate that has been washed shall not be used within 24 hours after being placed in the stockpile or until surplus water has disappeared and the material has a consistent free moisture content. Stockpiles shall be located and constructed so that surplus water will drain from stockpiles and the batcher.

(b) **Cement** that is reclaimed or that shows evidence of hydration, such as lumps or cakes, shall not be used.

Loose cement shall be transported to the mixer either in tight compartments for each batch or between the fine and coarse aggregate. Cement in original shipping packages may be transported on top of the aggregates, with each batch containing the number of bags required.

(c) **Latex modifier** shall be kept in enclosures that will protect it from exposure to temperatures below 5 °C or above 30 °C. Containers of latex modifier shall be protected from direct sunlight.

(d) **Admixtures** shall be stored and handled so that contamination and deterioration will be prevented. Liquid admixtures shall not be used unless thoroughly agitated. Admixtures that are frozen or partially frozen shall not be used.

217.04—Measurement of Materials.

Measuring devices shall be subject to the approval of the Engineer.

(a) **Stationary Production Plant:**

1. **Cement** shall be measured by mass. Cement in standard packages need not have its mass determined, but bulk cement and fractional packages shall have their masses determined within an accuracy of 1 percent of mass.

2. **Mixing water** shall be measured by volume or mass. The water measuring device shall be readily adjustable and capable of delivering the required amount. Under all operating conditions, the device shall have an accuracy of within 1 percent of the quantity of water required for the batch.

3. **Aggregates** shall be measured by mass within an accuracy of 2 percent. Fine and coarse aggregate shall have their mass measured separately. Prior to mixing concrete, the moisture content of aggregates shall be determined and proper allowance made for the water content. The moisture content shall be determined prior to the start of mixing and thereafter as changes occur in the condition of aggregates. The Contractor shall perform moisture determinations and tests for slump and air content and provide necessary testing equipment.

4. **Admixtures** shall be added within a limit of accuracy of 3 percent and dispensed to the mixing water by means of an approved, graduated, transparent, measuring device before they are introduced into the mixer. If a high-range water reducer is to be used, it shall be added in accordance with the manufacturer's recommendations. If more than one admixture is to be used, they shall be released into the mixing water in sequence rather than at the same instant. Once established, the sequence of dispensing admixtures shall not be altered. Admixtures shall be used in accordance with the requirements of the manufacturer's recommendations. However, when the amount of admixture required to give the specified results deviates appreciably from the manufacturer's recommended dosage, use of the material shall be discontinued.

(b) **Mobile Production Plant:** Aggregates, cement, and water shall be measured by mass or volume. If ingredients are measured by volume, the Contractor shall furnish, at his expense, approved scales and containers suitable for checking the calibration of the equipment's measuring system. The manufacturer's recommendations shall be followed in operating the equipment and calibrating the gages and gate openings. Mixing water shall be measured by a calibrated flow meter. The introduction of mixing water to the mixer shall be properly coordinated with the introduction of cement and aggregates. Ingredients shall be proportioned within the following tolerances,

which are based on the volume/mass relationship established by calibration of the measuring devices:

Ingredients	Tolerance
Cement	0 to +4%
Fine aggregate	±2%
Coarse aggregate	±2%
Admixtures	±3%
Water	±1%

Tolerances will be applied to approved mixture design quantities.

Means shall be provided whereby samples of the various ingredients can be taken from the feed prior to blending and mixing to test the calibration of the equipment.

217.05—Equipment.

Equipment and tools necessary for handling materials and performing all parts of the work shall be as approved by the Engineer.

(a) **Batching Equipment:** Bins with separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Bins for bulk cement shall be arranged so that the cement mass is determined on a scale separate from those used for other materials and in a hopper free and independent of hoppers used for determining the mass of the aggregates. The cement hopper shall be properly sealed and vented to preclude dusting during operation. Each compartment shall be designed to discharge aggregate efficiently and freely into the mass determining hopper. A means of control shall be provided so that material may be added slowly and shut off with precision. A port or other opening shall be provided to remove any overrun of any of the several materials from the hopper used for determining masses. Mass determining hoppers shall be constructed to prevent accumulation of materials and to discharge fully.

Scales used for determining the mass of aggregates and cement shall be approved and sealed in accordance with the requirements of Section 109. At least ten 225 kilograms of test masses shall be available at each plant to verify the continued accuracy of the mass determining equipment. Masses shall be calibrated by the Virginia Department of Agriculture and Consumer Services or other approved agencies when new and whenever there is visible evidence that they have been damaged.

When beam scales are used, provision shall be made for indicating to the operator that the required load in the mass determining hopper is being approached. The indicator shall indicate at least the last 90 kilograms of load. Scales and indicating devices shall be in full view of the operator while the hopper is charged, and the operator shall have convenient access to all controls.

(b) **Mixers and Agitators:** Mixers may be stationary or truck mixers. Agitators may be truck mixers or truck agitators. Each mixer and agitator shall have a metal plate(s) attached in a prominent place by the manufacturer on which the following are marked: the various uses for which the equipment is designed, capacity of the drum or container in terms of the volume of mixed concrete, and speed of rotation of the mixing drum or blades. Each stationary mixer shall be equipped with an approved timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. Each truck mixer shall be equipped with an approved counter by which the number of revolutions of the drum or blades may be readily verified.

The mixer shall be capable of combining ingredients of concrete into a thoroughly mixed and uniform mass and of discharging concrete with a satisfactory degree of uniformity.

The agitator shall be capable of maintaining mixed concrete in a thoroughly mixed and uniform mass and of discharging concrete within a satisfactory degree of uniformity.

Mechanical details of the mixer or agitator, such as the water measuring and discharge apparatus, condition of the blades, speed of rotation of the drum, general mechanical condition of the unit, and cleanliness of the drum, shall be checked before use of the unit is permitted. Upon request by the Engineer, consistency tests of individual samples at approximately the beginning, midpoint, and end of the load shall be conducted. If consistency measurements vary by more than 50 millimeters for slump between high and low values, the mixer or agitator shall not be used until the condition is corrected.

(c) **Mobile Production Plants:** The Contractor may produce Class 20 general use hydraulic cement concrete for incidental construction items from a mobile production plant. Mobile production plants will not be permitted to produce concrete used in bridges, except overlays; box culverts; pavements, except patching; or retaining walls. If the Contractor elects to use a mobile production plant as permitted, the equipment requirements specified hereinbefore will not apply and the concrete shall be mixed at the point of delivery by a combination materials transport and mixer unit conforming to the following:

1. The unit shall be capable of carrying ingredients needed for concrete production in separate compartments and of mixing ingredients at the point of delivery. The unit shall be equipped with calibrated proportioning devices to vary mixture proportions of dry ingredients and water. The unit shall be capable of changing the slump at any interval of continuous discharge of concrete.

2. The mixing mechanism shall be a part of the transportation unit carrying dry ingredients. The mixer may be any type capable of combining ingredients of concrete into a thoroughly mixed and uniform mass and of discharging concrete with a satisfactory degree of uniformity within the specified time of mixing.

3. Each unit shall have a metal plate(s) attached in a prominent place by the manufacturer on which the following are plainly marked: the gross volume of the transportation unit in terms of mixed concrete, discharge speed, and mass calibrated constant of the machine in terms of an indicator revolution counter.

4. During discharge, the consistency, determined by the slump cone method (AASHTO T119) on representative samples taken from the discharge of the mixer at random intervals, shall not vary by more than 25 millimeters.

217.06—Classification of Concrete Mixtures.

Classes and uses of concrete are specified in Table II-17.

217.07—Proportioning Concrete Mixtures.

The Contractor is responsible for having a Certified Concrete Batcher or a Certified Concrete Plant Technician present during batching operations, and a Certified Concrete Field Technician shall be present during placing operations.

A Certified Concrete Plant Technician is that person who is capable of performing adjustments in the proportioning of materials used to produce the specified concrete should adjustments become necessary.

A Certified Concrete Batcher is that person who actually performs the batching operation. He shall never initiate adjustment and will be permitted to implement adjustment only at the direction of the Certified Concrete Plant Technician unless his certification has this special authorization.

A Certified Concrete Field Technician is that person who is responsible for quality control of concrete work at the project site. The Contractor shall

TABLE II-17
Requirements for Hydraulic Cement Concrete

Class of Concrete		Design Min. Laboratory Compressive Strength at 28 Days (f'_c) (MPa)	Aggregate Size No.	Nominal Max. Aggregate Size (mm)	Min. Grade Aggregate	Min. Cement Content (kg/cu m)	Maximum Water (kg water/ kg cement)	Consistency (mm of slump)	Air Content (%)[1]
35-60 by 5's	Prestressed and other special designs[2]	35-50 in units of 5's	57 or 68	25	A	375	0.40	0-100	4 1/2 ± 1 1/2
35	General	35	57	25	A	375	0.45	50-100	6 1/2 ± 1 1/2
30	General	30	57	25	A	375	0.45	50-100	6 1/2 ± 1 1/2
30	Posts & rails[3]	30	7	13	A	375	0.45	50-125	7 ± 2
25	General	25	57	25	A	350	0.45	25-125	6 ± 2
20	General	20	57	25	A	350	0.49	25-125	6 ± 2
20	Paving	20	57	25	A	350	0.49	0-75	6 ± 2
15	Massive or lightly reinforced	15	57	25	B	300	0.58	0-100	4 ± 2
10	Massive unreinforced	10	57	25	B	250	0.71	0-75	4 ± 2
20T	Tremie seal	20	57	25	A	375	0.49	75-150	4 ± 2
25	Latex hydraulic cement concrete[4]	25	7 or 8	13	A	400	0.40	100-150	5 ± 2
35	Silica fume concrete concrete	35	7 or 8	13	A	400[5]	0.40	100-175	6 ± 2

[1]When a high-range water reducer is used, the target air content shall be increased 1% and the slump shall not exceed 175 millimeters.

[2]When Class 35-60 concrete is used as the finished bridge deck riding surface, or when it is to be covered with asphalt concrete with or without waterproofing, the air content shall be 5 1/2 ± 1 1/2%.

[3]When necessary for ease in placement, aggregate No. 7 shall be used in concrete posts, rails, and other thin sections above the top of bridge deck slabs.

[4]The latex modifier content shall be 13.25 liters per bag of cement. Slump shall be measured approximately 4 1/2 minutes after discharge from the mixer.

[5]Minimum 7% silica fume replacement by mass of the total cementitious material.

Note: The Contractor may substitute a higher class of concrete for that specified at his expense.

have at least one Certified Concrete Field Technician on the project for single or multiple incidental concrete placements. The Contractor shall have at least one Certified Concrete Field Technician present at each site during the placement of pavements, bridge decks, bridge piers and abutments, and box culverts and any placement of 40 or more cubic meters.

The Certified Concrete Field Technician shall provide control over methods used for discharging, conveying, spreading, consolidating, screeding, finishing, texturing, curing, and protecting the concrete. Deficiencies in conformance to specification requirements and good concreting practices shall be corrected as soon as they begin to occur.

The concrete producer shall plan batching operations so that delays do not occur because of the absence of certified personnel.

Concrete shall be proportioned to secure the strength and durability required for the pavement or the part of the structure in which it is to be used.

Prior to mixing concrete, the Contractor shall submit, or shall have his supplier submit, for approval concrete mixture design(s) conforming to the specifications for the class of concrete specified.

The Contractor shall furnish and incorporate an approved water-reducing and retarding admixture in bridge deck concrete and in other concrete when conditions are such that the initial set may occur prior to completion of approved finishing operations. An approved water-reducing admixture shall be furnished and incorporated in concrete when necessary to provide the required slump without exceeding the maximum water/cement ratio and shall be used in bridge deck concrete when the requirement for a water-reducing and retarding admixture is waived by the Engineer. The Contractor shall demonstrate that use of the admixture will not cause segregation. The two admixtures shall not be used together in the same concrete batch unless tests indicate the admixtures are compatible in accordance with the requirements of Section 215.02 (b). Costs for admixture(s) shall be included in the contract unit price for the respective concrete item.

Concrete shall be air entrained. The air content shall conform to the requirements of Table II-17.

Except for latex hydraulic cement concrete, the quantities of fine and coarse aggregates necessary to conform to these specifications in regard to consistency and workability shall be determined by the method described in ACI 211.2 or ACI 211.1 except that proportions shall be computed on the absolute volume basis and the 10 percent adjustment allowed in Table 5.3.6

will not be permitted. The actual quantities used, as determined by the methods described herein, shall not deviate more than ±5 percent from such quantities.

For latex hydraulic cement content, the dry mass ratio of cement/fine aggregate/coarse aggregate shall be 1:2.5:2. A maximum adjustment of 10 percent may be made in the masses of the aggregate, as approved by the Engineer, to compensate for grading changes and variable specific gravity.

Batch quantities shall be adjusted during the course of the work to compensate for changes in workability caused by differences in characteristics of aggregates and cements within the specification requirements. Such adjustments shall be made only by the Contractor and shall not change the yield.

If concrete cannot be obtained with the required workability or consistency or with the maximum design water content with the materials furnished, the Contractor shall make changes to secure the desired properties subject to the limiting requirements specified in Table II-17 and the approval of the Engineer. When the void content of the fine aggregate is more than 50.5 percent and the concrete does not have the desired properties, the Contractor shall use a fine aggregate having a void content of less than 50.5 percent. In lieu of changing the fine aggregate, the Contractor may take one or more of the following actions:

1. Use an approved water-reducing admixture.

2. Increase the cement content.

3. Change the source of coarse aggregate.

4. In hot weather, add ice or otherwise reduce the temperature to increase the workability.

5. Submit other recommendations to the Engineer for approval.

However, when any of the options is exercised, the Contractor shall make trial batches under the observation of the Engineer to verify that concrete of the required workability and consistency is obtained within the specified water content. At least one trial batch shall be made with the concrete temperature at approximately 30 °C to verify that the concrete mixture has sufficient workability and consistency without exceeding the specified water content. When the fineness modulus of the fine aggregate changes more than 0.2 from the original design and the concrete does not have the desired properties, the concrete mixture shall be redesigned. Costs incurred because of adjustments of concrete mixture design(s) and for trial batches shall be borne by the Contractor, and no additional compensation will be made.

217.08—Acceptance.

(a) **Air and Consistency Tests:** Air and consistency tests will be performed by the Department prior to discharge into forms to ensure that specification requirements are consistently being complied with for each class of concrete. The sample secured for the tests will be taken after at least 0.1 cubic meter of concrete has been discharged from the delivery vehicle. The Contractor shall provide a receptacle conforming to the requirements of AASHTO T23, Section 4.9, for the Department's use in obtaining its sample. If either determination yields a result that is outside the allowable range for air content or consistency, the following procedures will be used:

1. The Engineer will immediately perform a recheck determination. If the results confirm the original test results, the load will be rejected.

2. The Contractor's representative will be immediately informed of the test results.

3. The Contractor's representative shall notify the producer of the test results through a preestablished means of communication.

The Engineer may perform any additional tests deemed necessary and reject all remaining material that fails the tests.

Entrained air content will be determined in accordance with the requirements of AASHTO T152, T196, or T199. Rejections will be based on the results of tests performed in accordance with the requirements of AASHTO T152 or T196.

In general, a mixture that contains the minimum amount of water consistent with the required workability shall be used. Consistency will be determined in accordance with the requirements of AASHTO T119. Adding cement to loads previously rejected for excessive water content or consistency will not be permitted.

(b) **Strength Tests:** The 28-day strengths specified in Table II-17 are the strengths used in the design calculations. The Engineer will verify design strengths by tests made during the progress of the work in accordance with the requirements of AASHTO T22, T23, or T24. If the test results do not conform to the strengths specified in Table II-17, immediate steps shall be taken to adjust the design mixture and an investigation will be initiated to determine the acceptability of the concrete.

The Contractor shall provide a storage chamber at his expense for temporary storage of the Department's concrete cylinders. The

chamber shall be designed to maintain test cylinders in a continuously moist condition within a temperature range of 16 °C to 27 °C and shall be equipped with a maximum/minimum thermometer. The chamber shall be located near the concrete placement site in an area where test cylinders will not be subject to vibration and shall be of sufficient size or number to store, without crowding or wedging, the required number of test cylinders as determined by the Contractor based on his plan of operations.

When use of high-early-strength hydraulic cement concrete is authorized, it shall conform to the requirements of Table II-17 except that the 28-day strength shall be obtained in 7 days. Up to 475 kilograms per cubic meter of Type I or Type II cement may be used to produce high-early-strength concrete in lieu of using Type III modified cement.

217.09—Mixing.

The method of mixing shall be approved by the Engineer prior to the start of concrete work.

The volume of concrete mixed per batch shall be at least 15 but not more than 110 percent of the mixer's rated capacity.

Concrete that becomes nonplastic, unworkable, or outside the limits of the slump specified shall not be used. Retempered concrete shall not be used. Concrete delivery shall be regulated so that placement is at a continuous rate. Intervals between delivery of batches shall not be so great as to allow concrete in place to begin initial set.

(a) **Mixing at Job Site:** Concrete shall be mixed in a batch mixer designed to ensure a uniform distribution of materials throughout the mass. When bag cement is used, batches shall be proportioned on the basis of integral bags of cement.

Mixing shall be performed in accordance with the requirements of (b)3. herein.

Upon the cessation of mixing for more than 30 minutes, the mixer shall be thoroughly cleaned.

(b) **Ready-Mixed Concrete:** Ready-mixed concrete shall be delivered to the designated point ready for use.

Each load of transit or shrink-mixed concrete shall be accompanied by Form TL-28 issued by the batcher or technician. The form shall be

delivered to the Inspector at the site of the work. Loads that do not carry such information or that do not arrive in satisfactory condition shall not be used.

Upon cessation of mixing for more than 30 minutes, the mixer shall be thoroughly cleaned.

Each batch of concrete shall be delivered to the site of work and discharged within the allotted time. The allotted time will begin the instant the cement is introduced into the mixture. Times given for retarded concrete are provided to accommodate the physical limitations of a formed section or scattered locations of small increment placements and shall not be used to accommodate slow and noncontinuous placements caused by poor planning or scheduling, inadequate equipment or personnel, or excessive haul distances.

Maximum Time Between Introduction of Cement to the Mix and Completion of Discharge

	Concrete Temperature		
	Up to 25 °C	**25-30 °C**	**Above 30 °C**
Agitator Type Haul Equipment			
Retarded	2 1/2 hr	2 hr	1 1/2 hr
Unretarded	1 1/2 hr	1 1/4 hr	1 hr
Nonagitator Type Haul Equipment			
All concrete	1 hr	3/4 hr	1/2 hr

Mixing and delivery shall be in accordance with the following:

1. **Transit mixing:** Concrete shall be mixed in a truck mixer. Mixing shall begin immediately after all ingredients are in the mixer and shall continue for at least 70 but not more than 125 revolutions of the drum or blades at the rate of at least 14 but not more than 20 revolutions per minute.

   Additional rotations of the drum or blades shall be at the rated agitating speed. The mixer shall be operated within the capacity and speed of rotation designed by the manufacturer.

2. **Shrink mixing:** Materials, including water, shall be partially mixed in a stationary mixer for at least 30 seconds. Mixing

shall be completed in a truck mixer with at least 60 but not more than 100 revolutions of the drum or blades at the rated mixing speed. Additional rotations of the drum or blades shall be at the rated agitating speed. Mixers shall be operated within the capacity and speed of rotation designated by the manufacturer of the equipment.

3. **Central mixing:** Concrete shall be completely mixed in a stationary mixer and transported in the agitator equipment to the point of delivery. Use of nonagitator equipment will be approved only when the plant is in the immediate vicinity of the project.

   Mixing time for mixers having a capacity of 0.75 cubic meter or less shall be at least 60 seconds. Mixing time for mixers having a capacity of more than 0.75 but less than 7.5 cubic meters shall be at least 75 seconds. Mixing times for mixers having a capacity of more than 7.5 cubic meters shall be as determined by the Engineer. Performance tests shall be conducted in accordance with the requirements of VTM-17 by an approved commercial laboratory at the Contractor's expense. Lesser times will be approved if the requirements of VTM-17 are conformed to. In any event, mixing time shall be not less than 40 seconds.

   The requirements of VTM-17 shall not be construed as a nullification of the requirements of Table II-17. If subsequent evaluation check tests indicate that the reduced mixing time is not satisfactory, the Contractor shall reestablish the necessary mixing time.

   Concrete mixed for less than the specified time will be rejected. Mixing time starts when solid materials are in the mixing compartment and ends when any part of the concrete begins to discharge. The mixer shall be operated at the drum speed specified on the name plate of the approved mixer.

   Bodies of nonagitating equipment used to transport concrete shall be smooth, mortartight, non-aluminum metal containers capable of discharging concrete at a controlled rate without segregation. Upon discharge of concrete, the body of the equipment shall be free from concrete. Concrete shall be delivered to the work site in a thoroughly mixed and uniform mass. Upon the request of the Engineer, consistency tests of individual samples at approximately the beginning, midpoint, and end of the load shall be conducted. If consistency measurements vary by more than 50 millimeters for slump between high and low values, mixer or agitator equipment shall be used in lieu of nonagitating equipment.

(c) **Automatic Mobile Continuous Mixers:** Mobile continuous mixers shall be calibrated to proportion the mixture accurately and shall have been certified within 60 days prior to use on the project for the type of material specified. Certifications will be valid for 6 months or until the source of materials changes or the grading or moisture changes significantly so as to affect the consistency of the concrete. Evaluation and certification will be performed by the Department or an approved testing agency to determine that the true yield is within a tolerance of ±1.0 percent. A recording meter, visible at all times and equipped with a ticket printout, shall indicate the calibrated measurement.

(d) **Hand Mixing:** Hand mixing will be permitted only in case of emergency and with permission. Batches shall be not more than 0.4 cubic meter and shall be mixed in a watertight container in a manner approved by the Engineer. Ingredients shall be measured by placing them in any suitable, rigid container in the volumetric proportions of 1 part cement to 2 parts fine aggregate to 2 1/2 parts coarse aggregate. The container shall be filled and leveled with each ingredient to ensure the proportions specified as nearly as possible. Water shall be added to produce a slump of not more than 75 millimeters.

217.10—Placement Limitations.

The Contractor shall be responsible for the quality of concrete placed in any weather or atmospheric condition. At the time of placement, concrete shall have a temperature in accordance with the following:

1. Concrete used in the construction of bridge decks shall have a temperature of at least 5 °C but not more than 30 °C.

2. Concrete not used in bridge decks shall have a temperature of at least 5 °C but not more than 35 °C.

In cold weather, water and aggregates may be heated to not more than 65 °C to maintain concrete at the required temperature. The heating apparatus shall be such that materials will be heated uniformly and the possibility of the occurrence of overheated areas that might damage materials will be precluded. Steam shall not come in contact with aggregates. Cement shall not be heated. Heating equipment or methods that alter or prevent entrainment of the required amount of air in concrete shall not be used. Materials containing frost, lumps, crusts, or hardened material shall not be used.

In hot weather, aggregates or the mixing water shall be cooled as necessary to maintain the temperature of the concrete within the specified maximum.

SECTION 218—HYDRAULIC CEMENT MORTAR AND GROUT

218.01—Description.

These specifications cover hydraulic cement mortar and grout used in bonding units together, filling voids, and making surface repairs.

218.02—Materials.

(a) **Hydraulic cement** shall conform to the requirements of Section 214.

(b) **Fine aggregate** shall conform to the requirements of Section 202.

(c) **Water** shall conform to the requirements of Section 216.

(d) **Admixtures** shall conform to the requirements of Section 215.

218.03—Detail Requirements.

Hydraulic cement mortar and grout shall consist of a mixture of hydraulic cement, fine aggregate, water, and admixtures as specified herein.

Hydraulic cement mortar and grout shall contain from 3 to 7 percent entrained air. Air-entrained hydraulic cement may be used. Hydraulic cement mortar and grout shall be mixed with the minimum amount of water necessary to obtain the required consistency.

(a) **Hydraulic cement mortar** shall consist of 1 part hydraulic cement, 2 1/2 parts fine aggregate by mass, and sufficient water to produce a stiff mixture. Grading C fine aggregate shall be used.

(b) **Nonshrink mortar** shall consist of 1 part hydraulic cement, 2 parts fine aggregate by mass, a set retarder or other admixture that will reduce the amount of required mixing water, and sufficient water to produce a stiff mixture. Grading C fine aggregate shall be used.

(c) **Hydraulic cement grout** shall consist of 1 part hydraulic cement, 2 parts fine aggregate by mass, and sufficient water to produce a free-flowing mixture. Grading A or C fine aggregate shall be used.

(d) **High-strength grout and mortar** shall consist of a prepackaged, nonshrink hydraulic cement mixture conforming to the requirements of ASTM C1107 modified by the following: the grout/mortar shall

develop a 7-day compressive strength of at least 28 megapascals when tested in accordance with the requirements of ASTM C109, and a 7-day bond strength of at least 7 megapascals when tested in accordance with the requirements of VTM-41, except that epoxy shall not be used to develop the bond.

SECTION 219—RIGHT-OF-WAY MONUMENTS

219.01—Description.

These specifications cover concrete and metal markers used to designate right-of-way boundaries.

219.02—Detail Requirements.

Right-of-way monuments shall be manufactured from reinforced concrete or metal conforming to the dimensions shown on the standard drawings and in accordance with these specifications.

(a) **Concrete Monuments:** Concrete shall be Class 20 conforming to the requirements of Section 217 except that the use of Type I cement and a change in the aggregate size will be permitted.

Steel reinforcement shall conform to the requirements of Section 223 and shall be placed as shown on the standard drawings.

Monuments shall be cast in one piece with smooth and uniform surfaces.

Monuments shall withstand a cracking load of at least 15 kilonewtons and a destruction load of 20 kilonewtons when tested transversely on a 600 millimeter span and shall not have an absorption value of more than 10 percent. Tests will be performed in accordance with the requirements of AASHTO T177.

(b) **Metal Monuments:** Material for steel pins shall conform to the requirements of Section 223.

Material for locator posts shall conform to the requirements of Section 226 or 229.

Steel posts or pins shall be galvanized in accordance with the requirements of ASTM A123.

SECTION 220—CONCRETE CURING MATERIALS

220.01—Description.

These specifications cover materials used to maintain the humidity and temperature of freshly placed concrete to ensure satisfactory hydration and proper hardening of the concrete.

220.02—Detail Requirements.

Concrete curing materials shall consist of waterproof paper, PE film, a combination of burlap and PE film, liquid membrane-forming compound, or water. Concrete curing materials shall be free from impurities that may be detrimental to the surface of concrete.

(a) **Waterproof paper** shall conform to the requirements of AASHTO M171. One side shall be composed of white, light-reflecting paper.

(b) **PE film** shall conform to the requirements of AASHTO M171 except that its nominal thickness shall be 0.075 millimeter (3.0 mils). The thickness at any point shall be at least 0.063 millimeter (2.5 mils).

(c) **Burlap and PE film** may be used in combination. They shall be bonded securely so that they cannot be easily separated in a dry or saturated condition. White PE film shall conform to the reflectance requirements of AASHTO M171. Burlap shall conform to the requirements of AASHTO M182, Class 3.

(d) **Liquid membrane-forming compounds** shall be used on concrete masonry except bridge substructure elements. Fugitive dye compounds shall be used on bridge substructure elements. The Contractor shall remove liquid membrane-forming compound from concrete surfaces to which a bonding compound, joint sealer, or waterproofing material is to be applied.

Liquid membrane-forming compounds will be tested in accordance with the requirements of VTM-2 and shall conform to the following:

1. Liquid membrane-forming compounds shall contain an easily dispersed opaque, white, finely ground pigment or a fugitive dye. They shall not react with the components of concrete and shall not contain oils, waxes, or other materials that would prevent bonding of traffic paints. The resulting film shall be continuous, uniform, and free from pinholes, bubbles, or blisters and shall not darken the hardened concrete. The dye shall have sufficient color to be distinctly visible for at least 30 minutes after application and to disappear within 7 days.

2. The membrane shall not peel. It shall disappear by gradual disintegration from exposure to the elements over a period of at least 30 days but not more than 1 year. Within 60 days after application, the membrane shall be capable of being readily removed by means of steel wire brushes or another abrasive that will not damage the concrete surface.

3. When applied by pressure spray to a troweled, vertical, damp concrete surface at the rate specified, material shall adhere to the surface in a continuous, tenacious film without running off or sagging appreciably.

4. Shipping containers shall identify the trade name of the material and a lot or batch number except for small, locally repackaged containers bearing the Department's seal.

5. The average moisture loss at 24 hours shall be not more than 0.116 kilograms per square meter of exposed surface. At 72 hours, it shall be not more than 0.232 kilograms per square meter.

6. When applied to the test specimen, white pigmented material shall have a daylight reflectance of at least 60 percent of that of magnesium oxide.

(e) **Water** used for curing concrete shall be clean, clear, and free from oil and other deleterious substances and shall have a pH of at least 4.5.

SECTION 221—GUARDRAIL

221.01—Description.

These specifications cover material requirements for components of guardrail systems.

221.02—Detail Requirements.

Guardrail shall consist of rail or cable elements and fastenings fabricated to develop continuous beam or cable strength when installed.

(a) **Steel beam guardrail** shall conform to the requirements of AASHTO M180, Class A, Type 1. Where guardrail is to be constructed on curves that have a radius less than 50 meters, rail elements shall be

shop curved to the proper radius, with the road side of the rail either concave or convex as required.

(b) **Wire rope (cable)** shall conform to the requirements of AASHTO M30, Type I, Class A.

(c) **Brackets, turnbuckles, compensating assemblies, and attachment hardware** shall be of sufficient design and section to develop the full strength of the cable guardrail and shall be galvanized in accordance with the requirements of ASTM A153. The spring compensating device shall have a spring constant of 2.0 ± 0.2 kilonewtons and shall permit a travel of 150 ± 25 millimeters.

(d) **Concrete for precast reinforced concrete posts** shall conform to the requirements of Section 217 for Class 20 except that Type I cement and a smaller size of aggregate may be used.

(e) **Steel posts** shall be galvanized in accordance with the requirements of AASHTO M111.

1. **Structural rolled shapes** shall conform to the requirements of ASTM A36M.

2. **Sheet steel for fabricated shapes** shall conform to the requirements of ASTM A570M, Grade 36.

3. **Weld-fabricated shapes** shall conform to the requirements of ASTM A769M.

(f) **Wood posts** shall conform to the requirements of Section 236 and shall be pressure treated.

(g) **Anchor bolts** shall conform to the requirements of Section 226.02(d)2. for high-strength bolts.

(h) **Offset block** shall conform to either of the following:

1. **Steel** conforming to the requirements of ASTM A36M and galvanized in accordance with ASTM A153.

2. **Wood** conforming to the requirements of Section 236 and pressured treated.

3. **Recycled material:** Offset blocks shall be made from a minimum of 40 percent recycled plastic waste. Such plastic shall be accumulated from post consumer and post industry waste. The material for these blocks shall have a minimum specific gravity

of 0.950. The minimum compressive strength of these blocks in the lateral dimension shall be 11 megapascals. The maximum water absorption allowed over the theoretical lifetime of the block shall not exceed 5 percent by mass, when tested in accordance with ASTM D1037. Block attachment shall be in accordance with the standard drawings for wooden posts, standard GR-2, 2A W-Beam guardrail. The size tolerance in the direction of the bolt hole shall not be more than 6 millimeters. The blocks shall present a neat appearance and have plane surfaces. The blocks shall conform to the dimensions and tolerances listed on the standard drawings.

The manufacturer of the recycled plastic blocks must provide independent test results showing the material meets the velocity, acceleration, and post-impact trajectory requirements of National Cooperative Highway Research Program (NCHRP) Report 350.

The manufacturer shall also certify that the material components of the completed blocks are resistant to subterranean termites during its theoretical lifetime when tested in accordance with ASTM D3345. The theoretical lifetime is considered to be at least 20 years.

SECTION 222—MASONRY UNITS

222.01—Description.

These specifications cover masonry units manufactured of regular or lightweight concrete or brick made from clay or shale in a plant specifically designed for such a purpose.

222.02—Detail Requirements.

(a) **Wall Units:**

1. **Load bearing units** shall conform to the requirements of ASTM C90, Grade N-I.

2. **Hollow non-load bearing units** shall conform to the requirements of ASTM C129, Type I.

3. **Building bricks** shall conform to the requirements of AASHTO M114, Grade SW, or ASTM C55, Grade N-I.

(b) **Catch Basins and Manholes:**

1. **Masonry blocks** shall conform to the requirements of ASTM C139.

2. **Bricks** shall conform to the requirements of AASHTO M91, Grade MS, or ASTM C55, Grade N-I.

(c) **Sewer Brick:** Sewer brick shall conform to the requirements of AASHTO M91, Grade SM.

SECTION 223—STEEL REINFORCEMENT

223.01—Description.

These specifications cover steel items designed to give added flexural strength to hydraulic cement concrete or to control and reduce cracking.

223.02—Detail Requirements.

(a) **Reinforcement:**

1. **Deformed bars** shall conform to the requirements of ASTM A615M, Grade 300 or 400.

2. **Plain bars** shall conform to the requirements of ASTM A615M, Grade 300 or 400, deformation waived. When used as a dowel, material may be a plain bar, Grade 300 or 400 (ASTM A615M), or a plain dowel (ASTM A36M).

3. **Welded wire fabric** shall conform to the requirements of ASTM A185. When used in continuously reinforced pavement, wire fabric shall be deformed and furnished in flat sheets and shall conform to the requirements of ASTM A497.

4. **Longitudinal bars** for continuous reinforced concrete pavement shall conform to the requirements of ASTM A615M, Grade 400.

5. **Structural steel** shall conform to the requirements of Section 226.

6. **Bar mats** shall conform to the requirements of ASTM A184M.

7. **Spiral wire** shall conform to the requirements of AASHTO M32 (ASTM A82).

8. **Wire mesh** for use in gabions shall be made of galvanized steel wire at least 2.667 millimeters in diameter. The tensile strength of the wire shall be at least 400 megapascals. Wire mesh shall be galvanized in accordance with the requirements of ASTM A641, Class 3. When PVC coating is specified, it shall be at least 0.38 millimeter in thickness and shall be black.

   Wire shall be welded to form rectangular openings or twisted to form hexagonal openings of uniform size. The linear dimension of the openings shall be not more than 110 millimeters. The area of the opening shall be not more than 58 square millimeters. The unit shall be nonraveling. Nonraveling is defined as the ability to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section is cut.

(b) **Prestressing Tendons:** Seven-wire stress-relieved strands, stress-relieved wire, and low-relaxation strands shall conform to the requirements of ASTM A416, Grade 270; ASTM A421; and ASTM A416, Supplement I; respectively, with the following modifications:

1. Strands or wires used in units of any one bed layout shall be manufactured by the same plant.

2. A manufacturer's certification and load-elongation curve, in accordance with the requirements of ASTM A416 or A421, shall be obtained by the prestressed concrete fabricator for each lot of strand. The data shall be submitted to the Engineer for approval, in permanent record form.

(c) **Reinforcing Steel To Be Epoxy Coated:** Steel shall conform to the requirements herein and shall be coated in accordance with the requirements of AASHTO M284M.

1. Plants that epoxy coat reinforcing steel shall be CRSI certified for epoxy coating. CRSI inspection reports shall be on file at the plant and shall be available to the Engineer.

2. Handling and storage of the coated bars shall conform to the requirements of AASHTO M284.

3. Visible damage to the epoxy coating shall be patched or repaired with materials compatible to the existing coating in accordance with AASHTO M284.

SECTION 224—CASTINGS

224.01—Description.

These specifications cover items cast from metal to a specific design in a manufacturing plant.

224.02—Materials.

(a) **Malleable castings** shall conform to the requirements of ASTM A47M, Grade 32510.

(b) **Gray iron castings** shall conform to the requirements of ASTM A48, Class 30B.

(c) **Ductile iron castings** shall conform to the requirements of ASTM A536, Grade 60-40-18.

(d) **Steel castings** shall conform to the following:

1. **Carbon steel** shall conform to the requirements of ASTM A27M, Grade 450-240.

2. **Chromium alloy steel** shall conform to the requirements of ASTM A296M, Grade CA-15.

(e) **Steel castings for bridges** shall conform to the requirements of ASTM A27M, Grade 485-250.

224.03—Detail Requirements.

Tolerances, workmanship, and strength requirements for castings shall conform to FS RR-F-621. Strength tests shall be performed in the presence of the Engineer. When the alternate load test is used, test bars shall be fully identifiable with regard to the casting lot.

SECTION 225—STEEL FORGINGS AND STEEL SHAFTING

225.01—Description.

These specifications cover steel items specifically designed for a bridge structure and generally used where movement of a part of the structure is involved.

225.02—Detail Requirements.

(a) **Steel forgings** shall conform to the requirements of ASTM A668M, Class D, for use with structural carbon steel and Class F for use with high-strength low-alloy steel.

(b) **Steel shafting** shall conform to the requirements of ASTM A108, Grades 1016 through 1030.

SECTION 226—STRUCTURAL STEEL

226.01—Description.

These specifications cover steel structural shapes furnished to specific dimensions and associated hardware and fasteners.

226.02—Detail Requirements.

(a) **Bridge Structural Steel:** Structural steel for bridge shall conform to the requirements of ASTM A709M for the grade specified, except that stud shear connectors shall conform to Section 226.02 (e). Steel for tensile flanges and webs of plate girders, rolled beams, cover and splice plates, and any other components designated as main load carrying components subject to tensile stress shall conform to the supplemental requirements of ASTM A709M for the Charpy V-Notch Tests for Zone Two.

Fracture critical bridge steel members designated on the plans shall conform to the requirements of the AASHTO Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members.

One copy of the mill analysis for bridge steel shall be submitted to the Engineer.

(b) **Other Structural Steel:** Unless otherwise specified, steel for other structural members including H-piles shall conform to the requirements of ASTM Grade A36M. One copy of the mill analysis shall accompany steel piles shipped to the project site. Three copies of the mill analysis for structural steel members shall be submitted to the Engineer.

(c) **Anchor Bolts:**

1. Anchor bolts for general use shall conform to the requirements of ASTM A36M. Nuts shall conform to the requirements of ASTM A563M, and washers shall conform to the requirements of ASTM F844.

2. High-strength anchor bolts shall conform to the following:

Characteristic	Value
Min. yield strength	380 MPa
Ultimate tensile strength	515 MPa
Min. elongation (in 200 mm)	18%
Carbon equivalent	Max. 0.45%

Nuts shall be heavy hex and shall conform to the requirements of ASTM A563M, Grade 8S, or ASTM A194M, Grade 2H. Lock washers shall conform to the requirements of ANSI B18.21M. Flat washers shall conform to the requirements of ASTM F436M.

3. Galvanization of steel anchor bolts, nuts, and washers shall be in accordance with the requirements of ASTM A153.

4. Anchor bolts for railings shall conform to the following:

   a. **Stainless steel anchor bolts** shall conform to the requirements of ASTM A276, Type 430 or 410, annealed, hot finished.

   b. **Bimetallic anchor bolts** shall consist of stainless steel studs conforming to the requirements of ASTM A276, Type 304, welded by an automatic or semiautomatic end-welding process to a mild steel anchor. The minimum diameter of the anchor and the nominal diameter of the stud shall be 20 millimeters. The tensile strength of the complete anchor shall be at least 120 kilonewtons.

(d) **Stud shear connectors** shall conform to the requirements of AWS D1.1 Structural Welding Code or AWS D1.5 Bridge Welding Code as applicable. Stud shear connectors that conform to these requirements and are on the Department's approved list may be used without further testing.

(e) **Steel for Structural Supports for Light Poles and Traffic Control Devices:** Steel shall be suitable for the design requirements and conform to the following:

Characteristic	Value
Min. yield strength	250 MPa
Min. tensile strength	400 MPa
Min. elongation (in 200 mm)	18%
Min. elongation (in 50 mm)	20%
Carbon equivalent (as determined by AWS D1.1/D1.5)	Max. 0.45%

Charpy V notch values of 34 joules at -12 °C may be substituted for elongation requirements. ASTM A500 tubing shall have Charpy values of 34 joules at -12 °C.

Steel fabricated in accordance with the requirements of ASTM A588M shall not be used unless specified.

(f) **Steel for Timber Connectors:** Steel shall conform to the requirements of ASTM A711, AISI No. 1015.

(g) **Bolts, Nuts, and Washers:** Bolts shall conform to the requirements of ASTM A307 except where high-strength or other special types of bolts are required. Nuts for A307 bolts shall conform to the requirements of ASTM A563, and washers shall conform to the requirements of ASTM F844.

(h) **High-Strength Bolts, Nuts, Washers, and Direct Tension Indicators:** These items shall conform to the following ASTM specifications:

High-Strength Bolts	Nuts for Use with High-Strength Bolts, Heavy Hex	Direct Washers Hardened	Tension Indicators
A325M, Type 1	A563M, Grade 8S A194M, Grade 2H	F436M	F959M
A325M, Type 3	A563M, Grade 8S3	F436M	F959M
A325M, Galvanized	A563M, Grade 10S	F436M	F959M
A490M, Types 1 or 2	A563M, Grade 10S A194M, Grade 2H	F436M	F959M
A490M, Type 3	A563M, Grade 10S3	F436M	F959M

1. High-strength bolts, nuts, and washers fabricated in accordance with the requirements of ASTM A490M shall be plain (uncoated), and high-strength bolts, nuts, and washers fabricated in accordance with the requirements of ASTM A325M shall be galvanized.

2. The maximum hardness for bolts fabricated in accordance with the requirements of ASTM A325M shall be 33Rc. The maximum tensile strength shall be 1000 megapascals for bolts 24 millimeters or less in diameter and 825 megapascals for larger bolts.

3. High-strength fasteners (plain and coated) shall be subjected to a rotational-capacity test similar to the supplementary requirements of ASTM A563M as modified by the following:

   a. Washers shall be used in the rotational-capacity test even though they may not be specified for use. Each combination of a bolt production lot, a nut production lot, and a washer production lot shall be tested as an assembly. A rotational-capacity lot number shall be assigned to each combination of lots tested. When washers are not specified for use, they need not be included in the rotational-capacity lot number. The minimum frequency of testing shall be two assemblies per shipping lot.

      Starting with 10 percent of the specified proof load using a Skidmore-Wilhelm calibrator or equivalent tension measuring device, the assembly shall withstand the number of turns indicated without breaking:

      (1) Bolt length up to and including 4 diameters: 2/3 turn

      (2) Bolt length over 4 but not exceeding 8 diameters: 1 turn

      (3) Bolt length over 8 but not exceeding 12 diameters: 1 1/3 turn

      Bolts too short to test in a Skidmore-Wilhelm calibrator shall be tested using steel plate(s) without the specified proof load requirement.

   b. During this test, the recorded tension shall be at least 1.15 times the required bolt proof load as specified in ASTM A325M and A490M.

Bolt Size	1.15 x Proof Load (kN) A325	A490
M16x2	108.3	149
M20x2.5	169	233
M22x2.5	209	288
M24x3	244	337
M27x3	316	438
M30x3.5	387	536
M36x4	563	780

c. The measured torque to produce the required fastener tension shall not exceed the value obtained by the following equation:

$$\text{Torque} = 0.25\,PD$$

where torque = measured torque (newtonmeters), P = measured bolt tension (newtons), and D = nominal diameter (meters).

Bolt Size	Max. Torque 1.15 x Proof Load (Nm) A325	A490
M16x2	430	600
M20x2.5	850	1170
M22x2.5	1150	1580
M24x3	1460	2020
M27x3	2130	2960
M30x3.5	2900	4020
M36x4	5070	7020

d. Bolts shall be proof-load tested in accordance with the requirements of ASTM F606M Method I. Full-size bolts shall be wedge tested in accordance with the requirements of ASTM F606M. Nuts shall be proof-load tested in accordance with the requirements of ASTM F606M. Galvanized bolts shall be wedge tested after galvanizing. Galvanized nuts shall be proof-load tested in accordance with the requirements of ASTM F606M only when overtapping, galvanizing, and lubricating operations are completed.

e. Galvanized bolts, nuts, and washers shall be hot dipped galvanized by the hot dipped method in accordance with

the requirements of ASTM A153. If the bolts are to be top coated with paint, mechanically galvanized bolts, nuts, and washers in accordance with the requirements of ASTM B695, Class 50, may be used.

When galvanized nuts conforming to ASTM A563M are specified, the amount of over tapping may be less than specified; however, all nuts in each lot shall be over tapped the same amount. Galvanized nuts shall be lubricated in accordance with the requirements of ASTM A563M using a lubricant sufficiently tinted so as to be readily visible.

Galvanized bolts, nuts, and washers shall have the galvanization measured for thickness. Measurements for bolts shall be taken on the wrench flats or top of the bolt head. Measurements for nuts shall be taken on the wrench flats.

When galvanized washers are specified, hardness testing shall be performed after galvanizing. The coating shall be removed prior to testing.

f. All bolts, nuts, and washers shall be identified with a marking that identifies the manufacturer of such products. The Contractor shall provide an example of such marking and the certification of each manufacturer for the bolts, nuts, and washers supplied. The Contractor shall also provide written documentation of all tests required by ASTM and by specifications herein for bolts, nuts, and washers. Documentation shall indicate the results of such tests, the address where the tests were performed, and the date of testing. Test results of bolts and nuts shall also indicate the lot number of the product. Bolts, nuts, and washers from different rotational-capacity lots shall not be shipped in the same container. In addition, shipping containers shall be marked with the rotational-capacity test lot number of the product supplied.

SECTION 227—STEEL GRID FLOORING

227.01—Description.

These specifications cover plant-fabricated steel for use as a portion of a bridge deck.

227.02—Materials.

(a) **Steel** shall conform to the requirements of ASTM A36M except that if the material is not galvanized, it shall have a copper content of at least 0.2 percent.

(b) **Concrete** for filling steel grid floors shall conform to the requirements of Section 217 for Class 25, maximum aggregate size No. 7.

227.03—Detail Requirements.

(a) **Open flooring** shall be galvanized in accordance with the requirements of ASTM A123.

(b) **Painting**, when specified or permitted, shall be performed in accordance with the requirements of Section 411, except that dipping will be permitted.

SECTION 228—STEEL PILES

228.01—Description.

These specifications cover steel fabricated to a shape that will act as a foundation for a structure. One copy of each applicable mill analysis shall accompany steel piles shipped to the project, and four copies shall be submitted to the Engineer.

228.02—Detail Requirements.

(a) **H-piles:** H-piles shall be structural carbon steel conforming to the requirements of ASTM A36M.

(b) **Shell Piles:** Welded shells shall be fabricated with butt welds only.

End plates and other fittings shall be fabricated from the same material used for the shell or from steel conforming to the requirements of ASTM A36M.

1. **Steel for Type A shells** shall be classification SAE 1010 with a yield point of at least 345 megapascals. Shells shall be fluted and consist of a cylindrical upper section(s) and a lower section having a diameter diminishing at the rate of 1.0 to 2.0 percent.

The lower section shall have a welded point with a diameter of at least 200 millimeters.

2. **Steel for Type B shells** shall conform to the requirements of ASTM A252, Grade 1, 2, or 3. Shells shall be straight pipe having bottoms closed with end plates at least 19 millimeters in thickness and a diameter not more than 13 millimeters greater than the outside diameter of the shell.

3. **Steel for Type C shells** shall conform to the requirements of ASTM A569M or A366M. Shells shall be helically corrugated and cylindrical in the section and shall diminish in diameter toward the point by stepping at regular intervals at the rate of approximately 25 millimeters per step or at an average rate of 1.0 to 2.0 percent. The lower section shall have a welded point with a diameter of at least 200 millimeters.

4. **Steel for Type D shells** shall be classification SAE 1010 with a yield point of at least 345 megapascals. Shells shall be helically corrugated and of a constant cylindrical section or shall diminish uniformly in diameter at the rate of 1.0 to 2.0 percent. Bottoms shall have ends closed with plates at least 19 millimeters in thickness and not more than 13 millimeters greater in diameter than the outside diameter of the shell. Shells diminishing in diameter shall have welded points with a diameter of at least 200 millimeters.

(c) **Steel Sheet Piles:** Steel sheet piles shall conform to the requirements of ASTM A328M.

SECTION 229—ALUMINUM ALLOY

229.01—Description.

These specifications cover aluminum alloy products designed in shape and composition to serve a specific purpose, such as a sign panel, post, or conduit, including necessary fasteners.

229.02—Detail Requirements.

(a) **Sheets and plates** shall conform to the requirements of ASTM B209M, alloy 6061-T6, 6061-T651, 5052-H32, 5052-H34, 3003-H14, or 5086-

H116/H32. Aluminum sign panels shall be alloy 5052-H32, 5052-H34, 5052-H38, or 6061-T6.

(b) **Bars, rods, and wire** shall conform to the requirements of ASTM B211M, alloy 6061-T6 or 6061-T651.

(c) **Extruded bars, rods, shapes, and tubes** shall conform to the requirements of ASTM-B221M, alloy 6061-T6 or 6063-T6.

Aluminum alloy extrusions, extruded tubes, drawn tubes, or pipes that are to be bent on a radius of less than 1 meter may be made from alloy having a temper condition of 0.

(d) **Drawn tubes** shall conform to the requirements of ASTM B210M, alloy 6061-T6.

(e) **Pipe** shall conform to the requirements of ASTM B429 or B241M, alloy 6061-T6 or 6063-T6.

(f) **Bolts, studs, nuts, set screws, washers, and rivets** shall be furnished as commercial items suitable for the application.

(g) **Permanent-mold castings** for items other than rail posts shall conform to the requirements of ASTM B108, alloy 356.0-T6. Cast aluminum alloy rail posts shall conform to the requirements of AASHTO M193.

(h) **Sand castings** shall conform to the requirements of ASTM B26M, alloy 356.0-T6 and alloy 356.0-F.

(i) **Shims** shall be made from a sheet or plate conforming to the requirements of ASTM B209M, alloy 1100-O.

(j) **Aluminum filler metal for welding** shall conform to the requirements of AWS 1.2.

(k) **Rolled or extruded structural shapes** shall conform to the requirements of ASTM B308M, alloy 6061-T6.

(l) **Breakaway support couplings for light poles and sign posts** shall conform to the requirements of ASTM B209M, alloy 2024-T851.

(m) **Frangible bases for light and signal poles** shall conform to the requirements of ASTM B26M or B108, alloy 319 or 356.0-T6.

(n) **Aluminum alloy for controller, control center, and flasher cabinets** shall conform to the requirements of ASTM B209M, alloy 5052-H32.

(o) **Aluminum alloy for lighting and pedestal poles** shall conform to the requirements of ASTM B221M or B241M or B429, alloy 6063-T6.

SECTION 230—BRONZE AND COPPER ALLOY

230.01—Description.

These specifications cover the fabrication of specific bronze or copper alloys, usually in the construction of a bridge structure or for electrical purposes.

230.02—Detail Requirements.

(a) **Cast bronze** shall conform to the requirements of ASTM B22.

(b) **Copper alloy** shall conform to the requirements of ASTM B100, copper alloy No. 51000.

(c) **Copper sheets and strips** shall conform to the requirements of ASTM B370.

SECTION 231—PAINT

231.01—Description.

These specifications cover a mixture of pigment in a liquid vehicle that, when applied, will dry to an opaque solid film. Use of paint in these specifications refers to the requirements of highway construction.

231.02—Materials.

(a) **Paint vehicles** shall conform to the following:

Vehicle	Specification
Acrylic resin	100% straight acrylic polymer dispersed in water
Alkyd resin	FS TT-R-266, Type 1, Class A or B

Linseed oil:	
Boiled	FS TT-L-190
Heat bodied	FS TT-L-201
Raw	ASTM D234
Mineral spirits	FS TT-T-291E, Type II, Grade A
Soya isophthalic alkyd	Long oil soya isophthalic alkyd containing at least 80% soya oil resin (for use in acrylic emulsion paint only)
Soybean oil	FS TT-S-600
Spar varnish	FS TT-V-121
Volatile thinners	FS TT-T-291, Type II, Grade A

(b) **Paint pigments** shall conform to the following:

Pigment	Specification
Aluminum paste	FS TT-P-320, Type II, Class 2
Carbon black	FS TT-P-343
Chrome yellow	ASTM D211
Ethylene glycol monoethyl ether acetate	FS MIL-E-7125
Lamp black	FS TT-P-350
Magnesium silicate	ASTM D605
Methyl ethyl ketone	FS TT-M-261b
Micaceous iron oxide	Processed specular haematite ore with a amellar structure and conforms to the International Standards Organization Specifications ISO/DP ABXZ.2 Grade 1
Organo montmorillonite	Fine, creamy white powder, with high gelling efficiency in a wide range of organic liquids; water content less than 30% and fineness less than 5% retained on 75 μm sieve
Sienna	FS TT-P-435, Type I
Titanium dioxide	ASTM D476, Rutile
Toluene	FS TT-P-548
Tricresyl-phosphate	FS TT-T-656a

Yellow iron oxide	FS TT-P-458
Zinc dust	FS TT-P-460, Type I
Zinc oxide	FS TT-P-463, Type I

231.03—Detail Requirements.

Paints shall not settle excessively or cake in the container; shall be readily broken up with a paddle to a smooth uniform paint of acceptable consistency and working properties with a minimum of foaming; shall not thicken, liver, skim, or curdle; and shall retain these properties in storage for at least 12 months.

When applied in accordance with the standard practice, paint shall show good leveling properties; be free from laps, brush marks, orange peel, sags, or other surface defects; and shall flow out to a uniform, smooth finish.

Paints will be inspected, sampled, and tested in accordance with the requirements of Federal Test Method Standard No. 141.

Paint containers shall be plainly marked with the name of the material, lot number, VDOT color, quantity contained therein, and name and address of the manufacturer. Any package or container not so marked will not be accepted.

(a) **No. 1 paint** shall conform to the requirements of SSPC Paint 25.

(b) **Zinc-rich paint systems** shall consist of a zinc-rich primer, top coat, and any intermediate coats recommended by the system's manufacturer. They shall be selected from the Department's approved products list and shall be applied in accordance with the manufacturer's recommendations.

Paint shall not contain more than 420 grams per liter of volatile organic as applied. Primer for shop application shall conform to the slip coefficient requirements of AASHTO, Division I, Design, Table 10.32.3C, Class of Surface E or F.

The top coat shall not chalk or discolor. The system will be tested in accordance with the requirements of VTM-73.

(c) **No. 8 paint, micaceous iron oxide**, is a high-build alkyd resin paint. Materials that are not specified herein shall be selected by the Contractor.

1. **Composition:**

	% by Mass	
	Min.	**Max.**
Pigment	51.0	
Micaceous iron oxide	70.0	
Tinting compound		30.0
Vehicle		49.0
Alkyd resin	71.2	
Thixotropic bodying agent	1.9	
Mineral spirits, driers, and antiskinning agents		26.9

Tinting compounds shall consist of primer-hiding pigments only.

Sufficient quantities of driers shall be used to ensure satisfactory drying within the drying time specified for the paint.

Wetting and antiskinning agents may be used in appropriate quantities as required.

Vehicle shall be free from rosin and rosin derivatives.

2. **Physical requirements:**

	Min.	**Max.**
Viscosity (KU)	80	88
Density (kg/L)	1.49	
Set to touch (hr)	4	
Drying time (hr)	24	

3. **Skinning:** Paint shall not skin when allowed to stand 48 hours in a tightly closed container that is 3/4 full of paint.

4. **Color numbers:** The FS color numbers specified refer to color only and not to gloss requirements.

(d) **No. 11 paint, acrylic emulsion, exterior, white**, shall be for use on signs, buildings, posts, and other exterior surfaces. It shall have good brushing properties, and when applied to a smooth vertical surface shall dry to a uniform, smooth appearance free from flashings, sags, streaks, and objectionable brush marks.

1. **Composition:**

	% by Mass	
	Min.	**Max.**
Pigment		
Titanium dioxide, Type III	19	21
Zinc oxide, Type I, Grade A	3	5
Silicates	15	17
Vehicle		
Acrylic resin solids	15	17
Soya isophthalic alkyd resin	2	5
Water, additives, and stabilizers	40	42

2. **Physical requirements:** Neither paint thinner nor oil colors shall be added to paint. Thinning shall be accomplished only with water.

	Min.	**Max.**
Density (kg/L)	1.4	
Fineness of grind	4	
Viscosity (KU)	75	85
Time of setting to touch (min)		30
Recoat time (hr)		4

3. **Freeze-thaw stability:** When tested as specified in FS TT-P-19b, paint shall not show coagulation or flocculation or a decrease in wet abrasion resistance.

4. **Heat stability:** When tested as specified in FS TT-P-19b, paint shall not show coagulation, flocculation, or discoloration and shall not exceed the maximum viscosity requirement.

5. **Fungus resistance:** When tested as specified in FS TT-P-19b, paint shall not show fungus growth.

(e) **No. 13 paint, aluminum**, shall be a two-component aluminum paint composed of 0.18 kilograms of aluminum pigment paste for each liter of aluminum mixing varnish.

Aluminum mixing varnish shall be a long oil varnish and shall contain at least 50 percent nonvolatile oil and gums by mass. Varnish shall

be free from sulphur, sulphur compounds, and rosin. The acid number of varnish shall be not more than 10, based on the nonvolatile content.

Varnish shall pass a 100 percent Kauri reduction test.

The viscosity of varnish shall be from A to D inclusive, as determined with a Gardner bubble viscometer, varnish series.

When mixed with the paste, varnish shall produce a paint showing satisfactory leafing and spreading properties and shall not run or sag when applied to a smooth vertical surface.

Paint shall set to touch in not less than 2 or more than 6 hours and shall dry hard and tough in not more than 24 hours.

Aluminum paste and varnish shall be furnished in separate containers. The container for varnish shall be of a size that will permit mixing the paste and varnish in the proper proportions without overflowing.

Leafing paint shall be mixed in the presence of the Engineer immediately prior to application and shall be used within 24 hours after mixing.

Nonleafing paint shall be mixed in the presence of the Engineer and shall be used within 7 days after mixing.

Leafing and nonleafing paint shall not be mixed.

When two coats of aluminum paint are to be applied, the paste shall conform to the requirements of FS TT-P-320, Type II, Class 2, except that paste for the first coat shall be nonleafing.

(f) **No. 14 paint, aluminum epoxy mastic**, shall be a two-component, modified epoxy coating, aluminum in color.

1. **Composition:** Pigment shall be flake metallic aluminum and shall contain rust-inhibiting and inert pigments.

   Vehicle shall be modified epoxy resin and curing agent and shall not contain coal tar. The curing agent shall be insensitive enough to moisture to permit trouble-free application during normal humidity conditions.

   Paint shall be supplied as a two-package material with a 1:1 mixture ratio by volume.

2. **Physical requirements:** The epoxy mastic shall contain at least 90 percent solids by mass when tested in accordance with the

requirements of ASTM D1644, modified to a drying time of 72 hours at 38 °C.

The shelf life of epoxy mastic components shall be at least 6 months. There shall not be skinning, gelation, or hard indispersible settling.

The viscosity of mixed paints, measured immediately after blending and mixing of components, shall be from 80 to 140 Kreb units at 25 ± 1 °C.

The density of mixed paint shall be at least 1.29 kilograms at 25 ± 1 °C.

The appearance of the dry applied film shall be bright aluminum.

The epoxy mastic shall be suitable for use over properly prepared, inorganic zinc-rich primers.

Mixed paint, when thinned in accordance with the manufacturer's recommendations for application over wire-brushed rusty steel, shall be capable of being spray applied in one coat at a wet film thickness of 2.50 millimeters without runs or sags.

The epoxy mastic, when applied in a dry film thickness of 125 mm and air dried at 24 °C, shall be dry to the touch within 24 hours, dry enough to handle in 48 hours, and provide a hard tough film after 5 days.

The usable pot life of the mixture of components reduced as recommended shall be at least 3 hours at 21 °C and 1 1/2 hours at 32 °C.

The epoxy-mastic coating shall possess such flexibility that, when applied in a dry film thickness of 125 micrometers to a 3-millimeter steel panel that has been blast cleaned in accordance with the requirements of SSPC-5 and cured for 2 weeks at 24 °C, it shall not display signs of cracking or loss of adhesion when the panel is uniformly bent 180 degrees around a mandrel 200 millimeters in diameter.

3. **Resistance:** Steel test panels conforming to the requirements of ASTM D609 shall be abrasive blasted in accordance with the requirements of SSPC-SP 5, exposed to the atmosphere for 30 days so that a uniform rusting occurs, and then hand cleaned with a wire brush in accordance with the requirements of SSPC-SP 2. The panel shall then be spray applied with epoxy mastic

to achieve a dry film thickness of 125 micrometers and cured according to the manufacturer's recommendations.

a. **Fresh water:** Coated panels shall be scribed down to base metal with an X having at least 50-millimeter legs and immersed in fresh tap water at 24 ± 3 °C. Upon examination after 30 days of immersion, panels shall be unaffected except for discoloration of the epoxy-mastic coating. There shall not be blistering, softening, or visible rusting of the coating beyond 1.5 millimeter from the edge of the scribe mark.

b. **Salt water:** Panels shall be scribed down to the base metal with an X having at least 50-millimeter legs and immersed in a 5 percent sodium chloride solution at 24 ± 3 °C. Panels shall be unaffected, except for discoloration of the epoxy-mastic coating, upon inspection after 7, 14, and 30 days of immersion. There shall not be blistering, softening, or visible rusting of the coating beyond 1.5 millimeters from the center of the scribe mark. The sodium chloride solution shall be replenished with fresh solution after each examination.

c. **Weathering:** Panels shall be tested in accordance with the requirements of ASTM G23, Type D, at the beginning of the wet cycle. After 1,000 hours of continuous exposure, the coating shall not show rusting, loss of adhesion to the steel test panel, or blistering.

d. **Salt fog:** Panels shall be scribed with an X having at least 50-millimeter legs down to base metal. Test panels shall then be tested in accordance with the requirements of ASTM B117. After 1,000 hours of continuous exposure, the coating shall not show rusting or blistering beyond 1.5 millimeters from the center of the scribe mark or a loss of bond.

4. **Packaging and labeling:** Epoxy-mastic coating shall be packaged in two containers, labeled "Part A" and "Part B." Each container shall bear a label that clearly shows the manufacturer and brand name of the paint, lot number, and date of manufacture. The label on the vehicle container shall also include complete instructions for use. The container shall be coated, if necessary, to prevent attack by the paint components.

5. **Application:** The manufacturer's current printed instructions for applying aluminum epoxy-mastic coating shall be submitted to the Department for approval prior to application.

6. **Product certification:** The manufacturer shall certify that the modified aluminum epoxy mastic has been used successfully

for at least 2 years in a similar service and environment and that the material was applied in one coat at a dry film thickness of 125 micrometers. Successful performance shall include adhesion to steel and old coatings of the type found on bridges.

Prior to approval and use of an aluminum epoxy-mastic coat, the manufacturer, at the request of the Department, shall submit a certified test report from an independent testing laboratory showing specific test results conforming to all quantitative and resistance test requirements herein. The test report shall also contain the lot numbers from which the data were compiled, manufacturer's name, and brand name of the paint. Upon approval by the Department of the test report, further resistance and quantitative tests will not be required of that manufacturer for that brand name of paint unless random samples tested by the Department show nonconformance with any of the requirements herein. The manufacturer, upon the request of the Department, shall submit new certified test results any time the manufacturing process or paint formulation is changed.

To obtain final acceptance of the epoxy mastic, the manufacturer, at the request of the Department, shall furnish a certification stating that the material is formulated in the same manner as the material previously tested.

(g) **No. 15 paint**, a primer pretreatment coating (wash primer), shall conform to the requirements of MIL-P-15328D and shall be on the Department's approved products list.

(h) **No. 31 enamel** shall be an alkyd resin paint conforming to the requirements of FS TT-E-489, and the color shall conform to the requirements of the Federal Standard for the number specified.

(i) **No. 33 flat black enamel** shall be an alkyd resin paint conforming to the requirements of FS TT-E-527, and the color shall conform to the requirements of Federal Standard No. 595-37038.

(j) **Traffic zone paint, reflectorized fast drying**, shall be a fast drying water based, nonleaded, acrylic resin paint for use in traffic marking on highways on which glass beads conforming to the requirements of Section 234 shall be applied. The paint shall be selected from the Department's approved list.

(k) **No. 101, 102, and 103 water reducible paint**, shall be a one-component acrylic water reducible resin coating with sufficient additives and coalescing agents along with suitable solvents and pigmentation to produce a high-quality paint with a volatile organic solvent less than 0.24 kilogram per liter as applied.

1. **Composition:**

	No. 101 Min.	No. 101 Max.	No. 102 Min.	No. 102 Max.	No. 103 Min.	No. 103 Max.
Pigment (% by mass)[1]	20	25	35	40	10	20
Red iron oxide (86% Fe203)	45					
Zinc phosphate	10		5		5	
Phthalocyanine blue		2				
Calcium carbonate			30			
Titanium dioxide (ASTM D476, Type II)	45					
Magnesium silicate				12		
Tinting compounds[2]						95
Vehicle (% by mass)	75	80	60	65	90	80
HG-54 solids	30		30		30	
Water		55		55	58	
Methyl carbitol	5		5		5	
Texanol	2		2		2	
Dibutyl phthalate	2		2		2	
Paint Characteristics						
mass per liter(kilogram)	1.16		1.32		1.08	
Solids by volume	35		37		30	
Grind	5		5		5	
Viscosity (KU)	90	100	90	100	90	100
Drying time, set to touch, hr[3]		3		3		3
Drying time, through, hr[3]		24		24		24
Leneta sag	10		10		10	
pH	8.0	8.5	8.0	8.5	8.0	8.5
Adhesion (ASTM 3359)	3B		3B		3B	
Gloss, specular @ 80 deg.					40	

[1]Paint shall not be formulated from ingredients containing any of the heavy metals listed for characteristic waste analysis in the Regulations of the Virginia Department of Hazardous Waste Management.

[2]All tinting compounds shall be prime hiding pigments.

[3]50% relative humidity and 25 degrees C.

2. **Mixed paint** shall not liver, thicken, curdle, gel, or settle rapidly. After mixing, all course particles and skins shall not amount to more than 0.05 percent by mass of the total mixture when passed through a 60 mesh screen.

3. **Storage life:** The paint shall not show thickening, curdling, gelling, or gassing after being stored for 1 year from the date of manufacture when packaged in tightly covered unopened

containers at a temperature between 10 degrees and 32 degrees C.

4. **Working properties:** The paint shall spray easily and show no streaking, running, sagging, or other objectionable features when tested in accordance with Federal Test Method Standard 411, Methods 4331 and 4541.

5. **Packaging and labeling:** The material shall be packaged in substantial containers, each bearing a label that shall include complete written instructions and precautions for use. Each container shall contain the date of manufacture, the batch number and the product identification designation.

6. **Samples and test:** A sample of each batch of paint and the appropriate lot of acrylic resin shall be submitted for testing. All samples shall be a minimum of 1 liter identified with the manufacturer's name, address, batch number, and date of manufacture and shall be accompanied by an MSDS. All samples shall be taken by an approved representative of the Department. Tests shall be completed and results approved before any paint is used.

SECTION 232—PIPE AND PIPE ARCHES

232.01—Description.

These specifications cover materials used for the conveyance of water, including drainage, storm water, sanitary systems, and waste water.

232.02—Detail Requirements.

The Contractor shall obtain and provide from his supplier a quality control plan, acceptable to the Department, for determination of conformance with the applicable requirements in the production of concrete and corrugated metal culvert and underdrain pipe. The field strutting method of elongation will not be permitted except with the written permission of the Engineer or unless indicated on the plans.

When pipe is furnished with a paved invert, storage after manufacture shall be with the paved invert down.

(a) **Concrete Pipe:**

1. **Concrete pipe for culverts and sewers** shall be circular in cross section, either plain concrete or with circular reinforcement, and of the modified tongue-and-groove design in sizes up to and including 450 millimeters in internal diameter and either standard or modified tongue-and-groove in sizes above 450 millimeters in internal diameter. Pipe shall conform to the specified AASHTO requirements, except that pipe having a internal diameter of 450 millimeters or less shall be manufactured without lift holes, and pipe having an internal diameter of 900 millimeters or less and being 1.3 meters or less in length shall also be manufactured without lift holes.

   a. **Plain concrete culvert pipe** shall be composed of hydraulic cement, water, and mineral aggregates conforming to b(3) and b(4) herein. Pipe shall conform to the following:

Min. Inside Diameter (mm)	Min. Wall Thickness (mm)	Groove Depth (mm)	Crushing Strength (kN/m)
300	44	44	26.3
375	50	44	31.0
450	50	44	35.0
525	69	50	39.4
600	75	57	43.8

   Pipe shall also comply with the requirements of AASHTO M170M for manufacture, finish, marking, inspection, and rejection.

   b. **Reinforced concrete culvert pipe:**

      (1) **Circular pipe** shall conform to the requirements of AASHTO M170M, class as specified, or AASHTO M242M. Circular pipe that does not have values listed in the AASHTO M170M design tables for diameter, wall thickness, compressive strength, and reinforcement shall be certified in accordance with the requirements of Section 105.02. Pipe conforming to the requirements of AASHTO M242M shall also be certified in accordance with Section 105.02.

      (2) **Elliptical pipe** shall conform to the requirements of AASHTO M207M, class as specified. Elliptical pipe

that does not have values listed in the AASHTO M207M design tables for wall thickness, compressive strength, and reinforcement shall be certified in accordance with the requirements of Section 105.02.

(3) **Fine aggregate** shall conform to the requirements of Section 202 for quality except that the void content, grading, and uniformity shall be controlled as necessary to produce the specified level of strength and absorption.

(4) **Coarse aggregate** shall conform to the requirements of Section 203 for Grade A crushed stone or gravel.

(5) **Positioning of reinforcement** when two layers of wire or bar reinforcement are used shall be such that welded joints are at an angle of approximately 60 degrees to each other.

(6) **Strength tests** will be performed by the three-edge bearing method in accordance with the requirements of AASHTO T280 or by the testing of cores in accordance with the requirements of AASHTO T24. Hand cast pipe and end sections may be tested in accordance with the requirements of AASHTO T22 and T23.

(7) **Absorption tests** will be performed in accordance with the requirements of AASHTO T280 on specimens of broken pipe or cores.

2. **Concrete pipe for underdrains** shall conform to the requirements of AASHTO M86M, Class I, and the perforation requirements of AASHTO M175M, Type I, except that spalls shall be not more than 40 millimeters in diameter or 5 millimeters in depth and shall not adjoin. When used as combination underdrains, pipe shall not be perforated.

   Porous concrete pipe for underdrains shall conform to the requirements of AASHTO M176M, standard strength.

3. **Concrete pipe for water lines, water mains, and sanitary sewers:**

   a. **Concrete pressure pipe** (steel cylinder) shall conform to the requirements of AWWA C300, C301, or C303 for the size, minimum working pressure, protective coating, seal coat, and type of joint as specified.

b. **Nonreinforced concrete sanitary sewer pipe** shall conform to the requirements of AASHTO M86M for the class specified.

c. **Reinforced concrete water pipe** (noncylinder) shall conform to the requirements of AWWA C302 for size, minimum working pressure, seal coat, protective coating, and type of joint specified.

d. **Reinforced concrete sanitary sewer pipe** shall conform to the requirements of AASHTO M170M for the class specified.

(b) **Cast Iron and Ductile Iron Pipe and Fittings:**

1. **Cast iron pipe** shall conform to the requirements of ASTM A716 for the class specified .

2. **Ductile iron pipe** shall conform to the requirements of AWWA C151 for size, joint type, class, type of coating and lining as specified, and minimum working pressure if applicable. Flanged joints shall conform to the requirements of AWWA C115.

3. **Fittings for cast iron and ductile iron pipe for water lines, water mains, and sanitary sewers** shall conform to the requirements of AWWA C110 (ANSI A21.10) or AWWA C153 (ANSI A21.53) for size, joint type, pressure rating, and type of coating and lining as specified.

4. **Cement mortar linings** shall conform to the requirements of AWWA C104 (ANSI A21.4).

(c) **Steel Pipe:**

1. **Corrugated steel culvert pipe and pipe arches** shall conform to AASHTO M36M, except that helically formed pipe shall be tested in accordance with the requirements of AASHTO T249 at the rate of one test per week per corrugation machine per work shift. Records of such test shall be maintained for a period of 24 months. When connecting bands or flared end sections are required, helically formed pipe shall have rerolled ends with a minimum of two annular corrugations. Aluminum zinc alloy coated sheet steel conforming to the requirements of AASHTO M289 and fabricated in accordance with the requirements of AASHTO M36M may be used. End sections shall be fabricated from materials conforming to the applicable requirements of

AASHTO M218 for galvanized pipe, AASHTO M274 for aluminum-coated pipe, or AASHTO M289 for aluminum zinc alloy-coated pipe.

Pipe sections shall be joined with annular corrugated bands, hugger bands, or maxidimple bands conforming to the requirements of AASHTO M36M and shall be designed to form a leak resistant joint. Maxidimple bands shall have two rows of circumferential dimples spaced approximately 100 to 150 millimeters on center. Coupling band widths shall be at least 175 millimeters for pipe 300 through 750 millimeters in diameter and 265 millimeters for pipe 900 through 3000 millimeters in diameter. Coupling bands shall be not more than 2.8 millimeters and not less than 1.3 millimeters in thickness and shall be equal to the pipe thickness or up to two thicknesses lighter than the pipe thickness. Where required by the plans, the vertical diameter of round flexible pipe shall be increased 5 percent in accordance with the standard drawings.

2. **Asphalt-coated corrugated steel culvert pipe and pipe arches** shall conform to the requirements of AASHTO M190 with the following modifications:

   a. Steel to be coated shall be free from contaminants and shall be immersed in asphalt having a temperature of 200 ± 6 °C. When pipe is preheated to 150 °C, the temperature of the asphalt shall be at least 190 °C.

      The duration of the first immersion of the steel in the hot asphalt shall be at least as follows:

Pipe Thickness (mm)	**Time (min)**
1.3	2
1.6	2.5
2.0	3
2.8	5
3.5	6.5
4.3	8

   b. Steel shall be dipped a second time to give a total coating of at least 1.25 millimeters in thickness.

   c. Coupling bands need not be coated unless required for watertightness.

d. Samples for testing asphalt may be taken from the dipping vat prior to coating.

e. When a sheet thickness other than the minimum specified for a particular size of pipe or arch is to be coated, an embossed seal bearing the thickness of the steel shall be attached to each pipe or arch prior to dipping the pipe or arch in asphalt. The seal shall be secured through a drilled or punched hole, having a diameter of not more than 10 millimeters, approximately 25 millimeters from the end of the section of the pipe or arch. The seal shall remain attached to the pipe or arch for rapid identification of the thickness of the steel.

f. A mastic may be used in lieu of applying asphalt coating in the shop. Mastic shall conform to the requirements of, and be applied in accordance with the requirements of, AASHTO M243.

3. **Corrugated steel pipe for underdrains** shall conform to the requirements of AASHTO M36M.

4. **Black and galvanized steel pipe:**

a. **Black steel pipe for bridge deck drains and drainage systems** shall conform to the requirements of ASTM A53, extra strong (Schedule 80), with a wall thickness of at least 8.5 millimeters except that the hydrostatic test will not be required.

b. **Galvanized steel pipe for handrails** shall conform to the requirements of ASTM A53 for standard or extra strong pipe as indicated except that the hydrostatic test will not be required.

c. **Black and galvanized steel pipe for miscellaneous items** shall conform to the requirements of ASTM A53 except that the hydrostatic test will be required only when the pipe is used as pressure pipe.

5. **Smooth-wall steel pipe** (jacked or casing for general use) shall be round, seamless, or welded steel, new material certified with a mill report. The thickness of the pipe wall shall conform to the following:

Pipe Size (Outer Diameter) (mm)	Wall Thickness (mm)
320	6.0
400	6.0
450	8.0
600	10.0
750-1200	12.6

6. **Steel water pipe, flanges, and fittings:**

   a. **Steel pipe** shall conform to the requirements of AWWA C200 for the minimum design working pressure, wall thickness, and type of pipe ends as specified. The protective coating shall conform to the requirements of AWWA C203 for coal tar protective coating, and the lining shall conform to the requirements of AWWA C205 for cement mortar lining.

   b. **Flanges** shall conform to the requirements of AWWA C207 as specified for pressure rating and size.

   c. **Fittings** shall conform to the requirements of AWWA C208.

7. **Steel encasement pipe for water mains and sanitary sewers** shall conform to the requirements of ASTM A139 for the class and thickness specified and shall have beveled edges suitable for field welding.

8. **Galvanized steel water pipe and fittings:**

   a. **Galvanized steel pipe** shall conform to the requirements of ASTM A53, Schedule 40 or 80, for the size; method of manufacture; type, plain or threaded; couplings; and class specified.

   b. **Fittings** shall be galvanized, malleable iron conforming to the requirements of ASTM A47. Threads shall conform to the requirements of ANSI B2.1.

9. **Concrete lined corrugated steel pipe** shall conform to the requirements of (c)1. herein. Prior to placement of the concrete lining, steel pipe shall be asphalt coated in accordance with the requirements of (c)2. herein. The concrete lining shall be at least 3 millimeters in thickness over the inside crest of corrugation. Concrete for the lining shall be composed of cement, sand, and water, mixed to produce a dense, homogeneous lining.

Pipe sections shall be connected using a hugger band with O-rings. After pipe is installed, the separation between pipe sections shall be filled with a cement grout. After finishing, the area shall be sprayed with a liquid membrane forming compound.

(d) **Structural Plate Pipe, Pipe Arches, and Arches:** Pipe, pipe arches, and arches shall conform to the requirements of AASHTO M167M. When asphalt coating is required, it shall be an asphalt mastic applied to the structure after assembly. The asphalt mastic shall conform to the requirements of, and be applied in accordance with the requirements of, AASHTO M243.

Aluminum structural plate pipe, pipe arches, and arches shall conform to the requirements of AASHTO M219M.

(e) **Aluminum Alloy Pipe:**

1. **Corrugated aluminum alloy culvert pipe and pipe arches** shall conform to the requirements of AASHTO M196M.

   When the plans specify that corrugated aluminum pipe is to be furnished with a paved invert, the pipe shall be asphalt coated in accordance with the requirements of AASHTO M190, Type B.

   Aluminum pipe used for storm drains shall conform to the requirements of AASHTO M196M except that it shall be of smooth wall, spiral ribbed construction. Connecting bands for aluminum drain pipe shall conform to the corrugations or rib of the pipe to which it is connecting.

2. **Corrugated aluminum alloy pipe underdrains** shall conform to the requirements of AASHTO M196M, Type III. When used as combination underdrains, pipe shall not be perforated.

(f) **Vitrified Clay Pipe and Fittings:** Pipe and fittings shall conform to the requirements of AASHTO M65, extra strength, or, for sanitary sewer, may conform to the requirements of ASTM C700, extra strength. Joints for sanitary sewer shall conform to the requirements of ASTM C425. Plain and perforated clay pipe for drain fields shall conform to the requirements of ASTM C700, extra strength.

(g) **PVC Plastic Pipe:**

1. **PVC water and pressure sewer pipe** shall conform to the requirements of AWWA C-900, PC-150 for water facilities and ASTM D1785 for pressure sewers and shall have a pressure rating of at least 1.0 megapascal.

2. **PVC gravity sewer pipe** shall conform to the requirements of ASTM D3034; SDR35; ASTM F794, Series 46; or ASTM F949.

3. **PVC storm drains** shall conform to the requirements of AASHTO M304 or ASTM F949.

4. **PVC underdrains** shall conform to the requirements of ASTM F758, Type PS 28, or ASTM F949.

(h) **Glass Fiber Reinforced Epoxy Pipe and Fittings:** Pipe and fittings shall conform to the requirements of ASTM D2996, ASTM D2997, or AWWA C950 with a continuous rating of at least 1.0 megapascal at 66 °C for pipe, fittings, and adhesive joints.

(i) **ABS Pipe:**

1. **ABS semiround underdrain pipe with top shield** shall be at least 115 millimeters in diameter with drain holes 6 to 9 millimeters in diameter drilled at least 20 millimeters apart under the roof line. Pipe shall have a mass of at least 1.2 kilograms per meter. When used as combination underdrains, pipe shall not be perforated.

2. **ABS sewer pipe and fittings** shall conform to the requirements of ASTM D2680 for the type of joints specified and shall have a pressure rating of at least 1.0 megapascal.

(j) **PE Pipe:**

1. **PE corrugated underdrain pipe** shall conform to AASHTO M252. Pipe shall be supplied in individual lengths with no lengths shorter than 3 meters. Coil pipe will only be permitted in 100 millimeter diameter, provided it is machine installed. When used as combination underdrain or outlet, the pipe shall be smooth wall, nonperforated.

2. **PE corrugated culvert pipe** shall conform to the requirements of AASHTO M294. PE pipe used for storm drains and entrances shall conform to classification Type S. For all other applications, PE pipe shall be Type C.

3. **PE pipe and fittings** shall conform to the requirements of AWWA C-901 for water mains and ASTM D2239, Grade P34, for sanitary sewers and shall have a pressure rating of at least 1.0 megapascal.

(k) **Copper Water Pipe or Tubing:** Pipe or tubing shall conform to the requirements of ASTM B88M and shall have the cast or wrought

pattern. Fittings for concealed soft drawn pipe may be the flared mechanical type. Unions shall be the ground joint type.

(l) **Polybutylene Pipe and Fittings:** Pipe and fittings shall conform to the requirements of AWWA C902 for water mains and ASTM F809M for sanitary sewers.

SECTION 233—GALVANIZING

233.01—Description.

These specifications cover the use and repair of zinc coatings (galvanizing) on a variety of materials.

233.02—Detail Requirements.

Galvanizing of fabricated items shall be performed after fabrication.

Galvanized items shall be stored off the ground in a manner that will allow free drainage of water from galvanized surfaces.

(a) **Galvanizing of iron and steel hardware** shall conform to the requirements of ASTM A153 for the hot-dip process or ASTM B695, Class 50, for the mechanical process.

(b) **Galvanizing of rolled, pressed, and forged steel shapes, plates, bars, and strips** shall conform to the requirements of ASTM A123.

233.03—Repair of Galvanized Surfaces.

Galvanized surfaces that have been welded, abraded, or damaged shall be repaired by wire brushing the damaged areas thoroughly, removing foreign substances and the damaged coating until bare metal is attained, and treating the cleaned areas with a galvanizing compound in accordance with the manufacturer's recommendations.

Galvanizing repair compound may be furnished as either a stick, powder, or paint. The powder and stick forms shall be liquid at 250 °C when tested in accordance with the requirements of VTM-27.

1. **Powder** shall be a finely divided alloy of prime zinc, tin, and lead combined with a flux of zinc or ammonium chloride. Powder shall not become liquid in the container when exposed to the atmosphere.

2. **Stick** shall be cast from prime zinc, tin, and lead in combination with fluxing ingredients.

3. **Paint** shall conform to the requirements of FS TT-P-641 or MIL-P-21035.

SECTION 234—GLASS BEADS FOR REFLECTORIZING TRAFFIC MARKINGS

234.01—Description.

This specification covers glass beads for application on liquid traffic marking materials so as to produce a reflective surface.

234.02—Detail Requirements.

Beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and weather. Glass beads shall be spherical in shape and shall conform to AASHTO M247, Type 1, except that at least 80% of the beads shall be round when tested in accordance with the requirements of VTM-18. Beads shall be essentially free of sharp angular particles, milkiness, and surface scoring or scratching.

SECTION 235—RETROREFLECTORS

235.01—Description.

Retroreflectors shall consist of a housing/backing with a retroreflective surface on the front and back, if applicable.

Retroreflectors for delineators and pavement markers, except temporary markers, shall be molded of methyl methacrylate plastic conforming to Federal Specification L-P-380, Type I, Class 3.

Retroreflectors for temporary pavement markers shall have a surface consisting of reflective sheeting or a plastic prismatic element. The housing/backing for temporary pavement markers shall be constructed of methyl methacrylate plastic conforming to the requirements of Federal Specification L-P-380, Type I, Class 3.

Retroreflectors for delineators shall be the same color as the adjacent pavement marking. Retroreflectors for pavement markers shall be the same color as the adjacent pavement marking except the back side shall be as follows:

(a) **One-Way Markers:** The backside shall be red for white raised and white snow plowable raised pavement markers. The backside shall be blank for recessed, temporary pavement markers and yellow raised and yellow snow plowable raised pavement markers.

(b) **Two-Way Markers:** The backside shall match the adjacent pavement marking, except on recessed markers, which shall be blank.

Section 235.02—Detail Requirements

(a) **Steel castings for snow plowable pavement markers** shall conform to ASTM A536, hardened to 52-54 RC, and shall have a mass of approximately 2.5 kilograms. Keels shall be parallel, approximately 18 millimeters thick by 48 millimeters in depth, and shall have notched edges. The forward and rear noses of the casting shall be shaped to deflect snowplow blades. Castings shall retain their hardness after removal of adhesives and other foreign residues or shall be capable of conforming to the specified hardness with additional heat treating to ensure recyclability of the castings.

(b) **Plastic panels for delineators** shall be at least 2 millimeters thick, have a minimum tensile strength at yield of 35 megapascals when tested in accordance with ASTM D638, and have minimum impact strengths of 160 newtonmeters per meter of notch at -29 °C and 75 newtonmeters of notch at 23 °C when tested in accordance with ASTM D256, Method A. The panels shall be flexible and able to recoil, to within 5° of vertical after impact. Panels shall not deteriorate when exposed to the following:

1. Ultraviolet rays
2. Ozone
3. Exhaust fumes
4. Petroleum products
5. Deicing salts
6. Herbicides

(c) **Aluminum panels for delineators** shall be at least 1.6 millimeters thick conforming to ASTM B-209, alloy 5052.

(d) **Delineators** shall have the retroreflective surface and the housing/ backing fused to form a homogenous unit sealed against dust, water, and vapor. Retroreflectors shall show no change in shape or color when subjected to 4 hours in a circulating air oven at 75 ° to 80 °C. The adhesion system shall be as recommended by the manufacturer.

The specific intensity shall not be less than the values below:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		Clear	Yellow
0°	0.1°	119	71
20°	0.1°	47	28

(e) **Raised, recessed, and snow plowable raised pavement markers** shall have a retroreflective surface area of no less than 10 square centimeters, and the slope of the reflective surfaces shall be no less than 30° or more than 33° when measured from the pavement surface. The reflective surface shall be protected with a bonded glass face or coated with a clear acrylic compound that utilizes an ultraviolet inhibitor.

The specific intensity shall not be less than the values below when tested in accordance with VTM-70:

Raised and Recessed Pavement Markers

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)		
		White	Yellow	Red
0°	0.2°	3.0	1.8	0.75
20°	0.2°	1.2	0.72	0.25

Snow Plowable Raised Pavement Markers

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)		
		White	Yellow	Red
0°	0.2°	4.0	2.4	1.0
20°	0.2°	1.6	0.96	0.4

The crushing strength shall be not less than 1815 kilograms when tested in accordance with VTM-71.

Raised and recessed pavement markers shall be at least 100 millimeters and not more than 120 millimeters in width and not more than 14 millimeters in height.

Retroreflectors for snow plowable raised pavement markers shall be installed in steel castings conforming to Section 235.02(a) and shall have a nominal width of 100 millimeters excluding the castings.

(f) **Temporary pavement markers** shall have a retroreflective surface of no less than 625 square millimeters. The specific intensity shall not be less than the values below:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		White	Yellow
0°	0.2°	3.0	1.8
20°	0.2°	1.2	0.72

SECTION 236—WOOD PRODUCTS

236.01—Description.

These specifications cover structural timber and lumber, miscellaneous wood products, and preservative treatments.

236.02—Detail Requirements.

(a) **Structural timber and lumber** shall conform to the requirements of AASHTO M168. The species and grade of structural lumber shall be as shown on the plans. The Engineer may approve the substitution of another species of equal or greater strength selected from the "Allowable Unit Stresses for Structural Lumber—Visually Graded" of AASHTO's *Standard Specifications for Highway Bridges* or the supplement to *National Design Specification for Stress-Grade Lumber and Its Fastenings* of the National Forest Products Association.

Except as otherwise specified, the species and grade of structural lumber, timber, and posts for the following applications shall be as follows:

1. **Bridges** shall be at least 10,686 kilopascals Fb and:

   a. 125 millimeters x 125 millimeters and larger: Southern Pine, No. 1 Dense or higher grade

   b. 50 millimeters through 100 millimeters x 50 millimeters through 100 millimeters: Southern Pine, No. 2 Dense or higher grade

c. 50 millimeters through 100 millimeters x 125 millimeters and through 150 millimeters: Southern Pine, No. 1 or higher grade

d. 50 millimeters through 100 millimeters x 200 millimeters only: Southern Pine, No. 1 Dense or higher grade

e. 50 millimeters through 100 millimeters x 250 millimeters only: Southern Pine, Non-Dense Select Structural or higher grade

f. 50 millimeters through 100 millimeters x 300 millimeters only: Southern Pine, Non-Dense Select Structural or higher grade

2. **Signs** shall be at least 7,583 kilopascals Fb with material being dressed on all sides and:

   a. 100 millimeters and less in the least dimension: Southern Pine, No. 2 Non-Dense or higher grade

   b. Over 100 millimeters in the least dimension: Southern Pine, No. 1 or higher grade

3. **Guardrail** shall be at least 8,618 kilopascals Fb, Southern Pine, No. 1, Dense or higher grade. In lieu of sawn posts, round Southern Pine posts may be used. Round posts shall have at least a 200 millimeter diameter at the small end, and the diameter of the larger end shall not exceed that of the smaller end by more than 50 millimeters or be greater than 300 millimeters. Round posts shall be drilled and gained to accept the rail element or offset block.

4. **Fence** shall be Southern Pine, No. 2, for line, corner, and brace units.

5. **Signalization and electrical service** shall conform to ANSI Class 5.1.

Sawn material, both rough and dressed, shall be certified by the mill as to grade and shall be grade marked in accordance with the grading rules and basic provisions of the American Lumber Standards (PS-20-70) by a lumber grading or inspection bureau or agency approved by the Department. If dressed, grade mark shall be applied after dressing.

(b) **Timber piles** shall conform to the requirements of ASTM D25. Piles shall be clean peeled and have a butt diameter of at least 250 millimeters. Piles for fender systems or other non load bearing usages will be accepted under the following criteria provided the piles can be properly driven: A straight line from the center of the butt to the center of the tip may lie partly outside the body of the pile, but the distance between the line and pile shall be not more than 1/2 percent of the length of the pile or 75 millimeters, whichever is smaller.

Points for timber piles shall be steel or cast iron and of a shape that will allow a secure connection to the pile and will withstand driving.

Timber piles shall be branded prior to shipment with the supplier brand, year of treatment, species of timber and preservative treatment, retentions, class, and length. Brand symbols shall conform to the requirements of AWPA M6.

(c) **Timber preservatives** shall be used according to their suitability for the condition of exposure to which they will be subjected and shall not be used interchangeably. Treatments shall conform to the following limitations:

1. Waterborne preservatives shall be used for timber where a clean surface is desirable. The moisture content of wood material shall be not more than 19 percent at the time of treatment.

2. Pentachlorophenol may be used for timber that is not to be painted.

3. Preservatives shall conform to the requirements of AASHTO M133 except that coal tar creosote solution will not be permitted.

4. Pressure treatment shall conform to the requirements of AWPA C2 except for piles, which shall conform to the requirements of AWPA C3. Gauge readings will be the criteria for acceptance except in cases involving referee testing, in which the assay method will be the determining computation.

SECTION 237—BEDDING MATERIAL AND BEARING PADS

237.01—Description.

These specifications cover material used under bearing devices of structures.

237.02—Detail Requirements.

(a) **Elastomeric Bearing Pads:** The elastomer portion of pads shall be new neoprene compound. Pads shall be cast under heat and pressure and may be individually molded or cut from pressure-cast stock. Variations from the dimensions shown on the plans shall be not more than the following: thickness, ±1.5 millimeters; width, -3.0 to +6.0 millimeters; length, -3.0 to + 6.0 millimeters. Tolerances, dimensions, finish and appearance, flash, and rubber-to-metal bonding shall conform to the requirements of A 4-F3-T.063-B2, Grade 2, Method B, in accordance with the RMA Rubber Handbook. Pads shall be furnished in one piece and shall not be laminated unless otherwise specified. Pads shall be furnished in identifiable packages.

Adhesive for use with elastomer pads shall be an epoxy-resin compound, compatible with the elastomer, having a sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces.

Laminated pads shall consist of alternate laminations of elastomer and hot-rolled steel sheets molded together as a unit. Outer metal laminations shall be 4.5 millimeters, and inner laminations shall be 2.0 millimeters. Outer laminations of elastomer shall be 6.0 millimeters, and inner laminations shall be of equal thickness (at least 10 but not more than 13 millimeters), depending on the number of laminations and thickness of the pad. Edges of metal laminations shall have a cover of approximately 3.0 millimeters of elastomer. The top and bottom bearing surfaces shall each have an integral sealing rib approximately 3 millimeters in depth, in addition to the specified total thickness, and 4.5 millimeters in width around their peripheries. The bond between the elastomer and metal shall be such that failure shall occur in the elastomer and not between the elastomer and steel when tested for separation. Variations from specified dimensions for individual laminations shall be not more than those specified herein. The total thickness of the complete pad shall not vary more than ±3.0 millimeters.

Material having a nominal durometer hardness of 70 and 50 shall be used for nonlaminated pads and laminated pads, respectively. Test samples will be prepared from finished pads. Samples of each thickness will be taken from 2 full-size pads from each shipment of 300 pads or less, with 1 additional pad for each additional increment of 300 pads or fraction thereof. When tested using the ASTM methods designated, samples shall comply with the following physical requirements:

1. **Original physical properties:** Test results for tear resistance, tensile strength, and ultimate elongation shall be not more than 10 percent below the following specified value:

	Nominal Hardness 50	70
Min. tear resistance, ASTM D624, Die C (kN/m of thickness)	31	35
Hardness, ASTM D2240 (points)	50 ± 5	70 ± 5
Min. tensile strength, ASTM D412 (average MPa of longitudinal and transverse)	17	17
Min. ultimate elongation (%)	400	300

The compressive deflection tested in accordance with the requirements of ASTM D575, Method A, shall be as follows:

a. **Laminated pads:** The maximum compression deflection shall be 5 and 7 percent of the total rubber thickness at loads of 3.5 and 5.5 megapascals, respectively. The maximum shear resistance shall be 0.35 megapascals of the plan area at 25 percent shear deformation at -29 °C. Test pads shall be subjected to a compressive load of 1.5 times the maximum design load without visible damage.

b. **Nonlaminated pads:** When loaded within 2.0 to 5.5 megapascals, material shall show a compressive deflection within 20 percent of that given in the charts of VTM-23, interpolating for actual measured hardness.

2. **Changes in original physical properties:** When pads are oven aged 70 hours at 100 °C in accordance with the requirements of ASTM D573, changes shall be not more than the following:

Property	Value
Hardness (points change)	0 to +15
Tensile strength (% change)	±15
Ultimate elongation (% change)	-40

3. **Extreme temperature characteristics:** Compression set under constant deflection, ASTM D395, Method B, 22 hours at 100 °C, shall be not more than 35 percent. With the low temperature brittleness test, ASTM D746, breaks shall not occur above -29 °C.

4. **Ozone cracking resistance:** Upon exposure to 100 millipascals of ozone in air by volume at a strain of 20 percent and a temperature of 40 °C in a test otherwise in accordance with the requirements of ASTM D1149, cracks shall not develop within 100 hours. Samples shall be wiped with solvent before the test to remove traces of surface impurities.

5. **Oil swell:** The volume change shall be not more than +120 percent when tested in accordance with the requirements of ASTM D471 with ASTM Oil No. 3, 70 hours at 100 °C.

(b) **TFE Bearing Surfaces:**

1. TFE resin shall be virgin material conforming to the requirements of ASTM D1457. The specific gravity shall be 2.13 to 2.19. The melting point shall be 328 ± 1 °C.

2. Filler material shall be milled glass fibers, carbon, or other approved inert filler materials.

3. Adhesive material shall be an epoxy resin conforming to FS MMM-A-134, FEB film or equal, as approved by the Engineer.

4. When tested in accordance with the requirements of ASTM D1457, finished unfilled TFE sheets shall have a tensile strength of at least 19.3 megapascals and an elongation of at least 200 percent.

5. Filled TFE sheets shall contain inert filler material uniformly blended with TFE resin. Finished filled TFE sheets containing glass fiber or carbon shall conform to the following:

	ASTM Method	**15% Glass Fibers**	**25% Carbon**
Min. tensile strength	D1457	13.8 MPa	8.9 MPa
Min. elongation	D1457	150%	75%
Min. specific gravity	D792	2.20	2.10
Melting point	D1457	327 ± 10 °C	317 ± 10 °C

6. Fabric containing TFE fibers shall be manufactured from oriented multifilament TFE fluorocarbon fibers and other fibers as required by specific designs. When tested in accordance with the requirements of ASTM D2256, the tensile strength of TFE

fibers shall be at least 165 megapascals and the elongation shall be at least 75 percent.

7. Where TFE sheets are to be epoxy bonded, one surface of the sheet shall be factory treated by an approved manufacturer using the sodium naphthalene or sodium ammonia process.

8. Stainless steel mating surfaces shall be at least 1.6 millimeters in thickness and shall conform to the requirements of ASTM A240, Type 304. The mating surface shall be a true plane surface with a Brinnel hardness of at least 125 and a surface finish of at least No. 8 mirror finish in accordance with the requirements of ASTM A480M. Stainless steel mating surfaces shall be polished or rolled as necessary to conform to the friction requirements specified herein. The stainless steel shall be attached to the sole plate by means of a seal weld around the entire perimeter of the facing material.

9. The coefficient of friction for the completed bearing assembly shall be not more than the following:

	Bearing Pressure		
Material	**(3.5 MPa)**	**(13.8 MPa)**	**(24.1 MPa)**
Unfilled TFE, fabric containing TFE fibers, TFE perforated metal composite	.08	.06	.04
Filled TFE	.12	.10	.08
Interlocked bronze and filled TFE structures	.10	.07	.05

(c) **Sheet Lead and Common Desilverized Bedding Material:** Material shall conform to the requirements of ASTM B749 and shall be furnished in single sheets of the specified thickness.

(d) **Preformed Fabric Bedding Material:** Material shall be composed of multiple layers of 2.4 kilograms per square meter cotton duck impregnated and bound with high-quality natural rubber or its equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plys shall be such as to produce the specified thickness after compression and vulcanizing. Finished pads shall withstand compression loads perpendicular to the plane of the laminations of at least 69 megapascals without a detrimental reduction in thickness or extrusion.

SECTION 238—ELECTRICAL AND SIGNAL COMPONENTS

238.01—Description.

These specifications cover conduits, conductors, junction boxes, traffic signal components, and necessary fittings to complete a described electrical or traffic signal system.

238.02—Detail Requirements.

(a) **Metal Conduit and Fittings:** Conduit shall conform to the requirements of, and be galvanized in accordance with the requirements of, UL-6. Fittings for metal conduit shall conform to the requirements of, and be galvanized in accordance with the requirements of, UL-514. Conduit for use in underground installations, concrete encasements, or corrosive environments shall also be coated on the outside with an asphalt mastic in accordance with the requirements of AASHTO M243 or shall have a PVC coating of 1.00 millimeter or another approved coating.

(b) **PVC Conduit and Fittings:** Conduit shall be heavy wall conduit conforming to the requirements of UL-651. Fittings for PVC conduit shall conform to the requirements of UL-514. Exposed PVC conduit shall be UL listed or ETL Testing Laboratories, Inc. listed for use in direct sunlight. Each section of conduit shall be marked with the letters "UL" or "ETL." Solvent cement used for joining shall conform to the requirements of ASTM D2564. Protective shields shall be galvanized sheet steel of commercial quality with an ASTM A525M coating designation of G115 and a thickness of 1.6 millimeters.

(c) **Fiberglass Reinforced Epoxy Resin Conduit and Fittings:** Conduit and fittings shall conform to the requirements of NEMA TC-14. Conduit shall be standard wall except when the conduit diameter is 75 millimeters or less or when used in exposed areas. In such cases, conduit shall be heavy wall. Epoxy adhesive used for joining shall conform to the requirements of NEMA TC-14. Protective shields shall conform to the same requirements as those used with PVC conduit.

(d) **PE Conduit:** PE conduit shall conform to the requirements of NEMA TC-7 for a high-density PE duct except that the wall thickness of conduit with a diameter of 6 millimeters and less shall conform to UL-651 for heavy wall PVC conduit. Conduit shall have a carbon black loading of 2.5 ± 0.5 percent by mass per ASTM D1603. The average diameter of the carbon black shall not be larger than 40

nanometers in accordance with the requirements of ASTM D1514. Conduit shall contain at least 1,000 parts per million of hindered phenolic long term antioxidant per ASTM D3895.

(e) **Splice Boxes or Pull Boxes** (8 cubic decimeters or less): Boxes will be permitted only in exposed areas and shall conform to the requirements of UL-514 and be compatible with the appropriate conduit.

(f) **Electrical and Signal Junction Boxes:** Boxes, frames, and covers shall be watertight except for weep holes. Covers shall be fitted with synthetic rubber blend gaskets and secured with bronze or stainless steel screws.

Boxes, frames, and covers for bridge structure encasements shall be one of the following types:

1. steel castings conforming to the requirements of Section 224, galvanized inside and out

2. welded sheet steel having a thickness of at least 4.5 millimeters or 7 gage, galvanized inside and out

3. polymer concrete with fiberglass sides

Boxes, frames, and covers for other uses shall withstand H-20 loading in accordance with the requirements of AASHTO's Standard Specifications for Highway Bridges HS20-44. Boxes shall be one of the following types:

1. polymer concrete with fiberglass sides

2. cast iron with an asphalt mastic coating on exterior surfaces, except the cover, conforming to the requirements of AASHTO M243 or other protective coating materials specifically manufactured for use in corrosive environments as approved by the Engineer

3. concrete conforming to the requirements of Section 217

4. 6-millimeter steel plate conforming to the requirements of ASTM A36M, galvanized in accordance with the requirements of Section 233, and uniformly coated on exterior surfaces, except the cover, with an asphalt mastic conforming to the requirements of AASHTO M243

Alternate types of boxes may be submitted for review provided they conform to the following:

1. **Loading:** Boxes shall withstand H-20 loading in accordance with AASHTO's Standard Specifications for Highway Bridges HS20-44.

2. **Fire resistance:** Material shall be fire resistant and shall not burn at a rate greater than 3 millimeters per second per 1 meter of thickness when tested in accordance with the requirements of ASTM D635.

3. **Density:** Material shall have an absorption rate less than the requirement for a concrete pipe specified in Section 232.02(a)1.b(7).

4. **Chemical resistance:** Material shall not show appreciable change in physical properties after exposure to weather, oil, gasoline, or snow removal chemicals.

(g) **Conductor Cables:**

1. **Power conductor cables** shall be copper conforming to the requirements of ASTM B3 and B8. Conductor cable sizes shall be based on No. 8 AWG minimum. Conductor cables of No. 8 AWG and larger shall be stranded. Conductor insulation shall be UL listed for the use specified on the plans and rated for 600-volt operation.

   a. **Service entrance conductor cables** shall be UL with Type SE insulation.

   b. **Underground service entrance conductor cables** shall be UL with Type USE insulation.

   c. **Direct burial conductor cables** shall be UL with Type USE or UF insulation.

   d. **Conductor cables in conduit** shall be UL with Type THWN insulation except as follows: When the conduit size specified on the plans is such that the allowable percentage of conduit fill in Table 1, Chapter 9, of NEC is not exceeded, then UL Type RHW, TW, THW, XHHW, or XLPE insulation may be used.

      Where direct burial conductor cables enter a conduit, they may be spliced to THWN conductor cables only at accessible locations.

2. **Communication and signal cables:**

   a. **Signal cables from the controller cabinet to signal heads** shall be No. 14 AWG copper with 3, 4, 7, or 12 straight-lay conductors conforming to the requirements of IMSA 19-1 or 20-1 (aerial and duct) or 19-5 or 20-5 (direct buried). Signal cable used for preemption or pedestrian pushbuttons shall be two-conductor No. 14 AWG conforming to the requirements herein.

   b. **Interconnect cables between controllers** shall be No. 14 AWG solid copper conforming to the requirements of IMSA 19-2 or 20-2 (aerial and duct), 19-4 or 20-4 (self-supporting aerial), or 19-6 or 20-6 (direct buried). When interconnect cable is specified to be either No. 18, 19, or 22 AWG, it shall be solid copper conforming to the requirements of IMSA 39-2 or 40-2 (aerial and duct), 39-4 or 40-4 (self-supporting aerial), or 39-6 or 40-6 (direct buried).

   c. **Loop detector cables** shall be No. 12 AWG stranded copper conforming to the requirements of IMSA 51-3. Insulation shall be Type XHHW. Loop detector cable enclosed in tubing shall be No. 14 AWG stranded copper. Loop detector cable and tubing shall conform to the requirements of IMSA 51-5.

   d. **Loop and magnetic detector lead-in cables** shall be stranded copper, twisted pair, No. 14 AWG conforming to the requirements of IMSA 50-2.

(h) **Electrical Components:**

1. **Safety switches** shall be enclosed in a raintight box conforming to the requirements of NEMA 3R, with a lock on-lock off external switch handle. For signal installations, safety switches shall be rated at 60 AMP/240 volts, two pole, solid neutral, 120 volt AC, fused to be compatible with the equipment load.

2. **Circuit breaker boxes** (service panel) shall be a NEMA 3R enclosure rated at 60 AMP/240 volts with a solid neutral and shall contain two single-pole, 120-volt AC breakers with an ampere rating compatible with the equipment load, and shall have provisions for padlocking. The service load shall be wired to only one breaker.

3. **Ground rods** shall conform to the requirements of ANSI 135.3 and ASTM A153 or shall be copper-clad rods conforming to the requirements of UL-467. Ground rods shall have a diameter of at least 15 millimeters and a length of at least 2.4 meters.

4. **Ground wires** shall be at least No. 6 AWG conforming to the requirements of ASTM B2.

5. **Ground clamps** shall be heavy duty bronze or brass or galvanized malleable iron conforming to the requirements of ASTM A220, any grade.

6. **Signal head sections:**

   a. **Standard traffic signal head sections** shall conform to the ITE Standard for Vehicle Traffic Control Signal Heads, with the following exceptions and additions:

      (1) Lenses shall be made of glass.

      (2) Reflectors shall be made of glass or aluminum and shall be attached to the signal head housing by a hinged support system that is separate from the door and lens.

   b. **Selective view signal head sections** shall conform to the requirements of Section 4.04 of the ITE Standard for Vehicle Traffic Control Signal Heads.

   c. **Pedestrian signal head sections** shall be made of plastic, nonferrous metal, or a combination thereof. Strength requirements shall conform to the ITE Standard for Vehicle Traffic Control Signal Heads except the number of sections in an assembly shall be as required to provide "Walk" and "Don't Walk" indications.

   d. **Lane use control signal head sections** shall conform to the ITE Standard for Lane Use Traffic Control Signal Heads, with the following exceptions and additions:

      (1) Strength requirements shall conform to the ITE Standard for Vehicle Traffic Control Signal Heads.

      (2) Lenses shall be made of glass.

      (3) Reflectors shall be attached to the signal head housing by a hinged support system that is separate from the door and lens.

7. **Backplates for signal heads:**

   a. **Aluminum** shall conform to the requirements of ASTM B209M, alloy 5052-H38, 5154-H38, or 6061-T6, with a thickness of at least 1.25 millimeters.

b. **Virgin ABS plastic** shall contain 60 percent styrene, 20 percent rubber, and 20 percent acrylic, with a thickness of at least 3 millimeters. Plastic shall contain ultraviolet inhibitors and stabilizers and shall be compounded for application in cold weather. Plastic shall have a tensile stress at yield of at least 36 megapascals at 23 °C and a flexural strength at yield of at least 64 megapascals at 23 °C. Plastic shall conform to or exceed the requirements of UL-94 test H.B. for fire retardance. The color of backplates shall be impregnated into the plastic. Backplates shall be vacuum formed; the inside and outside edges shall be formed with at least a 13-millimeter flange turned away from the front surface.

8. **Cable clamps:**

   a. Two-bolt clamps shall be 100 millimeters in length, made to accommodate span wire ranging from 6 to 11 millimeters in diameter, and shall conform to the requirements of NEMA PH-23 except for clamp dimensions.

   b. Three-bolt clamps shall be the heavy 150-millimeter length type conforming to the requirements of NEMA PH-23 except the clamp dimensions shall be as required to accommodate span wire ranging from 10 to 16 millimeters in diameter.

9. **Cable rings and lashing wire**s shall be weather resistant and the industry standard.

10. **Connectors and terminals** shall conform to the requirements of NEC 110. Breakaway connectors shall consist of line and load side sections designed to separate without breaking the conductor. Connectors shall be waterproof with an insulation rating of 600 volts. Current carrying components exposed when the connector is separated shall be in the load section of the connector. Connectors for the hot conductors shall be designed for 10 millimeter by 38 millimeter cartridge type fuses. Fuses shall be rated at 10 amps.

11. **Angle thimbleyes** shall conform to the requirements of REA, Item 5.

12. **Span wire saddle clamps** for span wire connection on a bridle span shall use U-bolts for securing the clamp to the span wire and shall be galvanized malleable iron with a tensile strength of 110 kilonewtons.

13. **Stainless steel straps** shall be solid, with a tensile strength of at least 690 megapascals.

14. **Service entrance heads** shall be galvanized malleable iron.

15. **Signal lamps** shall conform to the requirements of the ITE Standards for Traffic Signal Lamps.

16. **Tether wire** shall conform to the requirements of ASTM A475, Common Grade, Class A, seven strand, or Type I, General Purpose, Class I, 6 x 7, iron, galvanized, fiber core, conforming to the requirements of FS RR-W-00410C. The breaking strength of tether cable shall be not more than 13.5 kilonewtons.

17. **Thimbleye bolts** shall conform to the requirements of ANSI C135.4 and the following:

    a. The tensile strength shall be at least 82 kilonewtons for 18-millimeter bolts.

    b. Dimensions for 18-millimeter bolts shall be in accordance with the following as related to Figures 1 and 2 in ANSI C135.4:

Bolt Diameter	A	D	E
18 mm	20 mm	14 mm	8.7 mm

18. **Thimbleye nuts** shall conform to the requirements of ANSI C135.4.

19. **Washers for use with thimbleye bolts** shall conform to the requirements of NEMA PH-10.

20. **Tape:**

    a. **Friction tape** shall conform to the requirements of ASTM D69.

    b. **Vinyl tape** shall conform to the requirements of ASTM D2301, Type 1.

    c. **Rubber tape** shall conform to the requirements of FS HH-T-111C.

21. **Photoelectric controls** shall conform to the requirements of ANSI C136.10 and the following. The photoelectric control shall be solid state, fail-on type, single voltage rated and shall be

factory preset and calibrated to turn on at 16 lux ± 5 lux. The ratio of the turn-off light level to the turn-on light level shall not exceed 1.6. The photoelectric control shall use a cadmium sulfide sensor. The output control relay shall have a time delay of 5 to 15 seconds. The photoelectric control shall have a built-in 160 joule metal oxide varistor for surge/transient protection. The contact shall be mechanical, and contact "chatter" upon opening of the contacts shall not exceed 5 milliseconds. The cover shall be an impact and ultraviolet resistant material that meets the flammability and impact requirements of UL 773. The window shall be made of acrylic with the proper ultraviolet stabilizers added to prevent discoloration. The control shall be capable of withstanding a drop of 1 meter onto a concrete floor without causing damage to the housing or changing the electrical operation.

22. **Miscellaneous signal line hardware and/or attachments** shall be galvanized or stainless steel.

23. **Span wires** shall conform to the requirements of ASTM A475, High-Strength Grade, Class A.

24. **Splice kits** shall be prepackaged and shall consist of a plastic molded body with a compound that moisture seals and provides insulation for the conductor cables for at least 1,000 volts.

25. **Balance adjusters** shall be galvanized ductile iron conforming to the requirements of ASTM A536, Grade 65-45-12; aluminum conforming to the requirements of ASTM B26M, alloy ZC81A; or bronze conforming to the requirements of ASTM B584, alloy C83600.

26. **Span wire clamps** for signal head mounting shall use U-bolts for securing the clamp to the span wire and shall be galvanized malleable iron or aluminum with a tensile strength of 27 kilonewtons.

SECTION 239—SODIUM CHLORIDE AND CALCIUM CHLORIDE

239.01—Description.

These specifications cover chloride used as a stabilizer or to control snow and ice.

239.02—Detail Requirements.

(a) **Sodium chloride** shall conform to the requirements of AASHTO M143, Type I, with the following exceptions:

1. The sodium chloride content shall be at least 97 percent of the dry mass.

2. The moisture content shall be not more than 5 percent.

3. When shipped in bulk, sodium chloride shall contain an anticaking additive.

4. Sodium chloride will be tested in accordance with the requirements of VTM-28.

When practicable, samples will be taken at the source from indoor storage or adequately protected outdoor storage at the rate of approximately one sample per 4,000 metric tons. Samples will not be taken from uncovered storage.

When inspection at the source is not practicable or when material is shipped from uncovered storage, samples will be taken at the destination at the time of delivery.

When shipments of sodium chloride are made from approved stock at the source, inspection service will be provided when the frequency of shipments makes it economically justified. This inspection will be indicated by the Inspector's stamp on the shipping or delivery report. When inspection service is not provided, the supplier may ship but shall certify that the material came from an approved source. The certification may be stamped on the shipping or delivery report but shall be signed by an authorized representative of the company.

(b) **Calcium chloride** shall conform to the requirements of AASHTO M144.

SECTION 240—LIME

240.01—Description.

These specifications cover lime to be used as a stabilizer or soil conditioner.

240.02—Detail Requirements.

(a) **Hydrated lime** shall conform to the requirements of ASTM C207, Type N, except that the average percentage of calcium oxide shall be at least 93. Single test results shall not be below 90 percent.

(b) **Hydraulic lime** shall conform to the requirements of ASTM C141.

(c) **Agricultural lime:**

1. **Ground limestone** shall be of such fineness that at least 86 percent will pass a 850 micrometer sieve, at least 47 percent will pass a 250 micrometer sieve, and at least 28 percent will pass a 150 micrometer sieve. Material shall have a calcium carbonate equivalent of at least 85 percent.

2. **Pulverized limestone** shall be of such fineness that at least 90 percent will pass a 850 micrometer sieve and at least 66 percent will pass a 150 micrometer sieve. Material shall have a calcium carbonate equivalent of at least 85 percent.

(d) **Lime for soil stabilization** shall be quicklime or hydrated lime conforming to the requirements of AASHT0 M216.

SECTION 241—FLY ASH

241.01—Description.

These specifications cover fly ash (burnt coal residue) used as an additive in hydraulic cement concrete or as a soil stabilizer.

241.02—Detail Requirements.

(a) Fly ash used in hydraulic cement concrete shall conform to the requirements of ASTM C618, Class F or Class C.

(b) Fly ash used in lime stabilization shall conform to the requirements of ASTM C593. Bulk material may be used as approved by the Engineer.

SECTION 242—FENCES

242.01—Description.

These specifications cover material requirements for fence components used in the construction of chain link, pedestrian, barbed wire, woven wire, and lawn fences and material specifications for temporary silt fences, geotextile fabric silt barriers, and filter barriers used for erosion control.

242.02—Detail Requirements.

Unless otherwise specified hereinafter, metallic fence materials shall conform to the requirements of AASHTO M181. Steel posts and braces for standard fence and chain link fence may be fabricated from pregalvanized material in lieu of galvanizing after fabrication provided ends and other areas of exposed metal are satisfactorily repaired using a material conforming to the requirements of Section 233.

(a) **Chain Link and Pedestrian Fences:** Fabric material shall be 3.76-millimeter diameter core, new, and shall conform to the following:

1. **Galvanized wire fabric** for use in chain link fence shall be hot-dip galvanized after weaving in accordance with the requirements of ASTM A392, Class II, and for use in pedestrian fence shall be hot-dip galvanized after weaving in accordance with the requirements of ASTM A392, Class I.

2. **Aluminum alloy wire fabric** shall conform to the requirements of FS RR-F-191/1B, Type III.

3. **Aluminum coated wire fabric** shall conform to the requirements of AASHTO M181, Type II.

4. **Vinyl coated wire fabric** shall conform to the requirements of AASHTO M 181, Type IV, Class B or Class A, extruded and bonded except that vinyl coated wire may be 3.76-millimeter overall diameter, including coating, provided it has a breaking strength of no less than 5.7 kilonewtons.

5. **End, corner, and gate posts** shall be one of the following:

   a. welded or seamless steel galvanized pipe conforming to the requirements of ASTM F1083, Schedule 40

   b. roll formed steel sections, galvanized in accordance with the requirements of ASTM A123

c. aluminum alloy pipe conforming to the requirements of ASTM B241M, alloy 6063-T6, Schedule 40

d. acrylic or polyurethane coated galvanized pipe fabricated from steel conforming to the requirements of ASTM A569M, galvanized with a zinc coating of at least 0.27 kilogram per square meter, a chromate coating of at least 23 milligrams per square meter, and an acrylic or polyurethane top coating with a zinc rich exterior thickness of at least 8 micrometers.

e. vinyl coated pipe conforming to the requirements of AASHTO M 181.

6. **Line posts** shall be one of the following:

a. steel H-columns conforming to the requirements of ASTM A572M or equivalent steel, galvanized in accordance with ASTM A123

b. round galvanized steel pipe conforming to the requirements of ASTM A53, Schedule 40

c. roll formed C-section, galvanized in accordance with the requirements of ASTM A123

d. aluminum alloy H-columns conforming to the requirements of ASTM B221M, alloy 6063-T6

e. aluminum alloy round pipe conforming to the requirements of ASTM B241M, alloy 6063-T6, Schedule 40

f. acrylic coated or polyurethane coated galvanized pipe conforming to the requirements of (a)5.d. herein

g. vinyl coated pipe conforming to the requirements of (a)5.e. herein

7. **Braces** shall be one of the following:

a. welded or seamless steel galvanized pipe conforming to the requirements of ASTM A53, Schedule 40

b. roll formed sections, galvanized in accordance with the requirements of ASTM A123

c. aluminum alloy pipe conforming to the requirements of ASTM B241M, alloy 6063-T6, Schedule 40

d. acrylic coated or polyurethane coated galvanized pipe conforming to the requirements of (a)5.d. herein

e. vinyl coated pipe conforming to the requirements of (a)5.e. herein

8. **Gates** shall be complete with hinges, latches, stops, and other necessary fittings. Gate frames furnished for use with galvanized or aluminum coated fabric shall be galvanized; those furnished for use with aluminum alloy fabric shall be aluminum alloy or galvanized; and those furnished for use with vinyl coated fabric shall be vinyl coated.

9. **Aluminum alloy post surfaces that will be in contact with concrete and up to 25 millimeters above concrete** shall be uniformly coated with aluminum impregnated caulking compound or a solvent asphalt fiber filled and aluminum pigmented coating conforming to the requirements of FS TT-C-00498. The coating shall be applied without the addition of thinner. Care shall be taken to prevent voids in the coating and the smearing of visible surfaces of concrete or posts except as otherwise noted herein.

10. **Tension wire** shall be 4.5-millimeter diameter, galvanized or vinyl coated coil spring wire.

11. **Fittings** shall be malleable iron, cast iron, or pressed steel galvanized in accordance with the requirements of ASTM A123; shall have the same finish as posts; or shall be aluminum alloy.

(b) **Barbed Wire Fence, Woven Wire Fence, and Lawn Fence:** Barbs shall be locked into position, prohibited from turning or slipping, and spaced on 125-millimeter (±13 millimeter) centers.

1. **Barbed wire** shall conform to one of the following:

a. ASTM A121, Class 1 or 2, double strands, 2.70-millimeter diameter with four barbs of 2.0-millimeter diameter wire.

b. ASTM A121, double strands, 1.70-millimeter diameter with four barbs of 1.48-millimeter diameter wire except that the tensile strength of the line wire shall be at least 2.0 kilonewtons per strand and the zinc coating shall be at least 200 grams per square meter.

c. single strand oval shaped wire having a diameter of at least 2.0 millimeter in its least dimension but not more than 3.5

millimeter in its greatest dimension and a tensile strength of at least 5 kilonewtons; wire shall have four barbs of 2.0-millimeter diameter wire and a zinc coating of at least 90 grams per square meter.

2. **Woven wire fence fabric** shall conform to the requirements of AASHTO M279. Standard FE-W1 shall conform to Design No. 1047-6-11, Class 3, or No. 1047-6-12, Class 3, having a breaking strength of no less than 3.0 kilonewtons or 4.25 kilonewtons, respectively. Standard FE-W2 shall conform to Design No. 1047-12-11, Class 3, or No. 1047-12-12, Class 3, having a breaking strength of no less than 3.0 kilonewtons or 4.25 kilonewtons, respectively. Brace wires shall be 3.76-millimeter diameter.

3. **Lawn fence** shall be the type shown on the plans, a similar type that will match the existing fence, or as desired by the landowner and approved by the Engineer.

4. **Wood post and braces:**

   a. **Species of wood:** Posts and braces for standard fence shall be Southern pine, Ponderosa pine, Douglas fir, Western hemlock, larch, or white or red cedar as defined in AASHTO M168. Locust may be used for woven wire farm fence and barbed wire fence.

   b. **Cutting requirements:** Round or square posts and braces shall be cut from live growing trees.

   c. **Seasoning:** Posts and braces shall be sufficiently air seasoned in an approved manner for a suitable length of time under favorable climatic conditions or otherwise conditioned as part of the treating process to permit adequate penetration of preservative without damage to the wood.

   d. **Peeling:** Posts and braces shall have the inner bark removed to the extent defined by the SPIB. Knots and projections shall be cut or shaved smooth and flush with the surrounding surface of the unit.

   e. **End finish:** Butt ends of posts shall be sawn square.

   f. **Dimensions:** Posts shall not vary from the length specified on the plans by more than 25 millimeters. Thickness dimensions shall be undressed dimensions and shall not vary from the dimensions shown on the plans by more than 6 millimeters.

g. **Straightness:** Wood posts and braces shall be free from bends in more than one place and free from short or reverse bends. The straightness of the post or brace shall be such that a straight line from the center of the tip to the center of the butt shall not depart from the center of the post by more than 2 percent of the length.

h. **Grading for square posts and braces:** Grading shall conform to the requirements of (b)4.a. herein.

i. **Preservative treatment:** Posts and braces, except cedar and locust, shall be treated with a preservative in accordance with the requirements of Section 236 except that waterborne preservatives shall not be used in the treatment of posts and braces to be erected in marshy areas. Oil-borne preservatives shall not be used where posts and braces will come in contact with salt water.

Cutting and trimming of ends shall be performed prior to treatment.

5. **Metal posts and braces:** Post anchor plates shall have a surface area of at least 100 cubic meters. Posts shall be in accordance with the following:

a. **Steel posts and braces** shall be galvanized and shall conform to the requirements of Section 233.

b. **Acrylic coated or polyurethane coated galvanized posts for corner and line braces** shall conform to the requirements of (a)5.d. herein.

6. **Gates** similar in type to those that exist may be substituted for gates shown on the plans or standard drawings if preferred by the landowner and approved by the Engineer.

(c) **Temporary Silt Fences, Geotextile Fabric Silt Barriers, and Filter Barriers:**

1. **Geotextile fabric** shall conform to the requirements of Section 245.

2. **Posts for temporary silt fences** shall be a nominal 50 millimeter by 50 millimeter No. 2 Southern pine or steel having a mass of at least 1.9 kilograms per meter and a length of at least 1.5 meters.

3. **Wire fence reinforcement for temporary silt fences** using standard strength geotextile fabric shall be at least 0.9 meter in

height, at least 1.9 millimeters in diameter, and shall have a mesh spacing of more than 150 millimeters.

4. **Burlap fabric for temporary filter barriers** shall conform to the requirements of AASHTO M182, Class 3, and shall provide at least 3 months of expected usable construction life.

5. **Supports for temporary filter barriers** shall be a nominal 25 millimeters by 50 millimeters or 38-millimeter diameter No. 2 Southern pine or steel having a mass of at least 1.5 kilograms per meter.

SECTION 243—EPOXY-RESIN SYSTEMS

243.01—Description.

These specifications cover epoxy-resin systems to be used for all applications requiring bonding of various materials or as patching or overlay of concrete slabs.

243.02—Detail Requirements.

Epoxy-resin materials shall conform to the applicable requirements of Tables II-19 and II-21. The infrared spectrum for each component shall essentially match that of the standard infrared spectrum for the particular component as specified in AASHTO T237, Sections 4 and 5.

TABLE II-19
Epoxide Equivalent

Type	EP-3B	EP-3T	EP-4	EP-5	EP-6
Property	**Max.**	**Max.**	**Max.**	**Max.**	**Max.**
Epoxide equivalent	245	220	225	270	245

(a) Epoxy Systems:

1. **Types EP-3B and EP-3T** shall be 100 percent reactive high build coatings designed as a two-coat (minimum) system for protection of concrete exposed to splash zones and tidal water. Type EP-3B shall be the prime or base coat, and Type EP-3T shall be the finish or top coat.

TABLE II-21

Requirements: Mixed Epoxy Systems

Property	EP-3B Red		EP-3T Gray		EP-4 Straw		EP-5[1] Straw		EP-6 Lt. Straw	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Pot life at 25 °C	40	65	40	65	35	55	35	35	20	30
Tensile strength MPa at 25 °C	—	—	—	—	20	—	15	—	10	—
Tensile elongation (%) at 25 °C	—	—	—	—	1	3	5	15	5	15
Water absorption (Max. %)	—	0.8	—	0.8	—	0.8	—	0.8	—	0.8
50 mm Cubes compressive (MPa, 24 hr, dry) (min.)	—		—		40		—		—	
Strength (MPa, 48 hr, wet) (min.)	—		—		50		30		30	
Bond strength: (7 day) Hardened concrete to hardened concrete or fresh concrete (MPa min.)	20 under max.		20 under max.		20 under max.		—		20	
Ash content (%)	20	30	10	20	—	0.5	—	0.5	5	15
Viscosity										
Pa·s	4.0	10.0	4.0	15.0	2.0	4.0	1.0	2.5	—	—
Spindle No.	4		4		3		3		Gel	
Speed	10 or 20		10 or 20		20		20			
Volatile content (max. %)			6.0		3.0		3.0		3.0	

[1]Epoxy system EP-5LV shall have the same requirements as epoxy system EP-5 except that the viscosity shall be less than 0.9 Pa·s.

2. **Types EP-4, EP-5, and EP-6** shall be moisture insensitive systems designed for structural bonding, sealing, and grouting of dry, damp, or wet structural material free from standing water. Mortar shall be prepared by mixing 3 1/4 parts by volume of loose oven-dried sand to 1 part of premixed Type EP-4 or EP-5 epoxy; however, Type EP-6 shall be mixed on a 1:1 ratio.

   Mortars shall be mixed to a uniform consistency.

   Type EP-4 shall be a high modulus, rigid, general purpose adhesive with a tensile elongation of 1 to 3 percent. Type EP-4, low viscosity, shall be used to seal rigid cracks.

   Type EP-5 shall be a low modulus patching, sealing, and overlay adhesive with an elongation of at least 10 percent. When used as a penetrating sealer and to repair nonrigid cracks, Type EP-5 shall be of a low viscosity.

   Type EP-6 shall be a low modulus, nonsagging, flexible adhesive with an elongation of at least 5 percent. Type EP-6 shall be used for bonding or repairing damp and underwater surfaces where a nonsagging, low modulus material is required.

(b) **Classes:** Epoxy resin shall be formulated for use at specific temperatures. Three classes of systems are defined according to the range of temperatures for which they are suited. The controlling temperature shall be that of the surface of the hardened concrete to which the bonding system is applied.

   Where unusual curing rates are desired and upon the approval of the Engineer, a class of bonding agent may be used at a temperature other than that for which it is normally intended. The class and gel temperature shall be as follows:

   1. **Class A:** for use below 5 °C

   2. **Class B:** for use between 5 °C and 15 °C

   3. **Class C:** for use above 15 °C

(c) **Mixing Epoxy:** Epoxy resin shall be furnished in two components for combining in accordance with the manufacturer's instructions immediately prior to use. Component A shall contain a condensation product of epichlorohydrin with bisphenol A and shall conform to the requirements of Table II-19. Component B shall contain one or more hardening agents that will cause the system to polymerize and harden on mixing with Component A in accordance with Table II-21. Thixiotropic agents used to control viscosity will be permitted in

accordance with the manufacturer's recommendations. If the mixture proportion of component A to component B exceeds 2:1, only complete units as packaged by the manufacturer shall be used.

Contents of the separate packages containing Components A and B shall be thoroughly stirred prior to use. The same paddle shall not be used to stir Component A that is used to stir Component B. The Contractor shall dispose of solvents used for cleaning in accordance with applicable Virginia Department of Waste Management policies and procedures. Components A and B shall be stored between 20 °C and 30 °C for at least 2 hours before use. Epoxy components may be heated in hot water or by indirect heat prior to mixing to bring them to the required temperature. Solvents and thinners shall not be used except for cleaning equipment.

Mixing of epoxy components shall be in accordance with the manufacturer's instructions.

When mineral fillers are specified, they shall be inert and nonsettling or readily dispersible. Materials showing a permanent increase in viscosity or the settling of pigments that cannot be readily dispersed with a paddle shall be replaced at the Contractor's expense. At least 95 percent of the filler shall pass the 270 µm sieve.

(d) **Aggregates:** Aggregate for surface application work shall be nonfriable, nonpolishing, clean, and free from surface moisture. Silica sand having a well rounded particle shape shall be used. Aggregates that will be exposed to traffic shall have a Mohs scale hardness of at least 7. In surface applications, the aggregate shall be applied on the epoxy surface in excess of the amount necessary to cover the surface, shall be sprinkled or dropped vertically in such a manner that the level of epoxy mixture is not disturbed, and shall be applied within 5 minutes after application of the epoxy. At temperatures below 20 °C, a maximum of 10 minutes will be allowed. The grading analysis of the fine aggregate (silica sand) shall conform to the requirements of Table II-22.

TABLE II-22
Fine Aggregate (Silica Sand)

	Amounts Finer Than Each Laboratory Sieve (Sieve Opening) (% by Mass)					
Grading	**2.36 mm**	**1.18 mm**	**850 mm**	**600 µm**	**425 µm**	**150 µm**
D	Min 100	50±10		Max 3		Max 1
E	Min 100	99±1	95±5		Max 10	

Grading D aggregate shall be used in Class I waterproofing and other skid-resistant applications. Grading E aggregate shall be used in epoxy patching mortars and loop detector sealants. Aggregates shall be oven dried.

243.03—Handling and Storing Materials.

The two components of the epoxy resin system shall be furnished in separate containers that are nonreactive with the materials. The size of the containers shall be such that the recommended proportions of the final mixture can be obtained by combining one container of Component A with one container of Component B. The size of the container shall be not more than 40 liters. When less than one complete unit is used, each component shall be measured within ±2 percent of the volume required. Batches of less than 200 milliliters shall be measured within ±1 percent.

Containers shall be identified as "Component A—Contains Epoxy Resin" and "Component B—Contains Hardener" and shall show the type, class, and mixing directions. Each container shall be marked with the name of the manufacturer; class, batch, or lot number; date of packaging; date of shelf life expiration; pigmentation, if any; and the quantity contained in kilograms and liters.

243.04—Acceptance.

Shipments of less than 60 liters may be accepted upon certification. The Contractor shall submit a certification from the manufacturer that Components A and B conform to these specifications. The certification shall consist of a statement by the manufacturer that Components A and B have been sampled and tested. The certification shall be signed by an authorized agent of the manufacturer and contain actual results of tests performed in accordance with the methods specified herein.

For shipments of 60 liters or more, at least one random test sample of each component from each batch or lot number will be taken by the Department. The quantity of Component A required to react with 1 liter of Component B will be a sufficient sample for the tests specified. Components shall be furnished in as few different batches or lots as possible.

Tests will be performed in accordance with the following methods:

Characteristics	Test Method	Other
Viscosity	ASTM D2393, Model RVF Brookfield viscometer	Determination to be made at: Class A - 0 °C Class B - 10 °C Class C - 25 °C

Epoxide equivalent	ASTM D1652 and VTM-43	
Volatile content	ASTM D1259, Method B, for mixed system	Sample cured 4 days at room temperature and mass determined on previously massed metal foil
Filler content	VTM-43	
Ash content	ASTM D482	
Pot life	AASHTO T237	Determination to be made at: Class A - 0 °C Class B - 10 °C Class C - 25 °C
Tensile strength	ASTM D638	
Bond strength	VTM-41	
Compressive strength	VTM-41	
Water absorption	ASTM D570	
Thermal shear	VTM-42	

SECTION 244—ROADSIDE DEVELOPMENT MATERIALS

244.01—Description.

These specifications cover the various materials, such as fertilizers, seeds, plants, sod, and mulch, for use in landscaping and materials used for soil retention to help prevent erosion.

244.02—Detail Requirements.

(a) **Herbicides:** Herbicides shall be registered with the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Pesticide Law and shall be supplied in the manufacturer's containers clearly labeled as to the composition, brand, and name and address of the manufacturer.

1. **Herbicide for control of broadleaf weeds** shall contain at least 0.36 kilograms per liter of 2,4-D as an oil-soluble, water-emulsifiable amine salt. It shall have a shelf life of at least 2 years and shall be homogeneous with slight agitation. The type of amine salt and the actual acid equivalent per liter shall be shown on the container.

2. **Herbicide for stump treatment** shall be dicamba CST, which shall be applied in accordance with the manufacturer's registered label.

(b) **Topsoil:**

1. **Class A topsoil** shall be stockpiled topsoil that has been salvaged in accordance with the requirements of Section 303.04(a). It shall be free from refuse or any material toxic to plant growth and reasonably free from subsoil, stumps, roots, brush, stones, clay lumps, or similar objects larger than 75 millimeters in their greatest dimension.

2. **Class B topsoil** shall be topsoil furnished from sources outside the project limits and shall be the original top layer of a soil profile formed under natural conditions, technically defined as the "A" horizon by the Soil Society of America. It shall consist of natural, friable, loamy soil without admixtures of subsoil or other foreign materials and shall be reasonably free from stumps, roots, hard lumps, stiff clay, stones, noxious weeds, brush, or other litter. It shall have demonstrated by evidence of healthy vegetation growing or having grown on it prior to stripping that it is reasonably well drained and does not contain substances toxic to plants.

3. **Topsoil for planting plants** shall be furnished by the Contractor and shall have a pH in the range of 6.0 to 7.0 prior to mixing with organic matter. If the pH is not within this range, the pH shall be corrected at the Contractor's expense or a different source of supply shall be selected. Topsoil shall be subject to inspection by the Engineer at the source of supply and immediately prior to use in planting and shall be mixed with organic matter as specified.

4. **Hydric soil for wetland mitigation** shall be an anaerobic soil, free from subsoil, stones, roots, debris, and material toxic to wetland plants.

(c) **Seeds:** Kinds and varieties of seeds shall be delivered to the project in separate sacks and shall be mixed under the observation of the Engineer on the project or at other approved locations. Seeds shall comply with applicable state and federal seed laws and contract requirements. Seed shall not be used until approved by the Engineer.

Seed shall be accompanied by the following affidavit:

FORM OF AFFIDAVIT

(Official Stationery of Supplier)

_____

(Date)

To: Virginia Department of Transportation

I hereby certify that seed as described below has been delivered to

_____

(Contractor's Name)

for Project Number(s) _____.

The shipment consists of:

Lab Test Results

Kind	Variety	Lot No.	Lab Test No.	Lab Test No.	kg	Purity %	Germ. %	Weed Seed %

Report of test is by the Virginia Department of Agriculture and Consumer Services, other official laboratory, or a commercial laboratory having a Registered Seed Technologist, other than that operated by the seed supplier.

Further, the label(s) and seed(s) meet all federal and state regulations and contract requirements.

Signature: _____

(Company Official)

_____

(Title)

Date: _____

Signature and Seal: _____

(Notary Public)

Seed shall be subject to inspection by Virginia State Seed Regulatory Inspectors of the Virginia Department of Agriculture and Consumer Services.

Seed test shall be completed within the 12-month period prior to the beginning of the "area" scheduled seeding period during which the seed is to be used.

Seed shall not be, or have been, stored in an enclosure where herbicides, kerosene, or other material detrimental to seed germination is stored.

Noxious weed seeds, as defined by the rules and regulations adopted for enforcement of the Virginia Seed Law, will not be permitted. The number of restricted noxious weed seeds shall be not more than the number per gram or per kilogram of noxious weed seeds specified in the rules and regulations.

The tag from each sack of seed shall be signed by the Contractor and delivered to the Engineer after each sack is completely used.

(d) **Fertilizers:**

1. **Fertilizer for seeding and sodding** shall be uniform in composition, free flowing, and suitable for application with approved equipment. Fertilizer shall be delivered to the project in bags or other convenient containers, each fully labeled, and shall conform to the applicable state and federal regulations. Additional nutrients shall be added only when specified. Delivery of fertilizers shall be accompanied by the following affidavit:

   Ureaformaldehyde shall be slow-release fertilizer material containing 38 percent nitrogen. The material shall have an activity index of 40 to 55 percent as determined by tests in accordance with the Association of Official Agricultural Chemists.

2. **Fertilizer for planting plants** shall have an analysis of approximately 10-30-6. Approximately 75 percent of the nitrogen shall be slow release nitrogen from methylene ureas, also termed ureaformaldehydes, that become slowly available for plants through nitrogen breakdown by soil microbes. Urea nitrogen shall not be used except as specified hereinafter. The phosphate fraction shall be triple superphosphate. Fertilizers to be mixed shall be delivered to the project or another approved location in separate bags bearing the manufacturer's label and shall be thoroughly mixed in the presence of the Engineer on the job or other approved location in the following percentages: 20

FORM OF AFFIDAVIT

(Official Stationery of Supplier)

_____
(Date)

To: Virginia Department of Transportation

I hereby certify that I have sold and delivered the amount and types of fertilizer materials indicated below and that the analysis given is in accordance with the Virginia Department of Agriculture and Consumer Services' test report referenced hereinafter:

_____ metric tons Ureaformaldehyde as _____
(No test required)

_____ metric tons _____ commercial fertilizer
(Report actual test results)

Laboratory Test No. _____ Laboratory Test Date _____

To _____ for Project No. _____
(Contractor's Name)

Material delivered on _____
(Date)

Further, the label(s) and the fertilizer comply with all federal and state regulations and contract requirements.

Signature: _____
(Company Official) (Title)

_____
(Date)

Signature and Seal: _____
(Notary Public)

percent of ureaformaldehyde as specified herein (38% N), 5 percent of urea (45% N), 65 percent of triple superphosphate (46% P_2O_5), and 10 percent of muriate of potash (60% K_2O).

(e) **Lime:** Lime shall be agricultural grade ground limestone. Agricultural grade pulverized limestone may be used at no additional cost to the Department.

The material source shall be registered with and approved by the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Agricultural Lime Law and shall conform to the requirements of Section 240.

(f) **Inoculating Bacteria for Treating Leguminous Seeds:** Bacteria shall be a pure culture of nitrogen fixing bacteria selected for maximum vitality. Cultures shall be not more than 1 year old and shall be subject to the approval of the Engineer.

(g) **Mulch:** Mulch shall conform to the following unless otherwise approved in writing by the Engineer:

1. **Mulch for seeding** (vegetative) shall consist of dry straw or hay, free from noxious weeds. Mulch shall be reasonably bright in color and shall not be musty, moldy, caked, decayed, or very dusty.

2. **Wood cellulose fiber mulch for hydraulic seeding** shall consist of specially prepared wood cellulose processed into a uniform fibrous physical state. Mulch shall be dyed green or contain a green dye in the package that will provide an appropriate color to facilitate visual inspection of the uniformly spread slurry. Mulch, including dye, shall not contain germination inhibiting or growth inhibiting factors. Mulch shall be manufactured and processed so that it will remain in uniform suspension in water under agitation and will blend with seed, fertilizer, and other additives to form a homogeneous slurry. Mulch shall form a blotterlike ground cover, on application, having moisture absorption and percolation properties and shall cover and hold grass seed in contact with the soil without inhibiting the growth of grass seedlings. Field and equipment performance determinations by the Department shall be prerequisites for the approval of a source of supply for mulch.

The manufacturer shall provide certification that the mulch conforms to the following:

Property	Value
Fiber or particle size	
Length	To approx. 10 mm
Thickness or diameter	Approx. 1 mm
Net dry mass content (VTM-47)	Min. stated on bag
pH range (TAPPI T509)	4.0 to 8.5
Ash content (TAPPI T413)	Max. 7.0%
Water holding capacity (VTM-46)	Min. 90%

Mulch shall not contain elements or compounds at concentration levels that will be phytotoxic.

In addition to making field performance determinations, the Department may sample and perform such other tests on mulch to ensure that it conforms to these specifications. Only those materials that have been evaluated by the Department and appear on its list of approved sources of supply will be accepted.

Mulch shall be delivered in packages of uniform mass bearing the name of the manufacturer, the net mass, and an additional statement of the net dry mass content.

3. **Wood chips** processed from clearing and grubbing operations may be used for mulch on seeded areas as directed by the Engineer. Wood chips shall be not more than 10 millimeters in thickness or 40 cubic centimeters in area.

4. **Mulch used in planting plants** shall be pine bark, wood chips, or other material specified on the plans or approved by the Engineer. Mulch shall not be used until it has been inspected and approved by the Engineer.

(h) **Sod:** Sod shall be cultivated material conforming to the requirements of the State Board of Agriculture for state-approved sod or the State Sod Certification Agency for state-certified sod. Root development shall be such that standard size pads will support their own mass and retain their size and shape when suspended vertically from a firm grasp on the uppermost 10 percent of the area. The top growth of sod shall be mowed so that the height of the grass will be 50 to 75 millimeters at the time of the stripping operation. Sod may be furnished in any standard pad width and length provided the dimensions do not vary from the average by more than 5 percent. Sod shall be machine stripped at a uniform soil thickness of at least 25 millimeters. Broken, torn, or irregularly shaped pads will be rejected.

(i) **Trees, Shrubs, Vines, and Other Plants:** The botanical and common name of plants shall be in accordance with the latest edition of *Standardized Plant Names*, prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature, in effect on the date of the Notice of Advertisement.

1. **Quality and size:** Plants shall conform to the requirements of *American National Standard for Nursery Stock*, by the American Association of Nurserymen, Inc., and these specifications. Plants shall be first class representatives of their normal species and varieties; shall have well furnished branch systems and vigorous fibrous root systems characteristic of their respective kinds; shall be nursery grown; and shall bear evidence of proper nursery care, including adequate transplanting and root pruning. Plants shall comply with state and federal laws governing inspection for plant diseases and insect infestation and shall be free from insect pests, plant diseases, disfiguring knots, stubs, sunscalds, bark abrasions, or any other form of damage or objectionable disfigurements. Where a minimum and maximum size or range is specified, an average size shall be furnished. Plants shall not be pruned before delivery or cut back from larger sizes to conform to the sizes specified. Sizes furnished shall be those specified at the time of delivery and before the usual pruning at the time of planting. Nursery-grown trees shall be free from cuts of limbs that are not healing and cuts more than 20 millimeters that have not completely callused over. Deciduous shade trees shall conform to the requirements for street trees as specified in the *American National Standard for Nursery Stock*. Plants from cold storage will not be accepted. Deciduous plants, except those grown in containers, shall be dormant when planted.

2. **Digging and protection:** Digging shall be done in a manner that will avoid damage to or loss of roots, but roots that are cut shall be cleanly cut. Balled and burlapped plants shall be properly dug and protected to preserve the natural earth in contact with the roots. Manufactured balls will not be accepted. Balls shall be firmly wrapped and tied with approved materials. Balled plants will not be accepted if the ball is broken, cracked, or loose. After plants are dug, their roots shall be protected from damage. Roots of bare root plants shall be kept moist at all times. Bare root plants shall be further protected by wrapping in wet straw, moss, burlap, or other suitable material.

3. **Plantable pots:** In lieu of using burlap with balled plants, plants may be dug as specified herein and placed in plantable pots. Pots shall be constructed of material that will readily decompose in soil and shall not be smaller in any dimension than the size

specified for balled and burlapped root systems. At the time of planting, the lip or rim of pots shall be broken away, and drainage holes shall be provided as directed. Plants with balls that have been grown in pots or with loose stems will be rejected.

4. **Container-grown plants:** In addition to the requirements of the *American National Standard for Nursery Stock*, container-grown plants shall conform to the following:

   a. The space between the rim or top of the container and the soil line within the container shall not be more than 35 millimeters for the 4 cubic decimeter and 8 cubic decimeter sizes and not more than 60 millimeters for the 20 decimeter size.

   b. Encircling roots shall not have grown in such a manner that they will cause girdling of the trunk or stems.

   c. Roots shall not protrude through drainage holes or over the rim of the container to the extent that they will be damaged while the root ball is removed from the container.

   d. Plants shall have been acclimated to outside conditions. Container grown plants may be used provided their use is approved in writing by the Engineer.

5. **Collected plants:** Collected plants from wild or native stands shall not be used without the written permission of the Engineer unless specified on the plans. Wild or native plants shall be clean, sound stock, and free from injury, and the quality of the plants shall be similar to that specified for nursery grown material. Stock shall have sufficient root systems to ensure successful transplanting. Balls, when specified, shall be tight and well formed.

6. **Clumps:** Clumps shall be dug from good soil that has produced a fibrous root system typical of the nature of the plant and shall have earth and incidental vegetation adhering to roots.

(j) **Miscellaneous Planting Materials:**

1. **Peat moss** shall be granulated, shredded, or milled sphagnum moss, nearly free from woody materials and consisting of at least 75 percent decomposed leaves and stems of sphagnum moss essentially brown in color. The texture may vary from porous to spongy fibrous. Peat moss shall be free from sticks, stones, mineral matter, or other foreign material. Peat moss shall have a pH of from 3.5 to 5.5.

2. **Tree wrap** shall be waterproof paper, 30-30-30 krinklecraft or its equivalent, in strips 100 millimeters in width.

3. **Twine** for wrapping trees shall be jute twine, at least two-ply.

4. **Soil mixture used to backfill planting pits** shall consist of 1 part peat moss and 4 parts topsoil as specified herein. Prior to use, peat moss and topsoil shall be thoroughly mixed. The method of mixing and the area in which the mixing operation is performed shall be approved by the Engineer.

5. **Water** used in watering plants shall be obtained from fresh water sources and shall be free from chemicals and other toxic substances harmful to plants. Brackish water shall not be used. The source of water will be subject to the approval of the Engineer.

(k) **Soil Retention Coverings:**

1. **Jute mesh** shall be a uniform, open, plain weave of undyed and unbleached single jute yarn. The yarn shall be loosely twisted and shall not vary in thickness by more than its normal diameter. Jute mesh shall be new, and its length shall be marked on each roll.

   Between strands lengthwise, openings shall be 15 millimeters ± 25 percent. Between strands crosswise, openings shall be 22 millimeters ± 25 percent. Jute mesh shall have a mass of 500 grams per square meter ± 5 percent.

2. **Soil retention mats** shall consist of a machine produced mat of wood fibers, wood excelsior, or manmade fiber that shall intertwine or interlock. Matting shall be nontoxic to vegetation and germination of seed and shall not be injurious to the unprotected skin of the human body.

   Mats shall be of consistent thickness, with fiber evenly distributed over its entire area, and covered on the top and bottom side with netting having a high web strength or covered on the top side with netting having a high web strength and machine sewn on 50-millimeter centers along the longitudinal axis of the material. Netting shall be entwined with the mat for maximum strength and ease of handling.

3. **Soil stabilization mats** shall be from the Department's approved products list for the use specified.

SECTION 245—GEOSYNTHETICS

245.01—Description.

These specifications cover artificial fiber textile products to be used in transportation construction work.

245.02—Detail Requirements.

Geotextile fabric shall be protected from mud, dirt, dust, sunlight, and debris during transport and storage. Material shall be inert to commonly encountered chemicals; resistant to mildew, rot, insects, and rodents; and biologically and thermally stable. Geotextile fabric for subsurface installation shall not be exposed to direct sunlight for more than 24 hours during installation.

Tensile strength requirements are in the machine and cross-machine directions.

245.03—Testing and Documentation.

Geosynthetics shall be tested by an independent commercial laboratory to verify the material requirements specified herein. The Contractor shall provide written documentation of all tests specified. Documentation shall include style, lot, roll numbers, and actual results of each test. In addition, the name, address, phone number of the testing laboratory, and date of testing shall be provided.

(a) **Geotextile Fabric for Use in Silt Fences, Silt Barriers, or Filter Barriers:** Fabric shall contain ultraviolet inhibitors and stabilizers to provide at least 6 months of expected, usable construction life at a temperature range of -20 °C to 50 °C. The tensile strength of the material after 6 months of installation shall be at least 50 percent of the initial strength.

1. **Silt fences:**

Physical Property	Test Method	Requirements (Min.)
Filtering efficiency	VTM-51	75%
Flow rate	VTM-51	130 mL/m^2/sec

Tensile strength @ 20% (max.) elongation	VTM-52	Extra strength: 10 kN/m Standard strength: 5 kN/m

2. **Silt barriers and filter barriers:**

Physical Property	Test Method	Requirements (Min.)
Filtering efficiency	VTM-51	75%
Flow rate	VTM-51	130 mL/m^2/sec
Tensile strength @ 20% (max.)	VTM-52	Standard strength: 5 kN/m

(b) **Riprap Bedding Material:**

Physical Property	Test Method	Requirements (Min.)
Apparent opening size	ASTM D4751	Equal to or greater than 300 µm sieve
Tensile strength @ 20% (max.) elongation	VTM-52	5 kN/m
Puncture strength	ASTM D4833	350 N

Seams shall be equal in strength to the basic material.

Additional fabric material or noncorrosive steel wire may be incorporated into fabric to increase overall strength.

(c) **Drainage Fabric:**

Physical Property	Test Method	Requirements (Min.)
Apparent opening size	ASTM D4751	Equal to or smaller than 0.300 mm
Permitivity	ASTM 4491	Min. 0.8 sec
Tensile strength @ 20% elongation	VTM-52	4.0 kN/m

SECTION 246—PAVEMENT MARKING

246.01—Description.

These specifications cover material for use in the various retroreflective pavement marking applications.

246.02—Detail Requirements.

Materials that must be heated for application shall not exude fumes that are toxic or injurious to persons or property when heated to the application temperature.

(a) **White and Yellow Pavement Marking Material:** White pavement marking material shall be equal to Federal Standard Color No. 595-17886, and yellow pavement marking material shall be equal to Federal Standard Color No. 595-13538.

(b) **Thermoplastic Material:** Material shall have the pigment, beads, and filler well dispersed in the resin. Material shall be free from skins, dirt, and foreign objects.

1. **Composition:**

Composition	White	Yellow
	(Percent by Mass)	
Binder	18.0 min.	18.0 min.
Glass beads	25.0 min.	25.0 min.
Titanium dioxide	8.0 min.	
Calcium carbonate and inert fillers	50.0 max.	

The amount and type of yellow pigment and inert filler for yellow material shall be at the option of the manufacturer provided all other requirements of this specification are complied with.

The binder shall be either alkyd or hydrocarbon. If an alkyd thermoplastic is used, the binder shall consist of synthetic resins, at least one of which is solid at room temperature, and high-boiling plasticizers. At least 1/2 of the binder composition shall be a maleic-modified glycerol ester of resin and shall be at least 10 percent by mass of the entire material formulation.

Alkyd and hydrocarbon materials shall not be mixed. Equipment shall be thoroughly cleaned before types of material are changed.

2. **Physical requirements:**

   a. **Reflectivity:** After heating for 4 hours at 220 °C and cooled to 25 °C, the white material shall have a daylight reflectance at 45 to 0 degrees of at least 75 percent. Yellow material shall have a daylight reflectance at 45 to 0 degrees of at least 45 percent.

   b. **Water absorption:** Materials shall not have more than 0.5 percent retained water by mass when tested in accordance with the requirements of ASTM D570, Procedure A.

   c. **Softening point:** Materials shall have a softening point of at least 90 °C as determined in accordance with the requirements of ASTM E28.

   d. **Specific gravity:** The specific gravity of the thermoplastic compound at 25 °C shall be from 1.7 to 2.2.

   e. **Impact resistance:** Impact resistance shall be at least 1.2 joules at 25 °C after material has been heated for 4 hours at 200 °C and cast into square cross sectional bars of 25 millimeters on a side, 75 millimeters long and placed with 25 millimeters extending above the vise in a cantilever beam, Izod-type tester, conforming to the requirements of ASTM D256, using the 3 J scale.

   f. **Abrasion resistance:** Material shall not lose more than 6 grams of material when tested in accordance with the requirements of VTM-56.

   g. **Drying time:** Material shall set to bear traffic in not more than 2 minutes when the road temperature is 10 °C or above.

   h. **Durability and wear resistance:** Material shall adhere to asphalt concrete and hydraulic cement concrete roadway surfaces and shall withstand air and roadway temperature variations from -20 °C to 60 °C without deforming, bleeding, staining, or discoloring and shall maintain its original dimensions and placement without chipping, spalling, or cracking. Material shall not deteriorate because of contact with sodium chloride, calcium chloride, mild alkalies and acids, or other ice control materials; oil in the pavement material; or oil and gasoline drippings from vehicles. Material shall be designed to provide a life expectancy of at least 3 years under seasonal weather conditions under an average daily traffic count per lane of approximately 9,000 vehicles.

i. **Glass beads:** Glass beads shall conform to the requirements of Section 234.

j. **Flashpoint:** The material shall have a minimum flashpoint of 260 °C when tested in accordance with the requirements of ASTM D92.

(c) **Epoxy-Resin Pavement Marking Material:** Epoxy-resin pavement marking material is a two-component material suitable for use on both old asphalt and hydraulic cement concrete surfaces. Pigment, beads, and filler shall be well dispersed in the resin. Material shall be free from skins, dirt, and foreign objects and shall conform to the following:

1. **Composition:**

Component	ASTM	White	Yellow
Epoxy resins	D1652	Max. 82%	Max. 77%
Titanium dioxide	D476	Min. 18%	
Chrome yellow	D211		Min. 23%

2. **Physical requirements:**

a. **Hardness:** Hardness, Shore D, ASTM D2240, shall be 65 to 90.

b. **Tensile strength:** Tensile strength, ASTM D638, shall be at least 40 megapascals.

c. **Compression strength:** Compression strength, ASTM D695, shall be at least 80 megapascals.

d. **Adhesion to concrete:** Adhesion, ACI 403, shall be 100 percent concrete failure.

e. **Drying time:** Material used for center lines shall be Type I (rapid cure) and shall cure to an adherent, nonpickup finish in not more than 10 minutes at 25 °C ambient temperature. Material used for edge lines shall be Type I or Type 2 (medium cure) and shall cure to an adherent, nonpickup finish in not more than 30 minutes at 25 °C ambient temperature.

f. **Epoxy values:** Part A of Type 1 (rapid curing) epoxy compounds shall have an epoxy value of 0.335 ± 0.034 as determined in accordance with the requirement of ASTM

D1652. Part A of Type 2 (medium cure) epoxy compounds shall have an epoxy value of 0.228 ± 0.023 as determined in accordance with the requirements of ASTM D1652.

Part B of both types shall have an amine number of 420 ± 50 as determined in accordance with the requirements of ASTM D2074.

g. **Durability and wear resistance:** Material shall provide a neat and durable marking that will not chip or spall because of roadway temperature variations from -20 °C to 60 °C. Material shall not deteriorate because of contact with sodium chloride, calcium chloride, mild alkalies and acids, other ice control materials, or oil or gasoline. Material shall be designed to provide a life expectancy of at least 3 years under seasonal weather conditions under an average daily traffic count per lane of approximately 9,000 vehicles.

(d) **Polyester-Resin Pavement Marking Material:** Polyester resin is a two-component pavement marking material suitable for use on both old asphalt and hydraulic cement concrete surfaces. The manufacturer of the material shall certify to the Engineer that the material has been successfully applied over both asphalt and hydraulic concrete surfaces and is identical with the material previously qualified.

1. **Composition (uncatalyzed material):**

	Min.	**Max.**
Pigment	36.0	40.0
Acrylic monomer	8.5	
Polyester resin		55.5

2. **Physical requirements (uncatalyzed material):**

a. **Viscosity:** Viscosity (25 °C), ASTM D562, shall be 80 to 90 Kreb units.

b. **Density:** Density shall be at least 1.38 kilograms per liter.

c. **Drying time:** The catalyst/resin ratio shall be adjusted by the operator so that the applied line shall dry to a no-tracking condition in 15 minutes or less when applied at an application temperature of 25 °C to 37 °C, a substrate temperature of at least 16 °C, a wet thickness of 0.35 to 0.65 millimeter, and with 1.2 to 1.8 kilograms of glass beads, conforming to the requirements of Section 234, applied per liter.

d. **Catalyst:** MEKP is the required catalyst for this system. The peroxide shall not be exposed to any form of heat, such as direct sunlight, radiators, open flame, or sparks. Heat may cause the organic peroxide to decompose violently or burn if ignited. The peroxide shall not come into contact with easily oxidized metals, such as copper, brass, or mild steel or galvanized steel, as this can also initiate a violent reaction.

e. **Mass loss:** Beaded catalyzed material shall not have a mass loss of more than 125 milligrams after 1,000 revolutions when abraded according to Federal Test Method Standard No. 141b, Method 6192, using CS-17 wheels with a 1,000-gram load on each wheel.

f. **Shelf life:** The shelf life of uncatalyzed material shall be at least 6 months when stored in a cool area below 30 °C.

g. **Durability and wear resistance:** Material shall provide a neat and durable marking that will not chip or spall because of roadway temperature variations from -20 °C to 60 °C when applied to either asphalt or hydraulic cement concrete surfaces. Material shall not deteriorate because of contact with sodium chloride, calcium chloride, mild alkalies and acids, other ice control materials, or oil or gasoline. Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles per day.

(e) **Preformed Tape:** Tape shall be selected from the Department's approved products list. Tape shall provide a neat and durable marking that will not flow or distort because of temperature variations; shall be weather resistant; shall show no appreciable fading, lifting, or shrinkage throughout the life of the marking; and shall show no significant tearing, rollback, movement, or other signs of poor adhesion under normal traffic conditions.

Tape shall be capable of conforming to pavement contours, breaks, and faults through the action of traffic at normal pavement temperatures. Tape shall be capable of being applied to previously applied marking material of the same composition under normal conditions of use.

Tape shall consist of high-quality preformed materials with pigments and glass beads uniformly distributed throughout its cross-sectional area and with a retroreflective layer of glass beads firmly bonded on the top surface. Line marking materials and prefabricated legends

and symbols shall be precoated with a pressure-sensitive adhesive and shall be capable of being applied to both hydraulic cement concrete and old, new, dense, or open graded asphalt concrete road surfaces. A primer shall be used when recommended by the manufacturer.

Tape shall be manufactured and packaged in a manner that will permit storage at normal shelf temperature for a period of at least 1 year from the date of shipment.

1. **Plastic backed preformed tape** shall conform to the applicable requirements of Table II-23 and the following:

TABLE II-23
Preformed Tape Pavement Marking Reflectivity

Pavement Marking	Type and Class[1]	Skid Resistance (BPN)[2]	Tensile (kPa)[3]	Reflectivity (SL)[4] White	Reflectivity (SL)[4] Yellow	Thickness, No. Adhesive (mil)
Plastic-backed tape	B, IV	35	700	500	450	1.5-2.5
Foil-backed tape	B, V	45		960	680	Min. 0.6
Temporary tape	C	35	275	1,770	1,310	Min. 0.6
Removable tape	D	45		1,770	1,310	Min. 1.0[5] Min. 0.5[6]

[1]In accordance with Table VII-1.
[2]When tested in accordance with the requirements of ASTM E303.
[3]When a 25-millimeter wide strip is tested in accordance with the requirements of ASTM D638 between 21 °C and 26 °C.
[4]When a 100 millimeter by 425 millimeter sample is tested at a distance of 15.24 meters at an entrance angle of 86 degrees and expressed in millicandelas per square meter per lux (SL) and a 0.2 observation angle.
[5]Thickest portion of the patterned cross section.
[6]Thinnest portion of the cross section.

a. **Plastic pull test:** A test specimen 25 by 75 millimeters shall support a dead mass of 1.8 kilograms for at least 5 minutes at a temperature between 21 °C and 26 °C.

b. **Adhesive shear strength:** Adhesion shall be tested in accordance with the requirements of ASTM D638M, as modified herein, to test the adhesive shear strength. Samples shall be prepared and tested as follows: Test specimens shall

be cut to dimensions of 25 by 150 millimeters, and a 25 by 75 millimeter piece of carborundum extra coarse emery cloth, or its equivalent, shall be applied to the adhesive face of the test strip such that there is an overlap of 650 square millimeters. A pressure of 350 kilopascals shall be applied over this area for 120 seconds by gripping each end of the test piece in a suitable tensile test machine, such as a Dillon or Scott tester. The speed of testing shall be 10 millimeters per minute. The test shall be run in triplicate at approximately 25 °C. The average load required to break the adhesive bond shall be 25 newtons.

c. **Glass beads:** Glass beads shall be colorless and shall have a refraction index of at least 1.50 when tested using the liquid oil immersion method. The size and quality of the bead shall be such that the retroreflectivity of the tape will be maintained as the tape wears through the surface course. Tape shall have at least 20 percent glass beads by mass, with at least 2 percent of the beads firmly adhered to the top of the tape. Bead adhesion shall be such that when a 100 by 100 millimeter specimen is tested in accordance with the requirements of VTM-14, the mass loss attributable to bead removal shall be not more than 10 grams per square meter.

2. **Foil backed preformed tape** shall conform to the applicable requirements of Table II-23 and the following:

a. **Acid resistance:** Under 20x magnification, no more than 15 percent of beads shall show a distinct opaque white (corroded) layer on their entire surface when tested in accordance with the requirements of VTM-61.

b. **Bead adhesion:** Tape shall have bead retention qualities such that when a 50 by 150 millimeter sample is bent over a mandrel 13 millimeters in diameter with the 50-millimeter dimension perpendicular to the mandrel axis, the area on the mandrel examined under magnification shall show that not more than 10 percent of the beads have an embedment of less than 40 percent.

3. **Construction preformed tape:**

a. **Temporary tape** shall be foil backed or plastic backed, shall conform to the applicable requirements of Table II-23, and shall be used for temporary markings on construction sites.

b. **Removable tape** shall be a patterned, non-metallic-backed plastic film. The patterned surface shall have a minimum

of 20% of the surface area raised. Tape shall conform to the requirements of Table II-23 and the following:

(1) **Glass beads:** Glass beads shall be colorless and have a refraction index of at least 1.50 when tested using the liquid oil immersion method. The size and quantity of beads shall be such that the retroreflectivity of the tape is maintained as the tape wears through the surface course. The tape shall have approximately 20 percent glass beads by mass, with at least 2 percent of the beads firmly adhered to the top of the tape. Bead adhesion shall be such that beads are not easily removed when the surface of the tape is scratched firmly with the thumbnail.

(2) **Removability:** Tape shall be removable intact or in large strips either manually or by a mechanical rollup device at temperatures above 5 °C without the use of heat, solvents, grinding, or blasting.

(3) **Adhesive:** Tape shall be precoated with a pressure-sensitive adhesive capable of being affixed to pavement surfaces without the use of heat, solvents, or other additional adhesives or activators. The adhesive shall not require a protective liner when tape is in a rolled form for shipment. The adhesive shall be capable of temporarily bonding to the pavement at temperatures of 10 °C and above without pickup or distortion by vehicular traffic.

SECTION 247—REFLECTIVE SHEETING

247.01—Description

This specification covers reflective sheeting used on various traffic control devices to provide a retroreflective surface or message. Color of the reflective sheeting shall be as specified by plans or other specifications. Reflective sheeting shall be certified in accordance with the requirements of Section 106.05.

247.02—Detail Requirements

Reflective sheeting, except fluorescent prismatic lens type, shall conform to FHWA's FP-92 specifications and the following requirements except the

accelerated weathering test shall be an unprotected outdoor weathering test; the minimum reflectance limit for the color white shall be 15 for sheeting used on cones and tubular delineators; and the impact resistance test for prismatic lens type sheeting shall conform to the same requirements as indicated in (e) herein. The outdoor weathering test shall be performed at the Southeastern Association of State Highway and Transportation Officials (SASHTO) Regional Test Facility or other Department-approved test facility for one year for Type III reboundable sheeting and two years for other sheeting with the same requirements as those for the accelerated weathering test. Sheeting shall be installed on the outdoor test deck facing the equator and inclined 45° from the vertical. Minimum coefficient of retroreflection for prismatic lens type sheeting for this test shall be 50 percent of the values indicated in (d) herein. Fluorescent prismatic lens type of sheeting shall conform only to the requirements in (e) herein.

(a) **Reflective sheeting used on signs except orange construction and maintenance activity signs** shall be encapsulated lens type conforming to the reflectivity for a Type III glass bead retroreflective material and the following supplementary table:

Minimum SIA (Candelas per lux per square meter)

Observation Angle (°)	Entrance Angle (°)	Brown
0.2	-4	12.0
0.2	+30	8.5
0.5	-4	5.0
0.5	+30	3.5

In addition, brown sheeting shall conform to the following color requirements:

Color Specification Limits

Color	1		2		3		4		Reflectance Limits Y (%)	
	x	y	x	y	x	y	x	y	Min	Max
Brown	0.430	0.340	0.430	0.390	0.550	0.450	0.610	0.390	3	9

(b) **Reflective sheeting used on barricades and vertical panels** (Group 2 channelizing devices) shall be encapsulated lens type conforming to the reflectivity for a Type III glass bead retroreflective material and the following supplementary table:

Minimum SIA (Candelas per lux per square meter)

Observation Angle (°)	Entrance Angle (°)	White	Orange
0.2	+50	75	25
0.5	+50	35	10

(c) **Reflective sheeting used on cones, tubular delineators, and drums** shall be reboundable type conforming to the same reflectivity requirements as indicated in (b) herein.

(d) **Reflective sheeting used on standard road edge delineators, special road edge delineators, barrier delineators, guardrail delineators, and interstate road edge delineators** shall be prismatic lens type conforming to the following color specification limits and minimum coefficients of retroreflection (equivalent SIA).

Color Specification Limits[1] (Daytime)

Color	1		2		3		4		Reflectance Limits Y (%)	
	x	y	x	y	x	y	x	y	min	max
White	0.305	0.305	0.355	0.355	0.335	0.375	0.285	0.325	40	-
Yellow	0.487	0.423	0.545	0.454	0.465	0.534	0.427	0.483	24	45

[1]The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colormetric system measured with standard illuminant D65.

Minimum Coefficient of Retroreflection R_A (Candelas per lux per square meter) (0° and 90° orientation)

Observation Angle (°)	Entrance Angle (°)	White	Yellow
0.2	-4	800	660
0.5	+30	400	340
0.2	+45	145	85
0.2	+60[1]	35	23
0.5	-4	200	160
0.5	+30	100	85
0.5	+45	75	60
0.5	+60[1]	30	20

[1]The 60° entrance angle shall be measured at 90° orientation only.

Minimum Coefficient of Retroreflection R_A
(Candelas per lux per square meter)
(45° orientation)

Observation Angle (°)	Entrance Angle (°)	Yellow
0.2	-4	550
0.2	+30	130
0.5	-4	145
0.5	+30	70

(e) **Reflective sheeting used on orange construction and maintenance activity signs and barrier vertical panels installed on concrete traffic barrier service** shall be fluorescent prismatic lens type conforming to the following:

1. **General:** The prismatic lenses shall be formed in a transparent fluorescent synthetic resin, sealed, and backed with a pressure sensitive adhesive protected by a removable liner.

2. **Color specification limits:** Daytime color and maximum spectral radiance factor (peak reflectance) of the sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with the requirements of ASTM E 991. The values shall be determined on a HunterLab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559, or approved equal instrument with circumferential viewing (illumination). Computations shall be done in accordance with the requirements of ASTM E 308 for the 2° observer. Color shall conform to the following requirements:

Color Specification Limits[1] (Daytime)

Color	1		2		3		4		Reflectance Limits Y (%)	
	x	y	x	y	x	y	x	y	Min	Max
Orange (new)	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	30	-
Orange (weathered)	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	20	45

[1]Maximum spectral radiance factor, new: min. 110%; weathered: min. 60%.

Nighttime color of the sheeting applied to aluminum test panels shall be determined instrumentally in accordance with the requirements of ASTM E 811 and calculated in the u', v' coordinate

system in accordance with the requirements of ASTM E 308. Sheeting shall be measured at 0.33° observation and -4° entrance angles at 90° orientation. Color shall conform to the following requirements:

Color Specification Limits[1] (Nighttime)

Color	1		2		3		4	
	u'	v'	u'	v'	u'	v'	u'	v'
Orange (new and weathered)	0.400	0.540	0.475	0.529	0.448	0.522	0.372	0.534

[1]The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colormetric system measured with standard illuminant D65.

3. **Minimum coefficients of retroreflection R_A (equivalent SIA):** Minimum coefficient of retroreflection values shall conform to the following when the sheeting is applied on aluminum test panels and tested in accordance with the requirements of ASTM E 810.

Minimum Coefficient of Retroreflection R_A (Candelas per lux per square meter) (90° orientation)

Observation Angle (°)	Entrance Angle (°)	Orange
0.2	-4	200
0.2	+30	120
0.2	+50	50
0.5	-4	80
0.5	+30	50
0.5	+50	20

4. **Accelerated weathering:** The retroreflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 1500 hours exposure in a xenon arc weatherometer in accordance with the requirements of ASTM G 26, Type B, Method A. Following exposure, panels shall be washed in a 5% HCl solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft clean cloth, and brought to equilibrium at standard conditions. After cleaning, the coefficient of retroreflection shall not be less than 100 when measured at angles of 0.2° observation, -4° entrance angles and 90° orientation, and the color shall conform

to the color specification limits stated in (e)2 for weathered sheeting. Where more than one panel of a color is measured, the coefficient of retroreflection shall be the average of all determinations. The sample shall show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting, or curling or more than 1 millimeter shrinkage or expansion.

5. **Impact resistance:** The retroreflective sheeting shall conform to the impact resistance requirements of ASTM D 4956 except the sheeting shall be subjected to a 115-joule impact using a 1.8-kilogram mass.

6. **Heat resistance:** The retroreflective sheeting, applied to a test panel as in (e)5 and conditioned for 24 hours, shall be measured for coefficient of retroreflection R_A in accordance with the requirements of (e)3 herein at 0.2° observation and -4° entrance angles at 90° orientation before and after being exposed to a temperature of 77 ± 3 °C for 24 hours in an air circulating oven. After heat exposure, the sheeting shall retain a minimum of 70 percent of the original coefficient of retroreflection.

(f) **Reflective sheeting used on the "STOP" side of sign paddles (hand signalizing devices)** shall be encapsulated lens type conforming to the same reflectivity requirements as indicated in (a) herein. Reflective sheeting used on the "SLOW" side of sign paddles shall be fluorescent prismatic lens type conforming to the same requirements as indicated in (e) herein.

Division III

ROADWAY CONSTRUCTION

SECTION 301—CLEARING AND GRUBBING

301.01—Description.

This work shall consist of clearing, grubbing, removing, and disposing of vegetation, debris, and other objects within the construction limits except for vegetation and objects that are designated to be preserved, protected, or removed in accordance with the requirements of other provisions of these specifications.

301.02—Procedures.

If approved by the Engineer, the Contractor may clear and grub to accommodate construction equipment within the right of way up to 1.5 meters beyond the construction limits at his own expense. The Contractor shall install erosion and siltation control devices prior to beginning grubbing operations.

The surface area of earth material exposed by grubbing, stripping topsoil, or excavating shall be limited to that necessary to perform the next operation within a given area. Grubbing of root mat and stumps shall be confined to the area over which excavation is to be performed within 30 days following grubbing.

Stumps, roots, other perishable material, and nonperishable objects that will be less than 1.5 meters below the top of earthwork within the area directly beneath the pavement and shoulders shall be removed. However, such material and objects that will be more than 1.5 meters below the top of earthwork within the area directly beneath the pavement and shoulders and all such material and objects beneath slopes of embankments shall be left in place unless removal is necessary for installation of a structure. The top of stumps left in place shall be not more than 150 millimeters above the existing ground surface or low water level.

Branches of trees that overhang the roadway or reduce sight distance and that are less than 6 meters above the elevation of the finished grade shall be trimmed using approved tree surgery practices in accordance with the requirements of Section 601.

Vegetation, structures, or other items outside the construction limits shall not be damaged. Trees and shrubs in ungraded areas shall not be cut without the approval of the Engineer.

Combustible cleared and grubbed material shall be disposed of in accordance with the following:

1. Trees, limbs, and other timber having a diameter of 75 millimeters and greater shall be disposed of as saw logs, pulpwood, firewood, or other usable material; however, treated timber shall not be disposed of as

firewood. Not more than 1 meter of trunk shall be left attached to grubbed stumps.

When specified that trees or other timber is to be reserved for the property owner, such material shall be cut in the lengths specified and piled where designated, either within the limits of the right of way or not more than 30 meters from the right-of-way line. When not reserved for the property owner, such material shall become the property of the Contractor.

2. When specified on the plans or where directed by the Engineer, material less than 75 millimeters in diameter shall be used to form brush silt barriers when located within 150 meters of the source of such material. Material shall be placed approximately 1.5 meters beyond the toe of fill in a strip approximately 3 meters wide to form a continuous barrier on the downhill side of fills. Where selective clearing has been done, material shall be piled, for stability, against trees in the proper location. On the uphill side of fills, brush shall be stacked against fills at approximately 30-meter intervals in piles approximately 1.5 meters high and 3 meters wide. Any such material not needed to form silt barriers shall be processed into chips having a thickness of not more than 10 millimeters and an area of not more than 40 square centimeters and may be stockpiled out of sight of any public highway for use as mulch.

3. Stumps and material less than 75 millimeters in diameter that are not needed to form silt barriers and that are not processed into wood chips shall be buried where designated on the plans and permitted by the Engineer, placed in disposal or borrow pits, or disposed of by burning in accordance with the requirements of Section 107.14(b)2.

301.03—Measurement and Payment.

Clearing and grubbing will be measured and paid for in accordance with one of the following methods, as specified:

1. **Lump sum basis:** No measurement of the area to be cleared and grubbed will be made.

2. **Hectare basis:** The work to be paid for will be the number of hectares, computed to the nearest 0.1 hectare, actually cleared and grubbed. Areas within the limits of any existing roadway or local material pit will not be measured.

3. **Unit basis:** The work to be paid for will be determined by the actual count of trees, stumps, structures, or other obstructions removed.

These prices shall include disposing of cleared and grubbed material.

When clearing and grubbing is not a pay item, the cost thereof shall be included in the price for other appropriate pay items. Allowance will not be made for clearing and grubbing borrow pits or other local material pits.

Payment will be made under:

Pay Item	Pay Unit
Clearing and grubbing	Lump sum, hectare, or unit

SECTION 302—DRAINAGE STRUCTURES

302.01—Description.

This work shall consist of installing pipe culverts, endwalls, box culverts, precast concrete and metal arches, storm drains, drop inlets, manholes, spring boxes, junction boxes, and intake boxes and removing and replacing existing structures in accordance with the requirements of these specifications and in reasonably close conformity with the lines and grades shown on the plans or as established by the Engineer.

302.02—Materials.

(a) **Pipe** shall conform to the requirements of Section 232 and shall be furnished in accordance with the diameter, wall thickness, class, and strength or corrugation specified for the maximum height of fill to be encountered along the length of the pipe culvert, storm drain, or sewer.

(b) **End sections** shall conform to the applicable requirements of Section 232. End sections used with rigid pipe shall be concrete. End sections used with asphalt-coated or paved pipe shall not be asphalt coated or paved.

(c) **Pipe fittings,** such as tees, elbows, wyes, and bends, shall conform to the applicable requirements of Section 232. Fittings shall be of the same type, class, thickness, and strength as the line in which they are used.

(d) **Steel grates, steel frames, and structural steel** shall conform to the requirements of Section 226 and shall be galvanized in accordance with the requirements of Section 233.

(e) **Concrete blocks** shall conform to the requirements of Section 222 for masonry blocks.

(f) **Brick** shall conform to the requirements of Section 222.

(g) **Hydraulic cement mortar** shall conform to the requirements of Section 218.

(h) **Cast-in-place concrete** shall conform to the requirements of Section 217 for Class 20.

(i) **Bedding material** shall conform to the requirements of Section 205.

(j) **Joint material and gaskets** shall conform to the requirements of Section 212.

(k) **Gray-iron castings** shall conform to the requirements of Section 224.

(l) **Reinforcing steel** shall conform to the requirements of Section 223, Grade 300 or 400.

(m) **Curing materials** shall conform to the requirements of Section 220.

302.03—Procedures.

Excavation and backfill operations shall be performed in accordance with the requirements of Section 303. Foundation exploration shall be performed in accordance with the requirements of Section 401 unless otherwise provided herein. Concrete construction shall conform to the requirements of Section 404. Reinforcing steel placement shall conform to the requirements of Section 406. Bearing pile operations shall be performed in accordance with the requirements of Section 403. When specified on the plans or directed by the Engineer, a temporary diversion channel shall be constructed to facilitate installation of a pipe or box culvert.

(a) **Pipe Culverts:** Not more than one type of pipe shall be used in any one pipe line.

When field cutting corrugated metal pipe is permitted by the Engineer, damaged areas of the protective coating shall be repaired in accordance with the requirements of Section 233.

1. **Jacked method:** The Contractor shall submit to the Engineer a complete plan and schedule for jacked pipe installation prior to beginning such work. The submission shall include complete details of sheeting, shoring, and bracing for protecting the roadbed and materials and equipment. The Contractor shall not proceed with pipe installation until the plan has been reviewed by the Engineer.

When work is stopped, the heading shall be bulkheaded.

The jacked method shall be by means of tunneling or boring. The jacked tunneling method shall be applicable for installing concrete pipe 750 through 2700 millimeters in diameter and smooth-wall steel pipe 750 through 1200 millimeters in diameter. The jacked boring method shall be applicable for installing concrete pipe 300 through 2700 millimeters in diameter and smooth-wall steel pipe 320 millimeters through 1200 millimeters in diameter.

Pipe shall have a design strength and wall thickness so as to withstand the jacking operation.

Construction shall be performed in such a manner that the ground surface above the pipe will not settle. Installation of the pipe line shall immediately follow heading or tunneling excavation. Voids occurring behind the pipe during installation shall be filled with hydraulic cement grout, placed under pressure, upon completion of the jacking operations

Joint sealant material on concrete pipe shall be placed ahead of the jacking frame. At his own expense, the Contractor shall replace or repair, as directed by the Engineer, pipe that is damaged during jacking operations. Joints of steel pipe shall be butt welded, watertight, as installation progresses.

2. **Open trench method:**

   a. **Foundation:** The foundation shall be explored below the bottom of the excavation to determine the type and condition of the foundation. However, explorations need not be made for routine entrance or crossover pipe 300 through 750 millimeters in diameter that is to be installed under fills 5 meters or less in height. Foundation exploration shall extend to a depth equal to 40 millimeters per meter of fill height or 200 millimeters, whichever is greater. The Contractor shall report findings of foundation exploration to the Engineer for approval prior to placing pipe.

      Where unsuitable foundation is encountered at the established grade, as determined by the Engineer, such material shall be removed and replaced.

      Backfill for foundations of soft, yielding, or otherwise unsuitable material shall be regular excavation or coarse aggregate conforming to the requirements of Section 203 as directed by the Engineer.

Backfill material required to replace unsuitable material beneath concrete pipe under fills more than 27 meters in height shall be a fine, granular material approved by the Engineer. Regular excavation may be used provided grading of the material conforms to the requirements of Section 207 for select material, Type 1.

Backfill for areas where unsuitable material has been removed shall be placed and compacted in accordance with the requirements of Section 303.04(g).

b. **Bedding:** Bedding material for pipe foundations shall be aggregate No. 25 or No. 26 conforming to the requirements of Section 205.

Pipe bedding shall be lightly and uniformly compacted and shall be carefully shaped so that the lower section of the pipe exterior is in contact with the bedding material for at least ten percent of the overall height of the pipe. Bedding material shall be shaped to accommodate the bell when bell and spigot pipe is used. The depth of bedding material shall be at least 100 millimeters.

c. **Placing pipe:** Pipe shall be placed beginning at the downstream end of the pipe line. The lower segment of pipe shall be in contact with the shaped bedding for its entire length. Bell or groove ends of rigid pipe shall be placed facing upstream.

Paved or partially lined pipe shall be placed so that the longitudinal center line of the paved segment coincides with the flow line.

Pipe will be inspected before backfill is placed. Pipe found to be out of alignment, unduly settled, or damaged shall be taken up and reinstalled or replaced.

d. **Joining pipe:**

(1) **Rigid pipe:** The method of joining pipe sections shall be such that ends are fully entered and inner surfaces are reasonably flush and even.

Joints shall be sealed with any one or combination of the following to form a leak-resistant joint: rubber, preformed plastic, or mastic gaskets from the Department's approved list; oakum and mortar; oakum and joint compound; or cold-applied pipe joint sealer.

Rubber ring gaskets shall be installed to form a flexible, leak-resistant seal. Where oakum is used, the joint shall be caulked with this material and then sealed with mortar or joint compound.

(2) **Flexible pipe:** Flexible pipe sections shall be aligned and firmly joined by approved coupling bands to form a leak-resistant joint.

e. **Structural plate pipe, pipe arches, and arches:** Erection shall be in accordance with the manufacturer's assembly diagrams and instruction sheets. Splices in the haunch areas of structural plate pipe arches shall be constructed using the reverse shingle method or the side plates shall be provided without longitudinal seams in the haunch areas. The complete line shall be assembled before backfill is placed. Bolts shall be tightened to a torque of 200 to 340 newtonmeters. Elongated pipe shall be erected with the long diameter in a vertical position. If spiraling occurs during erection, bolts shall be loosened and the pipe assembly adjusted to the correct position.

f. **Arch substructures, end walls, and pipe spillouts:** Each side of an arch shall rest in a groove formed into the masonry or on a galvanized angle or channel securely anchored to or embedded in the substructure. Where the span of the arch is more than 4.5 meters or the skew angle is more than 20 degrees, a metal bearing surface having a width at least equal to the depth of the corrugation shall be provided.

Metal bearings for arches shall be cold-formed galvanized channel conforming to the requirements of ASTM A569 at least 4.7 millimeters in thickness, with the horizontal leg securely anchored to the substructure at points spaced on centers of not more than 600 millimeters. When the metal bearing is not embedded in a groove in the substructure, one vertical leg shall be punched to allow bolting to the bottom row of plates.

g. **Backfilling:** Backfill material shall be placed alongside the pipe culvert in uniform layers not more than 150 millimeters, before compaction, and each layer shall be thoroughly compacted as specified in Section 303.04(g). Material shall be compacted thoroughly under haunches of pipe culverts. Each layer shall be compacted by rolling, tamping with mechanical rammers, or hand tamping with heavy metal tampers with a face of at least 160 square centimeters. If vibratory rollers are used in the backfill operation, vibratory

motors shall not be activated until at least 1 meter of backfill has been placed and compacted over the pipe.

Puddling will not be permitted. Rock more than 50 millimeters in its greatest dimension shall not be placed within 300 millimeters of pipe.

Backfill and compaction shall be advanced simultaneously on both sides of the pipe. The fill above the top of the pipe shall be completed as specified for embankment construction unless the induced trench method of installation is used.

When the induced trench method is required, the prism directly above the pipe culvert shall be furnished in accordance with the standard drawings for pipe bedding, Method B, or as shown on the plans. The induced trench or prism shall be constructed using one of the following procedures:

1. The embankment shall be constructed to the specified height above and to either side of the pipe. The prism of earth directly above the pipe shall then be removed, and the trench filled with the specified compressible material. Precautions shall be taken to ensure that the trench is centered directly over the pipe culvert and that the pipe culvert is not damaged by the trenching operation; *or*

2. The Contractor may install rigid forms to create the prism before the embankment is advanced above the pipe culvert. The prism between the side forms shall be filled with the specified compressible material, and the forms removed.

   Care shall be taken to prevent damage to the pipe culvert by construction traffic. Construction traffic will not be permitted to cross the pipe culvert until the requirements of standard drawing PC-1 for the cover and length of approach fills have been met. When pipe culvert is installed under fills more than 27 meters in height, construction traffic, except that necessary to place and compact embankment material over the pipe culvert installation, will not be permitted to cross the pipe culvert line until the embankment has been properly constructed full width to a height above the top of the pipe culvert equal to 5 times the outside diameter of the pipe culvert and for a distance of at least 30 meters on each side of the pipe culvert or to the intersection of a fill section with a cut section. Local areas of the fill above the pipe culvert that have become highly compacted by construction

traffic shall be removed and reconstructed to a uniform density before construction of the fill over the pipe culvert is resumed.

(b) **Precast Drainage Structures:** Submittal of designs for precast items included in the standard drawings will not be required provided fabrication is in accordance with the standard details. Submittal of designs for precast box culverts on the Department's approved list will not be required provided the Contractor submits a certification that the item will be fabricated in accordance with the preapproved design drawings.

Requests for approval of a precast design shall include detailed plans and supporting computations that have been reviewed and approved by a registered Professional Engineer having at least 5 years experience in structural design of the type of precast structures or components proposed. Concrete shall have a design strength at 28 days of at least 30 megapascals and an air content of 6 ± 2 percent. The design of the concrete mixture and the method of casting, curing, handling, and erecting shall be subject to review by the Engineer. Precast units may be shipped after reaching 85 percent of the design strength as determined by control cylinders tested in accordance with the requirements of Section 404. However, units shall retain their structural integrity during shipment and shall be subject to inspection at the job site. Approval to use precast units shall not be construed as waiving the size and weight hauling limitations of Section 105.14.

1. **Standard precast drainage units** shall conform to the material requirements of AASHTO M199 and the following:

   a. If the grade on the adjacent gutter is less than 1.5 percent, the grade on the invert of the throat section of the inlet shall be at least 1.5 percent. Precast throats having flat inverts will be permitted in sag locations provided the total length of the required throat opening does not exceed 1.8 meters.

   b. The pipe opening in precast units shall be at least 100 but not more than 200 millimeters larger than the outside diameter of the pipe. Pipe openings shall be formed, drilled, or neatly cut as approved by the Engineer.

   c. The Contractor may use brick and masonry block or concrete pipe cutoffs in conjunction with mortar to fill the void between pipe culverts and precast structures. Such materials shall be thoroughly wetted and bonded with mortar. The remaining exterior and interior void shall be filled with mortar to the contour of the precast structure.

d. When precast units are to be located adjacent to the subbase or base course, units with chambers shall be provided with weep holes 75 millimeters in diameter and hardware cloth and shall be located to drain the subbase or base.

e. Precast units located adjacent to cast-in-place concrete items, such as flumes, ditches, and gutters, shall be connected to the adjacent unit by means of 13-millimeter diameter smooth steel dowels spaced on approximately 300-millimeter centers throughout the contact length and extending at least 100 millimeters into both the precast unit and the cast-in-place item. If holes to receive the dowels are provided in the precast unit, they shall be not more than 16 millimeters in diameter. Other methods of providing the connection, such as keyed joints, shall be approved by the Department prior to fabrication.

f. The chamber section shall be installed in the plumb position. The throat and top sections shall have positive restraints, such as adjacent concrete, pavement, or soil, on all sides to prevent displacement and shall have a positive interlock, such as dowels, with the chamber section. The throat and top sections shall be installed to conform with the normal slope of the finished grade and may be canted up to a maximum grade of 10%. The chamber may be built up a maximum of 300 millimeters at any point to provide for complete and uniform bearing of the throat and top sections on the chamber flat slab top or other approved top section. The built-up section shall be constructed using whole concrete spacer units where feasible and partial and whole sections of concrete block or brick with high-strength grout and mortar. High-strength grout shall be used to provide the final grade adjustment and uniform bearing. The width of the built-up section shall match the wall thickness of the chamber section. The concrete block and brick shall be thoroughly bonded with mortar and the inside and outside of the built-up section shall be plastered with mortar except that the concrete spacer unit shall not be plastered.

2. **Precast arches** shall conform to the applicable requirements of AASHTO's *Standard Specifications for Highway Bridges* with the following modifications:

a. **Combination of loads:** For service load design: β_E vertical loads: 1.00; lateral loads: 1.00 and 0.5 (check both loadings).

For load factor design: β_E: vertical loads: 1.00; lateral loads: 1.30 and 0.5 (check both loadings).

b. **Protection against corrosion:** The concrete cover of reinforcement shall be at least 40 millimeters.

In corrosive or marine environments or other severe exposure conditions, reinforcement shall be epoxy coated in accordance with the requirements of Section 223.

Exposed reinforcing bars, inserts, and plates intended for bonding with future extensions shall be protected from corrosion as directed by the Engineer.

Reinforcement shall be designed and detailed in consideration of fabrication and construction tolerances so that the minimum required cover and proper positioning of reinforcement shall be maintained.

c. **Anchorage:** Sufficient anchorage shall be provided at the terminus of lines of precast units. Anchorage may consist of a cast-in-place end section at least 1 meter in length with a headwall or collar around the precast unit(s) provided adequate connection can be made between the collar and units.

d. **Joints:** Joints between units shall be sealed by preformed plastic or mastic gaskets or grout. When preformed gaskets are used, they shall be of a type listed on the Department's approved products list.

e. **Pipe openings:** Pipe openings will not be allowed in the precast arch but may be provided through the wingwalls. When required, openings shall conform to the requirements of 1.b. herein.

3. **Precast box culverts** shall conform to the applicable requirements of AASHTO M259 or M273 and AASHTO's *Standard Specifications for Highway Bridges* with the following modifications:

a. **Combination of loads:** For service load design or load factor design: β_F: new reinforced concrete boxes: vertical loads: 1.00; lateral loads: 1.00 and 0.5 (check both loadings).

b. **Protection against corrosion:** The following minimum concrete cover shall be provided for reinforcement: For boxes with more than 0.6 meter of fill over the top slab: 40 millimeters. For boxes with less than 0.6 meter of fill over the top slab: top reinforcement of top slab: 65 millimeters; bottom reinforcement of top slab: 50 millimeters; all other reinforcement: 40 millimeters.

The minimum cover for reinforcement may be reduced by not more than 13 millimeters, provided the reinforcement having reduced cover is epoxy coated or the concrete surfaces adjacent to the reinforcement are coated with Class I Waterproofing in accordance with the requirements of Section 421.

Reinforcing steel for box culverts used in 0 to 0.6 meter fills, used in corrosive or marine environments, or used in other severe exposure conditions shall be epoxy coated. When epoxy coated reinforcing steel is required due to these conditions, the minimum cover specified shall not be reduced.

c. The type of sealant used in joints between units shall be from the Department's approved list of preformed plastic or mastic gaskets.

Where double or greater lines of precast units are used, a buffer zone of 75 to 150 millimeters between lines shall be provided. This buffer zone shall be backfilled with porous backfill conforming to the requirements of Section 204. The porous backfill shall be drained by a 75-millimeter diameter weep hole, formed by non-rigid tubing, located at the top of the bottom haunch, centered in the outlet end section, and at approximately 15-meter intervals along the length of the box. Weep holes shall be covered with a 900-millimeter square section of filter barrier cloth firmly attached to the outside of the box. A 900-millimeter width of filter barrier cloth shall also be centered over the buffer zone for the entire length of the structure after placement of the porous backfill material. Filter barrier cloth shall conform to the requirements of Section 258.

Forming weep holes and furnishing and placing of the filter barrier cloth shall be included in the price bid per meter for the precast box culvert.

d. At the terminus of precast units, sufficient anchorage shall be provided. This anchorage may consist of a cast-in-place end section at least 900 millimeters in length with a headwall and curtain wall or a collar cast-in-place around the units provided adequate connection can be made between the collar and units.

When the ends of precast units are skewed, the end section shall be cast monolithically. The skew may be provided by forming, saw cutting, or other methods approved by the Engineer. Regardless of the method used, the variation in

the precast unit from the exact skew shall be not greater than 40 millimeters at any point.

e. Pipe openings shall conform to the requirements of 1.b. herein.

f. Bedding shall be at least 150 millimeters in thickness.

(c) **Drop Inlets, Manholes, Spring Boxes, Intake Boxes, and End Walls:** Masonry construction shall not be initiated when the air temperature is below 4 °C in the shade.

Brick and concrete block masonry shall be placed so that each unit will be thoroughly bonded with mortar. Joints shall be full-mortar joints not more than 15 millimeters in width. Where brick masonry is used, headers and stretchers shall be arranged to bond the mass fully. Every seventh course shall be placed entirely with headers. Inside joints shall be neatly pointed, and the outside of such walls shall be plastered with mortar as they are placed.

Iron fittings entering the masonry shall be placed as the work is built up, thoroughly bonded, and accurately spaced and aligned.

Inlet and outlet pipe connections shall conform to the same requirements as the pipe to which they connect and shall be of the same size and kind. Pipe sections shall be flush on the inside of the structure wall and shall project outside sufficiently for proper connection with the next pipe section. Masonry shall fit neatly and tightly around the pipe.

Immediately following finishing operations, hydraulic cement concrete shall be cured and protected in accordance with the requirements of Section 316.04(j).

Backfilling shall be performed in accordance with the requirements of Section 303.04(g). Surplus material shall be removed, and the site shall be left in a neat and orderly condition.

When grade adjustment of existing structures is specified, frames, covers, and gratings shall be removed and the walls shall be reconstructed as required. Cleaned frames shall be reset at the required elevation. Upon completion, each structure shall be cleaned of silt, debris, and foreign matter and shall be kept clear of such accumulation until final acceptance.

302.04—Measurement and Payment.

Pipe culverts will be measured in meters. The quantity will be determined by counting the number of sections and multiplying by the length of the

section used. When a partial section is required, the actual length of the partial section will be measured in place.

Structural plate pipe and pipe arches will be measured in meters along the invert line.

Pipe tees and elbows will be measured in meters of pipe.

Pipe reducers will be measured in meters of pipe for payment at the larger pipe size.

Pipe shall be paid for at the contract unit price per meter. This price shall include excavating, when not a pay item; sheeting; shoring; dewatering; disposing of surplus and unsuitable material; backfill material; and restoring existing surfaces. When unit prices for extended pipe lines are not specified, the unit price for new pipe of the same size shall apply. When not a pay item, the cost of temporary relocation of a stream or drainage facility shall be included in the price for the related pipe or box culvert. The cost of fittings and pipe anchor blocks shall be included in the price for the applicable type of pipe.

Jacked pipe will be measured in meters to the nearest 0.1 meter and will be paid for at the contract unit price per meter.

Reinstalled pipe will be measured in meters along a line parallel to the flow line and will be paid for at the contract unit price per meter of pipe and per cubic meter of minor structure excavation. This price shall include excavation involved in removing pipe, hauling, cleaning, relaying, backfilling, necessary cutting for joining to other sections of pipe, furnishing new coupling bands, disposing of surplus excavation, and replacing any otherwise usable sections damaged or broken because of the negligence of the Contractor.

End sections and pipe spillouts will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

Endwalls and arch substructures will be measured in cubic meters of concrete and kilograms of reinforcing steel, except that EW-12 endwalls will be measured in units of each, complete-in-place. Endwalls and arch substructures will be paid for at the contract unit price per cubic meter of miscellaneous concrete and per kilogram of reinforcing steel, except that crack control bars shall be included in the price bid for miscellaneous concrete and standard EW-12 endwalls will be paid for at the contract unit price per each.

Minor structure excavation will be measured and paid for in accordance with the requirements of Section 303.06.

Bedding will be measured and paid for as follows: The 100 millimeters of bedding required under pipe in accordance with the standard drawings shall be considered incidental to the pipe and will not be measured for separate payment.

Bedding material outside the initial 100 millimeters will be measured in metric tons. Except for the initial 100 millimeters, bedding material will be paid for at the contract unit price per metric ton, which price shall include placing, compacting, and shaping the material. Provisions that pertain to adjusting contract unit prices because of changes of contract quantities in accordance with the requirements of Section 104.02 will not apply to this pay item.

Backfill of pipe foundations will be measured in cubic meters and will be paid for at twice the contract unit price for regular excavation or will be measured in metric tons and will be paid for at the contract unit price per metric ton for aggregate. This price shall include placing, shaping, and compacting the material. The provisions of Section 104.02 that pertain to adjustment of contract unit prices due to changes in contract quantities will not apply to this contract item.

Excavation of the induced trench and the specified compressible material required therefor will not be measured for separate payment. The cost of constructing the induced trench, including furnishing and placing the specified compressible material therein, shall be included in the price for the pipe.

Box culverts will be measured in cubic meters of concrete and kilograms of reinforcing steel and will be paid for at the contract unit price per cubic meter of concrete and per kilogram of reinforcing steel. These prices shall include waterproofing.

Precast box culverts will be measured in meters along the center line of the barrel from face of curtain wall to face of curtain wall and will be paid for at the contract unit price per meter. This price shall include designing, casting, reinforcing, installing, waterproofing, sealing joints, anchoring, and providing buffer zones for multiple lines.

If the Contractor elects to furnish and install precast box culverts or precast arches, payment will be made for the original quantities shown on the plans for cast-in-place units. No additional compensation will be made for casting, prestressing, or shipping precast units or performing additional work, such as waterproofing, epoxy coating, or joint sealing, required as a result of the substitution.

Grates and frames will be measured in units of each and will be paid for at the contract unit price per each.

Pipe grate will be measured in meters and will be paid for at the contract unit price per meter. This price shall include fabricating, furnishing, galvanizing, and installing.

Drop inlets and intake boxes will be measured as complete units, including the frame and grate or cover, and will be paid for at the contract unit price per each. The contract unit price for drop inlets will be adjusted at the rate of

2% per meter for increases or decreases in the depth indicated on the plans except that no adjustment will be made for changes amounting to less than 150 millimeters in the height of a single drop inlet. Where curb or curb and gutter extend along the drop inlet, the contract unit price for drop inlets shall include that part of the curb or gutter within the limits of the structure.

Base sections of pipe tee units used as drop inlets and manholes will be measured in meters horizontally and will be paid for at the contract unit price per meter of pipe specified. The riser section and additional costs for the tee shall be included in the price for the drop inlet or manhole.

Manholes will be measured in meters, vertical measure, from top of foundation slab to top of masonry on which the casting frame is placed. However, when manholes are constructed as tee sections, measurement will be made to the pay limits shown on the plans. Manholes will be paid for at the contract unit price per vertical meter exclusive of frame and cover.

Concrete spring boxes will be measured in cubic meters of concrete, kilograms of reinforcing steel, and meters of pipe and will be paid for at the contract unit price per cubic meter of concrete, per kilogram of reinforcing steel, and per meter of pipe.

Junction boxes will be measured in cubic meters of concrete, kilograms of reinforcing steel, kilograms of structural steel, and each complete frame and cover assembly and will be paid for at the contract unit price per cubic meter of concrete, per kilogram of reinforcing steel, per kilogram of structural steel, and per each frame and cover assembly.

Casting frames and covers will be measured in units of one complete frame and cover and will be paid for at the contract unit price per unit.

Reconstructed manholes will be measured as a complete unit and will be paid for at the contract unit price per each.

Precast arches will be measured in meters along the center line of the invert from face of headwall to face of headwall. When a pay item, precast arches will be paid for at the contract unit price per meter. This price shall include designing, forming, casting, reinforcing, excavating, wingwalls, installing, waterproofing, sealing joints, anchoring and bedding, and providing buffer zones for multiple lines. The cost for cast-in-place work other than that specified on the plans shall be included in the price for precast arches.

Temporary diversion channel lining will be measured in square meters for the class specified and will be paid for at the contract unit price per square meter. This price shall include installing the channel lining and removal when no longer required.

Temporary diversion channel excavation will be measured in cubic meters and will be paid for at the contract unit price per cubic meter. This price shall include excavation, temporary pipe culverts and removal of pipe culverts when no longer required, backfilling, and site restoration including regrading and seeding.

Storm water management drainage structure will be measured in meters, vertical measure, from top of concrete foundation to the top of the concrete cover. The price bid shall include Class 20 concrete, reinforcing steel, concrete cover, debris rack, orifice, steps when required, and Class A1 riprap.

Storm water management riser pipe will be measured in meters for the size specified and will be paid for at the contract unit price per meter. The bid price shall include the riser pipe, perforated pipe, steel plate, debris rack, orifice, grate and cover when required, and Class A1 riprap.

Temporary sediment riser pipe will be measured in meters for the size specified and will paid for at the contract unit price per meter. The price shall include the riser pipe, steel plate, perforated pipe, debris rack, orifice and Class A1 riprap, and vortex device when required.

Storm water management dam will be measured and paid for at the contract unit price per cubic meter of concrete and kilogram of reinforcing steel.

Excavation, backfill, and disposal of unsuitable or surplus material for drop inlets, intake boxes, manholes both new and reconstructed, spring boxes, junction boxes, and base sections of pipe tee units used as drop inlets and manholes will not be measured for separate payment, and the cost thereof shall be included in the bid price for such items. In the event steps or invert shaping are required, the cost thereof shall also be included in the price for such items.

Payment will be made under:

Pay Item	Pay Unit
Pipe (Size and type)	Meter
Structural plate arch (Size)	Meter
Jacked pipe (Size)	Meter
Reinstalled pipe	Meter
End section (Standard and size)	Each
Pipe spillout (Standard)	Each
Concrete (Class)	Cubic meter
Reinforcing steel	Kilogram
End wall grate and frame (Standard)	Each
Bedding material, aggregate No. ( )	Metric ton
Precast box culvert (Size)	Meter
End wall pipe grate (Type)	Meter
Drop inlet (Standard and length)	Each
Intake box (Standard)	Each

Structural steel (Type)	Kilogram
Manhole (Standard)	Meter
Frame and cover (Standard)	Each
Reconstructed manhole	Each
Precast arch (Size)	Meter
Temporary diversion channel lining (Class)	Square meter
Temporary diversion channel excavation	Cubic meter
Endwall standard EW-12	Each
Storm water management drainage structure (Type)	Meter
Storm water management riser pipe (Size)	Meter
Temporary sediment riser pipe (Size)	Meter

SECTION 303—EARTHWORK

303.01—Description.

This work shall consist of constructing roadway earthwork in accordance with these specifications and in reasonably close conformity with the specified tolerances for the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer. Earthwork shall include regular, borrow, undercut and minor structure excavation; constructing embankments; disposing of surplus and unsuitable material; shaping; compaction; sloping; dressing; and temporary erosion control work.

303.02—Materials.

(a) **Borrow excavation** shall consist of approved material required for the construction of the roadway and shall be obtained from approved sources outside the project limits.

(b) **Materials for temporary silt fences, geotextile fabric silt barriers, and filter barriers** shall conform to the requirements of Sections 242 and 245.

303.03—Erosion and Siltation Control.

Erosion and siltation shall be controlled through the use of the devices and methods specified herein or as is otherwise necessary. The Department reserves the right to require other temporary measures not specifically described herein to correct an erosion or siltation condition.

Erosion and siltation control devices and measures shall be maintained in a functional condition at all times. Temporary and permanent erosion and

sedimentation control measures shall be inspected after each rainfall and at least daily during periods of prolonged rainfall. Deficiencies shall be immediately corrected. The Contractor shall make a daily review of the location of silt fences and filter barriers to ensure that they are properly located for effectiveness. Where deficiencies exist, corrections shall be made immediately as approved or directed by the Engineer.

Sediments shall be removed when the wet storage volume has been reduced by 50 percent. Removed sediment shall be disposed of in accordance with Section 106.04. Sediment deposits remaining in place after the device is no longer required shall be dressed to conform with the existing grade, prepared, and seeded in accordance with the requirements of Section 603.

Geotextile fabric that has decomposed or becomes ineffective and is still needed shall be replaced. In addition, temporary erosion and sediment control devices except brush silt barriers shall be removed within 30 days after final site stabilization or after the temporary devices are no longer needed as determined by the Engineer.

(a) **Earth Berms and Slope Drains:** The top of earthwork shall be shaped to permit runoff of rainwater. Temporary earth berms shall be constructed and compacted along the top edges of embankments to intercept runoff water. Temporary slope drains shall be provided to intercept runoff and adequately secured to prevent movement. Slope drains may be flexible or rigid but shall be capable of being readily shortened or extended. A portable flume shall be provided at the entrance to temporary slope drains.

(b) **Incremental Seeding**: Cut and fill slopes shall be shaped and topsoiled where specified. Seed and mulch shall be applied in accordance with the requirements of Section 603 as the work progresses in the following sequence:

1. Slopes whose vertical height is 6 meters or greater shall be seeded in three equal increments of height. Slopes whose vertical height is more than 24 meters shall be seeded in 8-meter increments.

2. Slopes whose vertical height is less than 6 but more than 2 meters shall be seeded in two equal increments.

3. Slopes whose vertical height is 2 meters or less may be seeded in one operation.

Seeding operations shall be initiated within 48 hours after attaining the appropriate grading increment or upon suspension of grading operations for an anticipated duration of greater than 15 days or upon completion of grading operations for a specific area.

(c) **Check Dams and Silt Settlement Boxes:** As an initial item of work, required check dams shall be constructed at 8-meter intervals, unless otherwise shown on the plans, below the outfall end of drainage structures.

Straw check dams shall not be constructed in streams and shall be installed only where designated on the plans to form settlement pools. Settlement pools shall be cleaned regularly as directed by the Engineer, and material removed shall be transported and deposited at locations where it will not reenter the stream or drainage ways.

When timber silt settlement boxes or log check dams are required, timber sheeting may be any grade that is structurally sufficient to maintain the general shape and function of the particular box or dam shown on the plans.

(d) **Baled Straw Silt Barriers:** Baled straw silt barriers may be substituted for temporary filter barriers with the approval of the Engineer in noncritical areas, such as pavement areas and rock locations where filter barriers cannot be installed in accordance with the plans and specifications, and locations where the Engineer determines that streams and water beds will not be affected.

(e) **Temporary Silt Fences, Geotextile Fabric Silt Barriers, and Filter Barriers:**

1. **Temporary silt fences:** Fences shall be erected at locations shown on the plans or determined by the Engineer. Extra-strength geotextile fabric or standard-strength geotextile fabric with wire fence reinforcement shall be provided. Posts shall not be spaced more than 3 meters apart. Posts shall be uniformly installed with an inclination toward the potential silt load area of at least 2 but not more than 20 degrees. Attaching fabric to existing trees will not be permitted.

   Fabric shall be firmly secured to the post or wire fence. The bottom of the fabric shall be entrenched in the ground at least 100 millimeters. Fabric may be spliced only at support posts and with an overlap of at least 150 millimeters. The top shall be installed with a 25-millimeter tuck or reinforced top end section. The height of the finished fence shall be a nominal 900 millimeters.

2. **Geotextile fabric silt barriers:** Existing fences or brush barriers used along the downhill side of the toe of fills or below pipe culvert installations shall have standard-strength geotextile fabric attached at specified locations. The bottom of the fabric shall be entrenched in the ground at least 100 millimeters, and the top

shall be installed with a 25-millimeter tuck or reinforced top end section.

Brush barriers shall be installed prior to any major earth-disturbing activity and trimmed sufficiently to prevent tearing or puncturing fabric. Fabric shall be fastened securely to the brush barrier or existing fence. A 150-millimeter overlap of fabric for vertical and horizontal splicing shall be maintained and tightly sealed.

3. **Temporary filter barriers:** Barriers shall consist of standard-strength geotextile fabric or 285-gram burlap fabric and shall be securely fastened to wood or metal supports that are spaced at not more than 1-meter intervals and driven at least 300 millimeters into the ground. At least three supports shall be used. The bottom of the fabric shall be entrenched in the existing ground at least 100 millimeters. The temporary filter barrier shall be at least 375 but not more than 450 millimeters in height. The top of the fabric shall be installed with a 25-millimeter tuck or reinforced top end section.

   Temporary filter barriers shall be installed in ditch lines and at temporary locations as directed or approved by the Engineer where construction changes the earth contour and drainage runoff.

(f) **Sediment Basins:** Sediment basins are required if stormwater runoff flowing across a disturbed area exceeds the standards of the Virginia Erosion and Sediment Control Regulations.

303.04—Procedures.

Loose rock 75 millimeters or larger shall be removed from the surface of cut slopes.

When slides occur, the Contractor shall remove and dispose of material as directed by the Engineer.

Where required, surface ditches shall be placed at the top of cut slopes or at the foot of fill slopes and at such other points not necessarily confined to the right of way or shown on the plans and shall be of such dimensions and grades as directed by the Engineer.

Allaying dust, when specified, shall be performed in accordance with the requirements of Section 511.

Prior to the beginning of grading operations in the area, necessary clearing and grubbing shall be performed in accordance with the requirements of Section 301.

(a) **Regular Excavation:** Existing foundations and slabs located within the construction limits shall be removed and disposed of in a location approved by the Engineer. In lieu of removal, foundations and slabs located 1.5 meters or more below the proposed subgrade may be broken into particles not more than 450 millimeters in any dimension and reoriented to break the shear plane and allow for drainage.

Cisterns, septic tanks, wells, and other such structures shall be cleared in accordance with the requirements of Section 516.

Balance points shown on the plans are theoretical and may vary because of actual field conditions.

When the material to be excavated necessitates the use of explosives, the requirements of Section 107.11 relating to the use of explosives shall apply. To prevent damage to newly constructed concrete, the Contractor shall schedule blasting operations in the proximity of proposed concrete structures so that work will be completed prior to placement of concrete.

Regular excavation shall consist of removing and disposing of material located within the project limits, including widening cuts and shaping slopes necessary for preparing the roadbed; removing root mat; stripping topsoil; cutting ditches, channels, waterways, and entrances; and performing other work incidental thereto. The Engineer may require materials in existing pavement structures to be salvaged for use in traffic maintenance.

Undrained areas shall not be left in the surface of the roadway. Grading operations shall be conducted so that material outside construction limits will not be disturbed.

Where rock or boulders are encountered, the Contractor shall excavate and backfill in accordance with the plans and contract documents.

When the presplitting method of excavation is specified for rock cuts, work shall be performed in a manner to produce a uniform plane of rupture in the rock and so that the resulting backslope face will be unaffected by subsequent blasting and excavation operations within the section. Rock shall be presplit along rock slopes at locations, lines, and inclinations shown on the plans or as determined by field conditions. A test section shall be provided to establish the spacing of drill holes and the proper blasting charge to be used in the presplitting operation. Drill holes shall be spaced not more than 1 meter apart and shall extend to the plan grade or in lifts of not more than 8 meters, whichever is less. If drilled in benches, an offset may accommodate the head of the drill, but

no offset shall be more than 300 millimeters. Presplitting shall extend at least 6 meters ahead of the limits of fragmentation blasting within the section.

Where the project has been designed and slopes have been staked on the assumption that solid rock will be encountered and the Contractor fails to encounter solid rock at the depth indicated, he shall cease excavation in the area and immediately notify the Engineer. If it is necessary to redesign and restake slopes, any additional excavation necessary will be paid for at the contract unit price per cubic meter.

Topsoil stockpiled for later use in the work shall be stored within the right of way unless the working area is such that the presence of the material would interfere with orderly prosecution of the work. Stockpile areas outside the right of way shall be located by the Contractor at his expense. Topsoil used in the work shall be removed first from stockpiles located on private property. Surplus topsoil remaining on private property after completion of topsoiling operations shall be moved onto the right of way and stockpiled, shaped, and seeded as directed by the Engineer.

Stripping topsoil shall be confined to the area over which grading is to be actively prosecuted within 15 calendar days following the stripping operation. Grading operations shall be confined to the minimum area necessary to accommodate the Contractor's equipment and work force engaged in the earth moving work.

(b) **Borrow Excavation:** The Contractor shall make his own arrangements for obtaining borrow and pay all costs involved in accordance with the provisions of Section 106.03.

If the Contractor places an excess of borrow and thereby causes a waste of regular excavation, the amount of such waste, unless authorized, will be deducted from the volume of borrow as measured at the source or computed by vehicle count as specified in Section 109.01.

When borrow is obtained from sources within the right-of-way and the excavation is performed simultaneously with regular excavation, borrow excavation will be designated as regular excavation. Material secured by widening cuts beyond slope stakes, when taken from previously excavated slopes, will be designated as borrow excavation. When such a procedure is approved, slopes shall be uniform and no steeper than shown on the plans.

Borrow excavation areas shall be bladed and left in a shape to permit accurate measurements after excavation has been completed.

(c) **Undercut Excavation:** Undercut excavation shall consist of removing and disposing of unsuitable material located within the construction limits in accordance with Section 303.06(a)3.

Undercut excavation shall be disposed of in accordance with Section 106.04.

(d) **Minor Structure Excavation:** Minor structure excavation shall consist of removing material necessary to accommodate the structure, such as box or arch culverts, including pipe arches, structural plate arches, structural plate pipe, pipe culverts, and storm drains with span(s) or opening(s) 900 millimeters or greater. Minor structure excavation shall also include dewatering, sheeting, bracing, removing existing structures, and backfilling. Removing existing structures shall also include foundations that might be necessary to clear the site.

(e) **Removing Unsuitable Material:** Where excavation to the finished graded section results in a subgrade or slopes of unsuitable material, such material shall be excavated below the grade shown on the plans or as directed by the Engineer. Areas so excavated shall be backfilled with approved material in accordance with (f) herein.

Excavation for structures shall be carried to foundation materials satisfactory to the Engineer regardless of the elevation shown on the plans. If foundation material is rock, the Contractor shall expose solid rock and prepare it in horizontal beds for receiving the structure. Loose or disintegrated rock and thin strata shall be removed. Excavated material, if suitable, shall be used for backfilling around the structure or constructing embankments.

Material shown on the plans as unsuitable and during construction found to be suitable for use shall first be used in embankments where needed in lieu of borrow. However, the use of this material in lieu of borrow shall not alter the provisions of Section 104.02 regarding underruns.

Material shown on the plans as suitable but found at the time of construction to be unsuitable shall be disposed of as unsuitable material.

Unsuitable material shall be disposed of in accordance with Section 106.04.

(f) **Backfill for Replacing Undercut Excavation:** Backfill shall be composed of regular excavation, borrow, select material, subbase material, or other material as directed by the Engineer. Backfilling operations shall be performed in accordance with (g) herein.

(g) **Backfilling Openings Made for Structures:** Backfill shall be suitable material removed for the structure, although the Engineer may require

that backfill material be obtained from a source within the construction limits entirely apart from the structure or other approved material. The opening to be backfilled shall be dewatered prior to backfilling. Backfill shall not be placed against or over cast-in-place box culverts or other structures until the top concrete slab section(s) has been in place 14 days, exclusive of days on which the average high-low ambient temperature is below 4 °C in the shade or until the concrete control cylinder(s) has attained a compressive strength equal to 93 percent of the 28-day design compressive strength.

Backfill shall be compacted in horizontal layers not more than 150 millimeters in thickness, loose measurement, and as specified in (h) herein. Backfill shall be placed in horizontal layers such that there will be a horizontal berm of compacted undisturbed material behind the structure for a distance at least equal to the remaining height of the structure or wall to be backfilled. Backfill shall be placed in a manner to deter impoundment of water and facilitate existing drainage. Backfill around piers in areas not included in the roadway prism shall be constructed in uniformly compacted layers. However, density requirements will be waived.

Box culverts shall not be opened to construction equipment traffic until concrete has attained 100 percent of the 28-day design compressive strength and has a backfill cover of at least 1.2 meters. The minimum height of backfill cover required to protect pipe culverts from construction equipment shall be in accordance with Standard Drawing PC-1 for the type and size specified.

Where only one side of abutments, wingwalls, piers, or culvert headwalls can be backfilled, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning or excessive pressure against the structure. When both sides of a concrete wall or box structure is to be backfilled, operations shall be conducted so that the backfill is always at approximately the same elevation on both sides of the structure.

Openings subject to flooding shall be backfilled as soon as practicable or as directed by the Engineer.

(h) **Embankments:** Work shall consist of constructing roadway embankments, placing and compacting approved material within roadway areas where unsuitable material has been removed; and placing and compacting approved material in holes, pits, utility trenches, basements, and other depressions within the roadway area.

Embankment shall be constructed with approved material and placed so as to be uniformly compacted throughout. Embankment shall be placed adjacent to structures in the same manner as for backfill, as

described in (g) herein. Embankment shall not contain muck, frozen material, roots, sod, or other deleterious material. Embankment shall not be placed on frozen ground or areas covered with ice or snow.

Unsuitable material used in widening embankments and flattening embankment slopes shall be placed in uniform layers not more than 450 millimeters in thickness before compaction. Each layer of material placed shall be compacted to the extent necessary to produce stable and reasonably even slopes.

Wherever rock excavation is available on the project, a 200 to 375 millimeter layer of such materials shall be dump spread over the lower region of embankments in the immediate vicinity of stream crossings and used to cover ditches, channels, and other drainage ways leading away from cuts and fills. However, drainage ways shall be prepared to receive the rock excavation to the extent necessary to avoid reducing their cross section. If rock excavation is not available on the project, riprap, jute mesh, or soil retention mats shall be used as the covering material and shall be installed in accordance with the requirements of Section 606. Limits of the area to be covered will be as noted on the plans or as directed by the Engineer.

Wherever sufficient right of way exists, surplus materials shall be used to widen embankments and flatten slopes as directed by the Engineer.

Rock excavation may be placed on slopes by uniform end dumping of the material from along the top of the embankment or as directed by the Engineer. Slopes that are covered with rock excavation shall not receive topsoil or seed.

When geotextile drainage fabric is required under rock fills, preparation shall be as specified in Section 414.

The Contractor shall schedule excavation and embankment work in a manner that will minimize the quantity of unsuitable material for which more than one handling is required prior to final placement. Therefore, the provisions for additional payment for each rehandling of material specified in Section 303.06(a) will not apply to placing unsuitable material for widening embankments and flattening embankment slopes.

The surface area directly beneath the pavement and shoulders on which embankments of less than 1.5 meters in depth are to be constructed shall be denuded of vegetation. These areas shall be scarified and compacted to a depth of 150 millimeters to the same degree as the material to be placed thereon.

Areas that contain material unsuitable as foundations for embankments shall be undercut and backfilled in accordance with (e) and (f) herein.

Embankments to be placed over saturated areas that will not support the mass of hauling equipment may be constructed by end dumping successive loads in a uniformly distributed layer of a thickness capable of supporting the hauling equipment while subsequent layers are placed. The nose, or leading edge, of the embankment shall be maintained in a wedge shape to facilitate mud displacement in a manner that will prevent its entrapment in the embankment. The front slope of the embankment shall be maintained steeper than 2:1. The use of compacting equipment will not be required on the original course. However, the remainder of the embankment shall be constructed in layers and compacted in accordance with these specifications.

When embankment is to be placed and compacted on an existing road, the surface shall be scarified to such degree as will permit an ample bond between old and new material. Hydraulic cement concrete and asphalt concrete pavement structures within the proposed roadway prism shall be demolished in accordance with Section 508.

Existing slopes shall be continuously benched where embankments are constructed 1/2 width at a time, against slopes of existing embankments or hillsides, or across existing embankments, hillsides, and depressions at a skew angle of 30 degrees or more, or where the existing slopes are steeper than 4:1. For slopes steeper than 4:1 but not steeper than 11/2:1, the bench shall be at least 1.8 meters in width. For slopes steeper than 11/2:1 but less than 1/2:1, the bench shall be at least 1.2 meters in width. Benching shall consist of a series of horizontal cuts beginning at the intersection with the original ground and continuing at each vertical intersection of the previous cut. Material removed during benching operations shall be placed and compacted as embankment material.

When excavated material consists predominantly of soil, embankment shall be placed in successive uniform layers not more than 200 millimeters in thickness before compaction over the entire roadbed area. Each layer shall be compacted within a tolerance of ± 20 percent of optimum moisture content, to a density of at least 95 percent of the theoretical maximum density as defined in Division II.

Material having a moisture content above optimum by more than 30 percent shall not be placed on a previously placed layer for drying unless it is shown that the layer will not become saturated by downward migration of moisture in the material.

Field density determinations will be performed in accordance with AASHTO T191, T205, or T214, modified to include material sizes used in the laboratory determination of density, with a portable nuclear field density testing device or by other approved methods. When a

nuclear device is used, density determinations for embankment material will be related to the density of the same material tested in accordance with VTM 1 or VTM 12 and a control strip will not be required.

As the compaction of each layer progresses, continuous leveling and manipulating will be required to ensure uniform density. Prior to placement of subsequent layers, construction equipment shall be routed uniformly over the entire surface of each layer or the layer shall be scarified to its full depth in the area where the equipment is routed.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing, or further breaking down the pieces resulting from excavation methods, such material may be placed in the embankment in layers that are not thicker than the approximate average size of the larger rocks. Rock not more than 1.2 meters in its greatest dimension may be placed in an embankment to within 3 meters of the subgrade. The remainder of the embankment to within 600 millimeters of the subgrade shall not contain rock more than 600 millimeters in its greatest dimension. Each layer shall be constructed so that rock voids are filled with rock spalls, rock fines, and earth. Rock shall be placed, manipulated, and compacted in uniform layers. However, density requirements may be waived. Rock, rock spalls, rock fines, and earth shall be distributed throughout each embankment layer and manipulated as specified herein so that the voids are filled. Rock shall not be end dumped over the edges of the layer being constructed but shall be deposited on the layer and moved ahead so as to advance the layer with a mixture of rock, rock spalls, rock fines, and earth. The 600 millimeters of the embankment immediately below the subgrade shall be composed of material that can be placed in layers of not more than 200 millimeters before compaction and compacted as specified herein for embankments. Rock more than 75 millimeters in its greatest dimension shall not be placed within 300 millimeters of the subgrade in any embankment.

Rock, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

The best material shall be reserved for finishing and dressing the surface of embankments. Work necessary to ensure the reservation of such material shall be the responsibility of the Contractor. The provisions in Section 303.06(a) will not apply to subsequent handling of capping material.

(i) **Settlement Plates and Surcharge:** The Contractor shall expedite construction of embankment to provide the maximum time possible for settlement prior to completing grading operations.

1. **Settlement plates:** The base of settlement plates shall be firmly seated into original ground for the full depth of the steel fins. The base shall be leveled. The Engineer shall be provided time to obtain the elevation of the seated base and the top elevation of the pipe extensions prior to placement of embankment material. Pipe extensions shall not be more than 1.2 meters in length and shall be vertically installed as the embankment is constructed such that the top of the pipe is not covered. As each extension is added, the Engineer shall be provided time to obtain the top elevation of the existing pipe and the top elevation of the new pipe extension. Pipe extensions shall be properly flagged at all times. Care shall be taken while placing and compacting embankment material around pipe extensions. Settlement plates shall be maintained until no longer required, as determined by the Engineer. Upon completion of the normal embankment plus 600 millimeters of the specified surcharge, the Contractor shall immediately commence placing the remaining surcharge to the limits shown on the plans or as directed by the Engineer. The remaining surcharge shall be placed in lifts of not more than 300 millimeters in depth and compacted uniformly with construction hauling and spreading equipment. Each lift shall be completed over the entire surcharge area before the next lift is begun.

   If a settlement plate is damaged, the Contractor shall notify the Engineer immediately and promptly repair it under the observation of the Engineer to the nearest undamaged pipe. Excavation, backfill, compaction, and repair of settlement plates shall be at the Contractor's expense. The Engineer shall be provided time to obtain the top elevation of the undamaged connection and the top elevation of each subsequent pipe extension.

   Settlement plates shall remain in place until settlement has been completed as indicated by elevation readings taken by the Department at approximately 2-week intervals. Evaluation of the readings by the Engineer will be the final and sole governing factor for releasing embankments for grading operations. Upon written release by the Engineer, extensions of settlement plate pipe shall be removed to at least 600 millimeters below the subgrade, the pipe capped, and the area backfilled and compacted.

2. **Surcharge:** When authorized by the Engineer, surcharge shall be removed to the subgrade and embankment slopes graded to the typical section. Removed surcharge shall be placed in roadway embankments not previously brought to grade or shall be disposed of in accordance with Section 106.04 or as directed by the Engineer.

(j) **Hydraulic Embankment:** Hydraulic embankment shall consist of dredging and pumping materials approved by the Engineer from

designated areas, placing the material in embankments, and dressing and completing the embankment. Material shall be nonplastic and of such grading that not more than 7 percent will pass the 75 μm sieve.

Unless otherwise shown on the plans, material for the embankment shall not be obtained from sources closer than 90 meters from the toe of the slope of the embankment. The Engineer may reject materials considered to be unsatisfactory for use in the embankment, and such materials shall be stripped at the Contractor's expense before the embankment is built. Muck and unsuitable material shall be removed to the line, grade, and section shown on the plans. Unsatisfactory material brought to the top of the embankment shall be removed by the Contractor at his own expense, and satisfactory material shall be substituted.

In placing material in the embankment, the Contractor shall begin at the centerline and deposit material in either or both directions toward the toe of slopes. Discharge shall always be in the direction of and parallel to the centerline. The maximum distance from the bottom of the discharge pipe to the surface on which material is being deposited shall be 1.5 meters unless otherwise directed by the Engineer. Material shall be deposited in a manner that will maintain a higher elevation at the center of the roadway than on either side. The Contractor will not be permitted to construct retaining levees along the roadway of such dimensions as to cause damage to the foundation of the roadway. The Contractor shall conduct operations so as to ensure the completion of an embankment that will conform to the cross section shown on the plans except that he will be permitted to flatten side slopes. However, if material is deposited on private property, the Contractor shall obtain permission in writing from the affected property owner(s). No payment will be made for material beyond the limits of the net pay section.

The embankment shall be placed so as to ensure a minimum relative density of 80 percent of the theoretical maximum density when tested in accordance with (h) herein. If the method of placing the embankment fail to produce the required density, the Contractor shall use approved methods to obtain the specified density.

The Contractor shall take all necessary precautions to prevent placing material in streams. The Contractor shall be responsible for all damage to or caused by the hydraulic embankment. The Contractor shall provide sufficient material to maintain the embankment in accordance with the typical cross section as shown on the plans or as directed by the Engineer until final acceptance.

The Contractor's plan for support of suction or discharge pipes shall be submitted to and approved by the Engineer. Traffic shall be protected by the display of warning devices both day and night. If dredging operations damage an existing traveled highway, the Contractor shall cease operations and repair damage to the highway.

(k) **Surplus Material:** Surplus material shall not be wasted or sold by the Contractor unless authorized in writing by the Engineer. When authorization has been given for surplus material to be wasted, it shall be disposed of in accordance with Section 106.04.

Material shown on the plans as surplus material will not be considered for overhaul payment.

1. **Disposal of surplus material within the right of way where the haul distance is 600 meters or less:** Surplus material shall be used or disposed of where directed within a haul distance of 600 meters of its origin. Usage in this manner will not be considered a change in the character of the work.

2. **Disposal of surplus material within the right of way where the haul distance is more than 600 meters:** The Department reserves the right to require the Contractor to use surplus material in lieu of furnishing borrow, or as otherwise directed, where the haul distance from the origin of the material is more than 600 meters. Disposal of surplus material at locations requiring a haul of more than 600 meters will be considered a change in the character of work unless otherwise noted on the plans.

   When material is declared surplus during construction and must be transported more than 600 meters from its origin, the Department will pay the Contractor $0.043 per station per cubic meter for overhaul. The quantity of surplus excavation will be determined by vehicle measurement in accordance with the provisions of Section 109.01 or from cross-section measurements by the average end area method. The haul distance will be measured along a line parallel to the center line of the roadway from the center of the excavated area to the center of the placement area. Overhaul will be the product of the quantity of surplus material in cubic meters and the haul distance in excess of 600 meters in 30 meter stations.

303.05—Tolerances.

(a) **Finished grade of subgrade** shall be 30 millimeters above or below the theoretical grade.

(b) **Slopes** shall be graded in the following manner:

1. **Earth excavation slopes:**

   a. **Slopes steeper than 2:1** shall be grooved in accordance with the standard drawings and shall not deviate from the theoretical plane surface by more than 150 millimeters.

b. **Slopes steeper than 3:1 up to and including 2:1** shall be rough graded in a manner to provide horizontal ridges and grooves having no more than 150 millimeters deviation from the theoretical line of the typical cross section as is accomplished by the normal operation of heavy grading equipment.

c. **Slopes 3:1 or flatter** shall be uniformly finished and shall not deviate from the theoretical plane surface by more than 150 millimeters.

2. **Earth embankment slopes:**

a. **Slopes steeper than 3:1** shall not deviate from the theoretical plane slope by more than 150 millimeters and shall be rough graded in a manner to provide horizontal ridges and grooves not more than 150 millimeters from the theoretical line of the typical cross section as is accomplished by the normal operation of heavy grading equipment.

b. **Slopes 3:1 and flatter** shall be uniformly finished and shall not deviate from the theoretical plane surface by more than 150 millimeters.

3. **Rock slopes** shall not deviate from a plane surface by more than 600 millimeters and shall not deviate from their theoretical location by more than 600 millimeters measured along any line perpendicular to the theoretical slope line.

Finished excavation and embankment slopes shall not deviate from their theoretical location by more than 150 millimeters measured along any line perpendicular to the theoretical slope line.

303.06—Measurement and Payment.

(a) **Excavation:** Excavation will be paid for at the contract unit price per cubic meter unless otherwise specified.

Excavation requiring more than one handling prior to final placement will be paid for at the contract unit price for regular excavation for each handling approved by the Engineer unless there is a pay item for the second handling, in which case work will be paid for at the contract price for such handling.

Quantities of regular or borrow excavation used to backfill pipe, pipe culverts, and box culverts will not be deducted from quantities due the Contractor for payment.

1. **Regular excavation:** When payment is specified on a cubic meter basis, regular excavation will be measured in its original position by cross sectioning the excavation area. This measurement will include overbreakage or slides not attributable to the carelessness of the Contractor and authorized excavation of rock, muck, root mat, or other unsuitable material except material included in undercut excavation. Volumes will be computed from cross-section measurements by the average end area method.

   When it is impractical to measure material by the cross-section method, other acceptable methods involving three-dimensional measurements may be used.

   Excavation for benching slopes to accommodate roadway embankments as specified in Section 303.04(h) will not be measured for separate payment. The cost thereof shall be included in the price for the related excavation or embankment item.

   Excavation of existing roadways required to incorporate old roadway into new roadway or remove salvageable materials for use in traffic maintenance, other than those covered under Section 508, will be measured as regular excavation.

   When presplitting rock cuts is shown on the plans, the work shall be considered incidental to the cost of excavation and will not be measured for separate payment.

   In cut sections, excavation of topsoil and root mat and material down to a point 300 millimeters below the elevation of the top of earthwork or to the depth specified on the plans will be measured as regular excavation. When areas of unsuitable material are shown on the plans, excavation down to a point 300 millimeters below the elevation of such material shown on the plans will be measured as regular excavation.

   In fill sections, excavation of topsoil and root mat and material down to an elevation of 300 millimeters below the bottom of topsoil and root mat will be measured as regular excavation. When areas of unsuitable material are shown on the plans, excavation down to a point 300 millimeters below the elevation of such material shown on the plans will be measured as regular excavation.

   If slide material approved for measurement cannot be measured accurately, or if the removal of slide material will require different equipment than that being used in the regular excavation operations, payment therefor may be made on a force account basis when authorized by the Engineer.

b. The quantity of unsuitable material will be measured and subtracted from the adjusted regular excavation quantity determined in 2.a. herein. Quantities of unsuitable material removed from fill areas or below the subgrade in cut areas will be determined by using plan dimensions and may be adjusted for deviations based on actual measurement. Actual dimensions will be used to determine the quantity of any other unsuitable material.

c. The total quantity shown on the plans will be adjusted for quantities not anticipated on the plans, such as changes in grade or undercut determined to be necessary during construction.

d. The quantity of suitable material determined in 2.b. herein will be subtracted from the adjusted total fill quantity determined in 2.c. herein. The resultant quantity will be the embankment quantity for which payment will be made.

The Contractor shall be responsible for determining the effect of the shrinkage or swell factor of the material, and no adjustment will be made in pay quantities for this factor.

Hydraulic embankment will be paid for as embankment.

3. When embankment is a pay item and regular excavation is to be paid for on the basis of measured quantities, the quantity of embankment will be measured in cubic meters computed by the average end area method from the dimensions of the embankment cross section.

Cross sections of the area to be covered by the embankment will be taken after the denuding or removal of unsuitable material and before any material is placed thereon. These cross sections shall extend laterally from the center line to the toes of slopes as indicated on the typical cross section. The elevations as determined by these sections will be considered the original ground line. The pay quantity to be measured will be the volume of material included in the section above the original ground and below the upper limits of the typical cross section.

When regular excavation is a pay item, the embankment area to be cross sectioned will exclude that portion of the fill constructed from regular excavation. Material outside the limits of typical cross sections as shown on the plans will not be measured or paid for.

4. Extra embankment required for subsurface consolidation will be determined by the use of settlement plates. The total settlement recorded at each settlement plate will be allowed across 75 percent of the lateral width of each section. Volumes will be computed

using the average end area method. Embankment quantities will be adjusted as specified herein to include extra embankment for subsurface consolidation.

Settlement plates will be measured and paid for in units of each, complete-in-place. This price shall include furnishing, installing, maintaining, and removing when no longer required.

Surcharge placement and removal will be measured in cubic meters as determined by plan quantity and will be paid for at the contract unit price per cubic meter. This price shall include furnishing, placing, and removing surcharge material and disposing of surplus and unsuitable materials.

5. When geotextile drainage fabric is a pay item, measurement and payment will be in accordance with Section 504.

(c) **Plan Quantities:** The quantity of regular excavation for which payment will be made when plan quantities are specified will be that specified in the Contract. However, borrow excavation, excavation for entrances, unsuitable material below the top of earthwork, undercut excavation, slide excavation, rock excavation that changes the slopes or causes undercut, and side, inlet, and outlet ditches not covered by plan cross sections will be measured in its original position by cross sections and computed in cubic meters by the average end area method.

Where there are authorized deviations from the lines, grades, or cross sections, measurements will be made and the volume computed in cubic meters by the average end area method for these deviations. The plan quantity will then be adjusted to include these quantities for payment.

When unauthorized deviations occur, allowances will not be made for overruns. However, if the deviation decreases the quantities specified in the Contract, only the actual volume excavated will be allowed.

(d) **Backfill:** Furnishing and placing backfill material, including backfill for undercut, will be included in the price for excavation and will not be measured for separate payment unless specific material is a pay item for backfill or unless suitable material is not available within the construction limits. When a specific material is a pay item, the unit of measure of the material will be in accordance with the unit specified in the Contract. When suitable backfill is not available within the construction limits, the material furnished and placed by the Contractor will be paid for in accordance with Section 109.05.

(e) **Erosion Control Items:**

1. Limiting the scope of construction operations, shaping the top of earthwork, and constructing temporary earth berms and

14. **Temporary sediment basin excavation** will be measured in cubic meters and will be paid for at the contract unit price per cubic meter. The price shall include excavation, maintenance, and when no longer required the removal of dam, pipe, riser pipe, trash rack, backfill, and site restoration.

Payment will be made under:

Pay Item	Pay Unit
Regular excavation	Cubic meter
Borrow excavation	Cubic meter
Sediment basin excavation	Cubic meter
Siltation control excavation	Cubic meter
Undercut excavation	Cubic meter
Minor structure excavation (Item)	Cubic meter
Earthwork	Lump sum
Embankment	Cubic meter
Silt settlement basin	Each
Settlement plate	Each
Surcharge placement and removal	Cubic meter
Check dam (Type) (Log, rock, or straw)	Each
Temporary silt fence	Meter
Geotextile fabric	Square meter
Temporary filter barrier	Meter
Slope drain	Each
Storm water management basin excavation	Cubic meter
Temporary sediment basin excavation	Cubic meter

SECTION 304—CONSTRUCTING DENSITY CONTROL STRIPS

304.01—Description.

This work shall consist of constructing control strips in accordance with the requirements of these specifications for the purpose of determining density requirements.

304.02—Materials.

Materials shall conform to the requirements for the material to be used in the course. Material used in each control strip shall be furnished from the same

source and shall be of the same type as the material used in the test sections whose density requirements are established by the control strip.

304.03—Equipment.

Equipment shall be approved by the Engineer prior to use. The type and mass of compaction equipment shall be such that a uniform density is obtained throughout the depth of the layer of material being compacted. Control strips shall be compacted using equipment of the same type and mass to be used on the remainder of the course.

304.04—Procedures.

The subgrade or pavement structure course upon which a control strip is constructed shall be approved by the Engineer prior to construction of the control strip.

One control strip shall be constructed at the beginning of work on each roadway and shoulder course and each lift of each course. An additional control strip shall be constructed when a change is made in the type or source of material or whenever a significant change occurs in the composition of the material from the same source.

The project will be divided into "control strips" and "test sections" by the Engineer for the purpose of defining areas represented by each series of tests. The size of each control strip and test section will be in accordance with the requirements of VTM-10.

Control strips shall be constructed using the same procedure to be used in the construction of the remainder of the course. Rolling of the control strip shall be continued until no appreciable increase in density is obtained by additional roller coverages.

Upon completion of rolling, the mean density of the control strip will be based on 10 tests taken at randomly selected sites within the control strip area using a nuclear testing device. Compaction of the remainder of the course shall be governed by the density obtained in the control strip.

Each test section will be tested for required thickness. Areas that are deficient by more than the specified allowable tolerance shall be corrected in accordance with the applicable requirements of these specifications.

The Department may require an additional control strip after the completion of each 10 test sections.

Each control strip shall remain in place and become a section of the completed roadway.

The subgrade shall then be shaped and checked to ensure a typical cross section and uniform grade prior to placement of any subsequent courses. If the subgrade becomes eroded or distorted prior to placement of material for subsequent courses, it shall be scarified, reshaped, and recompacted in accordance with the original requirements.

At the time of placing material for subsequent courses, the subgrade shall be compacted to the required density, free from mud and frost, and in a condition that will permit compaction of subsequent courses without distortion.

If the approved subgrade becomes unstable after placement of the subbase or base course and becomes mixed with the aggregate therein, material from the unstable area and contaminated aggregate shall be removed. The area shall then be backfilled and compacted, and the subsequent course thereon reconstructed.

2. **Subgrade consisting of treated materials in place:** Subgrade shall be treated in accordance with the requirements of the applicable provisions of Sections 306 and 307 except that the tolerance for depth will be waived when lime or cement is being used to bridge or correct extremely weak areas.

   If lime can be satisfactorily manipulated during initial mixing, and bridging of the weak area has been performed satisfactorily, additional mixing and compacting will not be required. Additional layers of fill may be placed without delay.

   Field density determinations will be performed in accordance with the requirements of AASHTO T191, T205, or T214, modified to include material sizes used in the laboratory determination of density; with a nuclear density testing device; or by other approved methods. When a nuclear device is used, the nuclear density determination for treated in-place subgrade material will be related to the density of the same material tested in accordance with the requirements of VTM-1 or VTM-12 and a control strip will not be required.

3. **Subgrade consisting of imported material:** The area to receive the material shall be graded to a true crown and cross section.

   Material shall be placed and compacted in accordance with the requirements of the applicable specifications governing the type of material. When select material is used, material shall be placed and compacted in accordance with the requirements of Section 308 except that the provision for mixing will be waived. The

top 150 millimeters of the finished subgrade shall be compacted in accordance with the requirements of the provisions of 1. herein.

The provisions of 1. herein that are not specifically amended herein shall apply. Imported material shall be placed in approximately equal layers not more than 200 millimeters for commercial material and 150 millimeters for local material, compacted measure. Material will be tested after compaction for thickness and density. If material fails to conform to thickness requirements, it shall be corrected by scarifying, adding material if necessary, mixing, reshaping and recompacting, or removing and replacing. If the material fails to conform to density requirements, additional rolling will be required until the required density is obtained provided the material is compacted at optimum moisture, within ±20 percent of optimum. If the moisture content is outside the allowable tolerance, the layer shall be scarified, brought to optimum moisture within the allowable tolerance, and recompacted to the specified density.

An aggregate spreader will not be required in the placement of select material and other imported materials used as subgrade and shoulder courses.

(b) **Treatment of Unsuitable Subgrade:** When solid rock occurs in cuts or the material is not suitable for subgrade or finishing purposes, the roadbed shall be excavated below the grade shown on the plans in accordance with the standard drawings.

When solid rock or other unsuitable material has been removed, excavated areas shall be backfilled in accordance with the standard drawings.

(c) **Finishing Subgrade:** The Contractor shall provide effective drainage for the subgrade and maintain it in a satisfactory condition until the next course is placed.

When practicable, the subgrade shall be prepared at least 150 meters ahead of placement of any subbase, base, or surface course. Material for subsequent courses shall not be placed until the subgrade has been checked and approved. The finished subgrade elevation shall be within ±10 millimeters of the plan elevation unless otherwise specified. When imported material is used, acceptance of the course will be based on the requirements of Section 308.04.

(d) **Shoulders:** Aggregate shoulder material shall be placed in accordance with the requirements of the applicable specifications governing the type of material or construction being used and shall be compacted at optimum moisture, within ± 2 percentage points of optimum. Except when aggregate material No. 18 is used, the density of the aggregate

Payment will be made under:

Pay Item	Pay Unit
Borrow excavation	Cubic meter
Select material (Type and min. CBR)	Cubic meter or metric ton
Borrow (Min. CBR)	Cubic meter or metric ton
Aggregate material (No.)	Cubic meter or metric ton
Aggregate base material (Type and no.)	Cubic meter or metric ton

SECTION 306—LIME STABILIZATION

306.01—Description.

This work shall consist of stabilizing roadbed material and constructing one or more courses of the pavement structure using a mixture of soil or approved aggregates, lime or lime and fly ash, and water.

306.02—Materials.

(a) **Lime** shall conform to the requirements of Section 240.

(b) **Fly ash** shall conform to the requirements of Section 241. Bulk fly ash may be transported dry in bulk trucks and stored in tanks or may be transported in the dampened condition (15 percent moisture, maximum) and stockpiled at the job site. Excessively wet or contaminated surface material shall not be used in mixing operations.

(c) **Water** shall conform to the requirements of Section 216.

(d) **Aggregate** shall conform to the applicable requirements of Sections 205, 207, and 208 or other requirements described in the Contract.

306.03—Procedures.

Lime stabilization will not be permitted when aggregate or the surface on which the course is to be placed is frozen. Manipulation shall not be started until the surface is free from mud and frost and the temperature is at least 4 °C.

(a) **Preparing the Roadbed:** The surface of the roadbed shall be cut or bladed to the approximate line, grade, and cross section. However, compaction of the roadbed for the depth of the material to be treated will not be required prior to application of lime. When the course placed

directly on the roadbed is to be stabilized, the surface of the roadbed shall be prepared in accordance with the requirements of the applicable provisions of Section 305.

Temporary ramps constructed adjacent to existing pavements, bridges, culverts, and similar items shall be removed to the depth necessary to provide the required thickness of pavement structure.

Drains shall be cut through excavated shoulder material on shoulders to drain the roadbed. Drains shall be cut through windrowed base materials at sufficient intervals to prevent ponding of water. Windrowed material shall be moved, when necessary, to permit the subgrade to dry.

(b) **Preparing Materials:** The prepared roadbed shall be scarified to the depth and width required for stabilization. The material thus prepared shall be partially pulverized. The depth of scarification and the blading operation shall be controlled in such a manner that the surface of the roadbed below the scarified material shall remain undisturbed and shall conform to the established cross section. Prior to the beginning of stabilization work, material retained on the 75 millimeter sieve shall be removed.

(c) **Applying Lime:** The application rate of lime shall be as shown on the plans or as directed by the Engineer. Lime may be applied to the partially pulverized material as a slurry or in a dry form. When quicklime is used in a dry form it shall be applied at the same rate as hydrated lime.

Where quicklime is slaked on the project to produce a slurry, measurement will be calculated as indicated herein for each truckload using the certified lime purity for that load. No measurement will be made of any lime added or replaced for corrective measures during construction or for repairing damaged areas.

A = Certified mass of quicklime delivered x % purity x 1.32
B = Certified mass of quicklime delivered x % inert material
A + B = Total hydrated lime produced (pay quantity)

Lime applied by slurry application shall be mixed with water in approved agitating equipment and applied to the roadbed as a thin water suspension or slurry. The distributing equipment shall provide continuous agitation from the mixing site until applied on the roadbed. The proportion of lime shall be such that the "Dry Solids Content" shall be at least 30 percent by mass. A lower percent solid may be authorized by the Engineer provided a uniform suspension of the slurry can be maintained. A mass and purity certification shall accompany each shipment of quicklime to be used in slurry applications.

Payment will be made under:

Pay Item	Pay Unit
Lime	Metric ton
Fly ash	Metric ton
Manipulation (Depth)	Square meter
Aggregate material (Type)	Cubic meter or metric ton

SECTION 307—HYDRAULIC CEMENT STABILIZATION

307.01—Description.

This work shall consist of stabilizing roadbed material as specified or as directed by the Engineer and constructing one or more courses of the pavement structure using a mixture of soil, or approved aggregates and hydraulic cement, on a prepared surface in accordance with the requirements of these specifications and in reasonably close conformity with the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer.

307.02—Materials.

(a) **Cement** shall conform to the requirements of Section 214, Type I, IP, or II. Cement shall be transported, stored, and otherwise protected in accordance with the requirements of Section 217.

(b) **Water** shall conform to the requirements of Section 216.

(c) **Asphalt** used for curing or priming shall conform to the applicable requirements of Section 210.

(d) **Aggregate** shall conform to the applicable requirements of Sections 205, 207, or 208 or other contract requirements.

(e) **Select borrow** shall consist of approved material having the specified CBR.

307.03—Field Laboratory.

When a field laboratory is furnished by the Department, the Contractor shall move the laboratory to various points along the project as necessary.

307.04—Weather Limitations.

Cement stabilization will not be permitted when aggregate or the surface on which the course is to be placed is frozen. Manipulation operations shall not be started until the air temperature is at least 4 °C in the shade and rising. When material may be exposed to freezing temperatures during the first 24 hours of curing, the Contractor shall protect the stabilized material from freezing for 7 days or shall cover the stabilized surface with the next pavement course within 4 hours after the cement stabilization has been finished as specified.

307.05—Procedures.

If full-width paving equipment is to be used in the subsequent placement of asphalt concrete base, the width of the stabilized course upon which the base will be placed may be extended 0.3 meter beyond the designed typical section on each side.

(a) **Preparing Existing Surface:** When the roadbed is to be stabilized, its surface shall be cut or bladed to the approximate line, grade, and cross section. However, compaction of the roadbed for the depth of the material to be treated will not be required prior to application of cement. When the course placed directly on the roadbed is to be stabilized, the surface of the roadbed shall be prepared in accordance with the requirements of the applicable provisions of Section 305.

Additional material needed to bring the roadway surface into compliance with the required specifications shall be obtained from within the limits of the right of way, if available. When authorized, the Contractor shall obtain such material from borrow pits as provided for in Section 303.

The surface shall be sufficiently firm to support, without displacement, the construction equipment and shall be in such condition that the compaction can be obtained as specified herein. Soft, yielding, or wet areas shall be corrected and made stable before construction proceeds.

(b) **Preparing Materials:** When the roadbed is to be stabilized, material to be treated shall be scarified and pulverized prior to application of cement. Pulverizing shall continue during mixing operations until at least 80 percent of the material, exclusive of coarse aggregate, will pass the 4.75 millimeter sieve. Any material retained on the 75 millimeter sieve and other objectionable objects shall be removed.

Applying and mixing cement with material in place or aggregate material shall be performed in accordance with the following methods except that aggregate subbase, aggregate base course, select material,

percent the material is outside the process tolerance. If the total adjustment is 8.0 percent or less and the Contractor does not elect to remove and replace the material, the contract unit price paid for the material will be reduced at the rate specified herein. The adjustment will be applied to the metric tonnage represented by the samples.

b. **Mixing:** Cement in the mixture shall not vary more than ±7.0 percent by mass from that specified. Feeders and meters for introducing cement into the mixer shall be of such design that the amount of cement can be accurately determined before cement is introduced into the mixer.

(c) **Compacting and Finishing:** Prior to the beginning of compaction, the mixture shall be brought to a uniformly loose condition for its full depth and shall have a moisture content of not less than optimum or more than optimum +20 percent of optimum. For subgrade stabilization, the mixture shall be compacted to a density of at least 100 percent of the maximum density as determined in accordance with the requirements of VTM-1 or VTM-12. For subbase and base stabilization, the mixture shall be compacted to conform to the density requirements of Section 309.05.

Compaction equipment shall be subject to the approval of the Engineer, and the number of such units shall be sufficient to ensure the specified density and completion of the processed section within 4 hours from the time the water is added to the mixture. Initial compaction of soil mixtures shall be accomplished with a tamping roller.

After the mixture has been compacted, the surface shall be shaped to the required lines, grades, and cross sections.

If the material to be shaped is a type in which surface compaction planes will form, the Contractor shall lightly scarify the surface continuously with a drag harrow or similar equipment during the shaping operation. The surface shall then be rolled with steel wheels or pneumatic tire rollers, or both. The moisture content of the surface material shall be maintained at not less than the specified optimum during finishing operations. Compacting and finishing operations shall be completed within the specified time and carried out in a manner that will produce a smooth, dense surface, free from surface compaction planes, cracks, ridges, or loose material.

(d) **Construction Joints:** Each day's operation shall tie into the completed work of the previous day by the remixing of approximately 0.6 meter of the completed course prior to the processing of additional sections. An amount equal to 50 percent of the original amount of cement shall be added to such sections. When the completed section remains

undisturbed for more than 24 hours, a transverse construction joint shall be made by cutting back into the completed work to form an approximate vertical face.

(e) **Tolerances:** The finished stabilized course shall conform to the specified thickness and density, subject to the following tolerances:

1. **Density:** The density of the completed work for each day's operations will be determined at representative locations. Any portion on which the density is more than 80 kilograms per cubic meter less than that specified shall be removed and replaced.

2. **Thickness:** Thickness will be determined in accordance with the requirements of VTM-38A. The Contractor shall remove and replace areas that are deficient in thickness by more than 25 millimeters; or, with the approval of the Engineer, the Contractor shall correct sections on stabilized base courses that are deficient in depth by applying asphalt concrete at his own expense. Mixed-in-place areas that are excessive in thickness by more than 25 millimeters shall be removed and replaced.

   When the central plant method of mixing is used, acceptance of the course will be based on the requirements of Section 308.04 except when the depth is deficient by more than 25 millimeters. In such event, correction shall be as specified herein.

(f) **Protecting and Curing:** The next course may be placed after the cement stabilization has been approved. However, the stabilized course shall be protected against surface drying by application of moisture or approved cover material until the next course is placed or until asphalt cover material is applied. In any event, the next course shall be placed or asphalt cover material applied within 7 days after stabilization is finished as specified. If asphalt cover material is used, it shall be applied at the rate of approximately 1.13 liter per square meter or as shown on the plans. The exact rate of application necessary to produce full coverage without excessive runoff shall be as directed by the Engineer.

The stabilized course shall be tightly knit and free from loose and extraneous material. The surface shall be slightly moistened prior to application of asphalt material or other approved cover.

If asphalt is used, application shall be made with an approved pressure distributor as specified in Section 314.04 and the asphalt material shall be immediately covered with the specified covering material.

The protective cover shall be maintained so that all of the cement stabilization shall be effectively and continuously covered.

Where the required thickness is more than 150 millimeters, the material shall be spread and compacted in two or more layers of approximately equal thickness. The compacted thickness of any one layer shall be not more than 150 millimeters. When vibrating or other approved types of special compacting equipment are used, the compacted depth of a single layer of subbase course may be increased to 200 millimeters upon the approval of the Engineer.

Each layer of subbase course shall be compacted at optimum moisture, within ±20 percent of optimum. The density of each layer of subbase aggregate material, when compared to the theoretical maximum density as determined in accordance with the requirements of VTM-1, shall conform to the following:

% Material Retained on 4.75 mm Sieve	**Min. % Density**
0-50	100
51-60	95
61-70	90

Percentages will be reported to the nearest whole number.

Not more than one sample in every five shall have a density less than that specified, and the density of such a sample shall be not more than 2 percent below that specified.

If the surface of the subbase becomes uneven or distorted and sets up in that condition, it shall be scarified, reshaped, and recompacted. If the subbase when compacted and shaped shows a deficiency in thickness or if depressions occur in the surface, the Contractor shall scarify such sections at his own expense before additional material is added.

Field density determinations will be performed with a nuclear field density device using the density control strip as specified in Section 304 and VTM-10 or in accordance with the requirements of AASHTO T191, T205, or T214. The method of density determination will be as directed by the Engineer.

308.04—Tolerances.

The thickness of the subbase course will be determined by the depth measurement of holes dug in the subbase in accordance with the requirements of VTM-38B.

Acceptance of the subbase course for the physical property of depth will be based on the mean result of tests performed on samples taken from each lot of material placed. A *lot* of material is defined as the quantity being tested for acceptance except that the maximum lot size will be 3.2 kilometers of paver application width.

A lot will be considered acceptable for depth if the mean result of the tests is within the following tolerance of the plan depth for the number of tests taken except that each individual test shall be within ± 25 millimeters of the plan depth: mean of two tests, ± 20 millimeters; mean of three tests, ± 15 millimeters; and mean of four tests, ± 13 millimeters.

If an individual depth test exceeds the ±25 millimeter tolerance, that portion of the lot represented by the test will be excluded from the lot. If the individual test result indicates that the depth of material represented by the test exceeds 25 millimeters, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If the individual test result indicates that the depth of the material represented by the test is deficient by more than 25 millimeters, correction of the subbase course represented by the test shall be made as specified herein.

If the mean depth of a lot of material is in excess of the allowable tolerance, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test.

If the mean depth of a lot of material is deficient by more than the allowable tolerance, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot.

For excessive depth subbase courses, when metric tonnage measurement is used, the rate of deduction from the metric tonnage allowed for payment as subbase material will be calculated at a mass of 60 kilograms per square meter per 25 millimeters of depth in excess of the tolerance. Areas that are deficient in depth by more than 25 millimeters and areas that do not provide a smooth uniform surface shall be scarified, material added or removed, reshaped, and recompacted to the specified density so as to conform with the depth tolerance and provide a smooth, uniform surface.

308.05—Measurement and Payment.

Subbase course will be measured in cubic meters or metric tons as specified and will be paid for at the contract unit price per cubic meter or metric ton. When the cubic meter unit is specified, the quantity will be determined by compacted measurements on the road unless otherwise specified. When the metric ton unit is specified, the quantity shall be determined in accordance with the requirements of Section 109.01.

This price shall include furnishing, hauling, placing, manipulating, and compacting subbase course; clearing and grubbing local pits; material royalties; and access roads.

Moisture, in excess of optimum +2 percentage points, will be deducted from the net mass of both truck and rail shipments.

309.06—Measurement and Payment.

Aggregate base course will be measured in cubic meters or metric tons, as specified, and will be paid for at the contract unit price per cubic meter or metric ton. When the cubic meter unit is specified, the quantity will be determined by compacted measurements on the road unless otherwise specified. When the metric ton unit is specified, the quantity shall be determined in accordance with the requirements of Section 109.01 and moisture, in excess of optimum +2 percentage points, will be deducted from the net mass of both truck and rail shipments.

Calcium chloride and sodium chloride will be measured in metric tons and will be paid for at the contract unit price per metric ton.

These prices shall include preparing and shaping the subgrade or subbase and shoulders, adding moisture, removing and replacing unstable subgrade or subbase and constructing the base course thereon, and filling test holes.

Payment will be made under:

Pay Item	Pay Unit
Aggregate base material (Type/No.)	Cubic meter or metric ton
Aggregate material (No.)	Cubic meter or metric ton
Calcium chloride	Metric ton
Sodium chloride	Metric ton

SECTION 310—TACK COAT

310.01—Description.

This work shall consist of preparing and treating an existing asphalt or concrete surface with asphalt in accordance with the requirements of these specifications and in reasonably close conformity with the lines shown on the plans or as established by the Engineer.

310.02—Materials.

Asphalt for tack coat shall be CRS-1, CRS-2, CRS-1h or CSS-1h, and conform to the requirements of Section 210. CMS-2, conforming to the requirements of Section 210, may be used during the winter months. With the exception of CMS-2, asphalt for tack coat may be diluted with 50 percent water provided that resulting material produces a uniform application of the tack.

310.03—Procedures.

Equipment for heating and applying asphalt shall conform to the requirements of Section 314.04(b). The maximum application temperature of liquid asphalt shall conform to the requirements of Table III-1.

TABLE III-1
Liquid Asphalt Application Temperature

Grade	Max. Temperature (° C)
RC-70	85
RC-250	105
RC-800	105
RC-3000	145
MC-70	85
MC-250	105
MC-800	125
MC-3000	145
AC-5	150
AC-10	150
AC-20	150
AC-40	150
RS-2	80
SS-1h	80
AE-4	65
CRS-2	80
CSS-1h	80
CMS-2	95
CRS-1h	80
CRS-1	80

The existing surface shall be patched, cleaned, and rendered free from irregularities to the extent necessary to provide a reasonably smooth and uniform surface. Unstable corrugated areas shall be removed and replaced with suitable patching materials. The edges of existing pavements that are to be adjacent to new pavement shall be cleaned to permit adhesion of asphalt.

Tack material shall be uniformly applied with a pressure distributor conforming to the requirements of Section 314.04(b). Hand spray equipment shall not be used except in areas inaccessible by a pressure distributor. Undiluted asphalt shall be applied at the rate of 0.22 to 0.45 liter per square meter. Diluted asphalt shall be applied at the rate of 0.45 to 0.68 liter per square meter.

The tack coat shall be applied in a manner to offer the least inconvenience to traffic and permit one-way traffic without pickup or tracking of the asphalt.

The tack coat shall not be applied immediately prior to the course being placed. The tack coat shall be applied in accordance with the same weather limitations that apply to the course being placed. The quantity, rate of application, temperature, and areas to be treated shall be approved prior to application.

During the application of asphalt, care shall be taken to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, equipment shall be parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.

310.04—Measurement and Payment.

Tack coat, when a pay item, will be measured in liters and will be paid for at the contract unit price per liter. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Patching will be paid for at the contract unit price for the various items used unless a reconditioning item is included in the Contract.

Payment will be made under:

Pay Item	Pay Unit
Tack coat	Liter

SECTION 311—PRIME COAT

311.01—Description.

This work shall consist of preparing and treating an existing surface with asphalt, and cover material if required, in accordance with the requirements of these specifications and in reasonably close conformity with the lines shown on the plans or as established by the Engineer.

311.02—Materials.

(a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to the applicable requirements of Section 210.

(b) **Cover material** shall conform to the applicable requirements of Section 202 or 203. Lightweight aggregate shall conform to the

requirements of Section 206. Cover material shall not be hauled directly from a washing plant for immediate use in the work.

311.03—Procedures.

The rates of application of materials shall be determined in accordance with the method described in Education Series No. 12 of the Asphalt Institute entitled *Asphalt Surface Treatments Construction Techniques.*

The weather limitations of Section 314.03 shall apply to asphalt prime coat work. When asphalt is to be used as a cover for cement stabilization or as a primer for asphalt concrete, the weather limitations specified for these particular operations shall apply.

Equipment for heating and applying asphalt and cover material shall conform to the requirements of Section 314.04. The maximum application temperature of the liquid asphalt shall conform to the requirements of Table III-1.

The surface to be primed shall be shaped to the required grade and section; rendered free from ruts, corrugations, segregated material, or other irregularities; and uniformly compacted.

Delays in priming may necessitate reprocessing or reshaping to provide a smooth compacted surface.

Asphalt shall be applied by means of a pressure distributor in a uniform continuous spread. When traffic is maintained, not more than 1/2 the width of the section shall be treated in one application. Care shall be taken that the application of asphalt at junctions of spreads is not in excess of the specified amount. Excess asphalt shall be removed from the surface by a squeegee. Skipped areas or deficiencies shall be corrected.

During the application of asphalt, care shall be taken to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, equipment shall be parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.

When traffic is maintained, one-way traffic shall be permitted on the untreated portion of the roadbed. When the asphalt has been absorbed by the treated surface and will not pick up, traffic shall be transferred to the treated portion and the remaining width of the section primed.

The quantity, rate of application, temperature, and areas to be treated shall be approved before application of the prime coat.

If after application of the prime coat the asphalt fails to penetrate within the time specified and the roadway must be used by traffic, cover material shall

be spread at the Contractor's expense in an amount that will prevent pickup of the asphalt.

311.04—Measurement and Payment.

Prime coat will be measured and paid for at the contract unit price per liter for asphalt and per metric ton for cover material, in accordance with the requirements of Section 313.

SECTION 312—SEAL COAT

312.01—Description.

This work shall consist of applying asphalt followed by applying cover material in accordance with the requirements of these specifications and in reasonably close conformity with the lines shown on the plans or as established by the Engineer.

312.02—Materials.

(a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to the applicable requirements of Section 210.

(b) **Cover material** shall conform to the applicable requirements of Section 203. Lightweight aggregate shall conform to the requirements of Section 206. Cover material shall not be hauled directly from a washing plant for immediate use in the work.

312.03—Equipment.

The following equipment or its equivalent is required:

1. equipment for heating and applying asphalt conforming to the requirements of Section 314.04(b)

2. a rotary power broom

3. at least one pneumatic tire roller. Additional rollers that may be required may be tandem steel wheel or three-wheel rollers weighing at least 7.5 metric tons. The pneumatic tire roller shall be self-propelled, and the gross load adjustable to apply 3500 to 6500 kilograms per meter of rolling width as directed. Tires shall be designed for a tire pressure

of at least 600 kilopascals. Steel wheel rollers shall be operated at a maximum speed of 5 kilometers per hour, and pneumatic tire rollers at a maximum speed of 8 kilometers per hour.

4. a mechanical roller-type hopper or a self-propelled aggregate spreader of an approved design

312.04—Procedures.

The rates of application of materials shall be determined in accordance with the method described in Education Series No. 12 of the Asphalt Institute entitled *Asphalt Surface Treatments Construction Techniques.*

The weather limitations specified in Section 314.03 shall apply to seal coat work.

Seal coating operations shall not be started until the surface is thoroughly compacted and cleaned of dust, mud, and foreign matter and the section to be sealed has been approved by the Engineer.

Asphalt shall be applied by means of a pressure distributor in a uniform continuous spread over the section to be treated and within the temperature range given in Table III-1. A strip of building paper at least 900 millimeters in width and having a length equal to that of the spray bar of the distributor plus 300 millimeters shall be used at the beginning of each spread. If the cutoff is not positive, the use of paper may be required at the end of each spread. The paper shall be removed and disposed of legally. The distributor shall be moving forward at the proper application speed at the time the spray bar is opened. Skipped areas and deficiencies shall be corrected. Junctions of spreads shall be carefully made to ensure a smooth riding surface.

The length of the spread of asphalt shall be regulated by the quantity of cover material in loaded trucks on the project.

The spread of asphalt shall be not more than 150 millimeters wider than the width covered by the cover material from the spreading device. Asphalt shall not be allowed to chill, set up, dry, or otherwise impair retention of the cover material.

During asphalt application, care shall be taken to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, equipment shall be parked so that the spray bar or mechanism will not drip asphalt material on the surface of the traveled way.

Immediately following asphalt application, cover material shall be applied in full-lane widths up to 3.6 meters. Laps shall be made only at lane dividers

or at the crown of the roadway. Successive laps at lane dividers and the roadway crown shall be staggered from 75 millimeters to 150 millimeters. Spreading shall be accomplished in a manner so that the tires of the truck or aggregate spreader do not contact the uncovered and newly applied asphalt.

If directed, cover material shall be moistened with water to eliminate or reduce dust coating of aggregate. Moistening shall be done the day before the use of aggregate.

Immediately after cover material is spread, deficient areas shall be covered by additional material. Rolling shall begin immediately behind the spreader and shall consist of at least three complete coverages.

After application of cover material, the wearing surface shall be lightly broomed or otherwise maintained until cured as directed. Maintenance of the surface shall include distributing cover material over the surface to absorb free asphalt and cover any area deficient in cover aggregate. Maintenance shall be conducted so as not to displace embedded material. Excess material shall be swept from the surface by means of rotary brooms as required or as directed by the Engineer.

312.05—Measurement and Payment.

Seal coat will be measured and paid for at the contract unit price per liter for asphalt and per metric ton for cover material, in accordance with the requirements of Section 313.

SECTION 313—ASPHALT SURFACE TREATMENT

313.01—Description.

This work shall consist of constructing a single or multiple course asphalt surface treatment in accordance with the requirements of these specifications and in reasonably close conformity with the line and grade shown on the plans or as established by the Engineer.

313.02—Materials.

(a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to the applicable requirements of Section 210.

(b) **Cover material** shall conform to the applicable requirements of Sections 202 and 203. Coarse aggregate shall be a minimum Grade B. Lightweight aggregate shall conform to the requirements of Section

206. Cover material shall not be hauled directly from a washing plant for immediate use in the work.

313.03—Procedures.

Asphalt surface treatment may consist of applying one or more seal coats or a prime coat followed by one or more seal coats as specified. The weather limitations of Section 314.03 shall apply to asphalt surface treatment work. The Contractor shall have a certified Asphalt Paving Technician present during the paving operation.

(a) **Prime Coat:** When specified, a prime coat shall be applied in accordance with the requirements of Section 311. When cover material is specified, rolling shall be performed in accordance with the requirements of Section 312.

The prime coat shall be permitted to cure prior to the next application of asphalt.

During the period between application of the prime coat and the seal coat, the primed surface shall be kept in repair. Holes, ravels, and areas deficient in primer shall be patched and repaired with asphalt-treated materials by penetration methods or other approved procedures.

(b) **Seal Coat:** Each seal coat shall be applied in accordance with the requirements of Section 312. Successive applications of asphalt using emulsion or asphalt cements may be applied without any delay for curing. When cutback asphalt is used, the first seal coat shall be maintained and permitted to cure for at least 48 hours.

(c) **Opening to Traffic:** The roadway shall be kept open to traffic at all times. As soon as the final layer is placed, controlled traffic may be permitted thereon.

(d) **Rates of Application:** The application rates of asphalt surface treatment materials will be furnished to the Contractor by the Department.

313.04—Measurement and Payment.

Liquid asphalt will be measured in liters and cover material will be measured in metric tons complete-in-place for the type specified, in accordance with the requirements of Section 109.01. Asphalt surface treatment will be paid for at the contract unit price per liter for liquid asphalt and per metric ton for cover material. These prices shall include furnishing and applying materials and maintaining the treatment.

Payment will be made under:

Pay Item	Pay Unit
Liquid asphalt	Liter
Cover material (Type)	Metric ton

SECTION 314—PENETRATION SURFACE COURSES

314.01—Description.

This work shall consist of constructing a wearing surface of crushed stone, slag, or crushed gravel penetrated with asphalt in accordance with the requirements of these specifications and in reasonably close conformity with the lines shown on the plans or as established by the Engineer.

314.02—Materials.

(a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to the applicable requirements of Section 211.

(b) **Aggregate** shall be crushed stone, slag, or crushed gravel that conforms to the applicable requirements of Section 203. Aggregate shall not be hauled directly from a washing plant and used in the work.

(c) **Fine aggregate** shall be Grading B sand conforming to the requirements of Section 202.

314.03—Weather Limitations.

Penetration courses shall not be placed when surfaces are wet, when the air temperature is below 10 °C, or when the surface temperature is below 20 °C. The Contractor shall furnish a properly calibrated infrared instrument for the purpose of measuring the surface temperature and shall measure the surface temperature prior to placement.

314.04—Equipment.

Equipment shall be approved prior to performance of the work. Equipment that will handle the materials and produce the completed course or courses in accordance with the requirements of these specifications is acceptable.

(a) **Spreaders:** Spreaders for coarse aggregate shall be self-propelled spreading and leveling machines or spreader boxes equipped with shoes

or runners of sufficient width and length to preclude damage or displacement of the subgrade or other courses.

The mechanical spreader for the fine aggregate shall conform to the requirements of Section 312.03.

(b) **Distributor:** The distributor shall be so designed, equipped, maintained, and operated that asphalt at the specified temperature range may be applied uniformly on variable widths of surface up to 4.5 meters at readily determined and controlled rates from .02 to 9.0 liter per square meter, with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.09 liter per square meter. Distributor equipment shall include a tachometer, pressure gages, accurate volume-measuring devices or a calibrated tank, and a thermometer for measuring temperatures of the contents of the tanks. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically. The distributor shall be equipped with a positive shutoff control that will prevent lapping at the junction of two applications. When necessary, the distributor shall be equipped with a positive means of deflecting the spray to prevent coating of adjacent structures and appurtenances. A connection shall be provided and hand spraying equipment shall be used to cover variable width areas, patches, and other areas where spray bar application is impractical or would result in excessive asphalt material.

(c) **Rollers:** The number, type, and mass of rollers shall be sufficient to compact the mixture to the required density.

314.05—Procedures.

Cover material shall be applied in full-lane widths up to 3.6 meters. Laps shall be made only at lane dividers or at the crown of the roadway. Successive laps at lane dividers and the crown of the roadway shall be staggered from 75 to 150 millimeters.

Conditioning of the road surface shall conform to the requirements of Section 312.04.

(a) **Rates of Application:**

	Asphalt (L/m^2)	**Aggregate (kg/m^2)**
Light courses		
Coarse aggregate No. 56		32.55-75.41
Asphalt for penetration	3.29-5.26	

Choke aggregate		
No. 68, or		10.85-16.28
No. 78, or		11.94-15.19
No. 8, or		9.77-13.56
Grading B sand		5.43-8.14
Asphalt for seal	0.66-1.32	
Seal aggregate,		
No. 78, or		11.94-15.19
Seal aggregate,		
No. 8		9.77-13.56
Heavy courses		
Asphalt for tack coat	0.45-0.91	
Coarse aggregate, No. 56		75.95-108.50
Asphalt for penetration	5.89-8.15	
Choke aggregate, No. 68		10.85-16.28
Asphalt for seal	0.91-1.58	
Seal aggregate, No. 78 or		11.94-15.19
Seal aggregate, No. 8		9.77-13.56

(b) **Sequence and Methods:**

1. If deemed necessary or specified, a tack coat shall be applied in accordance with the requirements of Section 310 immediately prior to the application of coarse aggregate.

2. The coarse aggregate shall be uniformly spread on the prepared base or surface at the specified rate of application. This application shall be mixed and shaped by the use of multiple-blade road planers or other approved equipment.

   Immediately following mixing and shaping operations, the surface shall be rolled with a 9 metric ton, three-wheel or tandem steel wheel roller and, for a heavy penetration surface course, uniformly choked with No. 68 aggregate. The surface will be tested by the Engineer using a 3-meter straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall be not more than 5 millimeters. Humps or depressions exceeding the specified

tolerance shall be corrected. For a light penetration course, the coarse aggregate shall be uniformly choked with the fine aggregate.

3. The prepared course shall be penetrated with asphalt at the rate specified and immediately covered with the choke aggregate. Rolling operations shall immediately follow the application of covering aggregate and shall continue until the treatment is bonded. Subsequent rolling and applications of covering aggregate, if required, shall be performed on successive days following the application.

4. After the penetration course has cured, a seal coat shall be applied and rolled.

314.06—Measurement and Payment.

Asphalt will be measured in liters and aggregate and cover material will be measured in metric tons, complete-in-place, in accordance with the requirements of Section 109.01. Penetration surface course will be paid for at the contract unit price per liter for asphalt and per metric ton for aggregate and cover material. These prices shall include furnishing and applying materials and maintaining the treatment.

Payment will be made under:

Pay Item	Pay Unit
Liquid asphalt	Liter
Cover material (Type)	Metric ton
Aggregate (No.)	Metric ton

SECTION 315—ASPHALT CONCRETE PAVEMENT

315.01—Description.

This work shall consist of constructing one or more courses of asphalt concrete on the prepared foundation in accordance with the requirements of these specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or as established by the Engineer.

315.02—Materials.

(a) **Asphalt concrete** shall conform to the requirements of Section 211. If Marshall design densities begin to exceed 98 percent of the theoretical maximum density during construction, the Contractor shall alter the design.

(b) **Asphalt for tack coat and prime coat** shall conform to the requirements of Section 310. Asphalt may be changed one viscosity grade by the Engineer at no change in the contract unit price.

(c) **Curb backup material** shall be asphalt concrete conforming to any surface or intermediate mixture listed in Table II-12.

315.03—Equipment.

(a) **Hauling Equipment:** Trucks used for hauling asphalt mixtures shall have tight, clean, smooth metal bodies equipped with a positive locking metal tailgate. Metal surfaces in contact with asphalt mixtures shall be given a thin coat of an aliphatic hydrocarbon invert emulsion release agent (nonpuddling), a lime solution, or other material on the Department's list of approved release agents. Except where a nonpuddling release agent is used, the beds of dump trucks shall be raised to remove excess agent prior to loading. Only a nonpuddling agent shall be used in truck beds that do not dump. Each truck shall be equipped with a tarpaulin or other cover that will protect the mixture from moisture and foreign matter and prevent the rapid loss of heat during transportation.

(b) **Asphalt Pavers:** The asphalt paver shall be approved prior to the beginning of any paving operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed and prevent segregation. The screed or strikeoff assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

Pavers shall be capable of smoothing and adjusting longitudinal joints between adjacent strips or courses of the same thickness.

(c) **Rollers:** Rollers shall be steel wheel, static or vibratory, or pneumatic tire rollers and shall be capable of reversing without backlash. Rollers shall be operated at speeds slow enough to avoid displacement of the mixture. The number and mass of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment that results in excessive crushing of aggregate or marring of the pavement surface will not be permitted.

If, during construction, it is found that the equipment being used mars the surface to the extent that imperfections cannot satisfactorily be corrected or produces permanent blemishes, the use of the equipment shall be discontinued and it shall be replaced with satisfactory units.

(d) **Rotary Saw:** A gasoline-powered rotary saw with a carbide blade shall be furnished for cutting test samples from the pavement. The Contractor shall furnish gasoline, oil, additional carbide blades, and maintenance for the rotary saw. The Contractor shall cool the pavement prior to sawing the sample. In lieu of a rotary saw, the Contractor may furnish the necessary equipment for coring and testing 150-millimeter core samples in accordance with the requirements of VTM-22.

315.04—Placement Limitations.

Asphalt concrete mixtures shall not be placed when weather or surface conditions are such that the material cannot be properly handled, finished, or compacted. The surface upon which asphalt mixtures are to be placed shall be free of puddled water and the base temperature shall conform to the following:

1. When the base temperature is above 25 °C, mixture laydown will be permitted at any temperature conforming to the limits of Section 211.

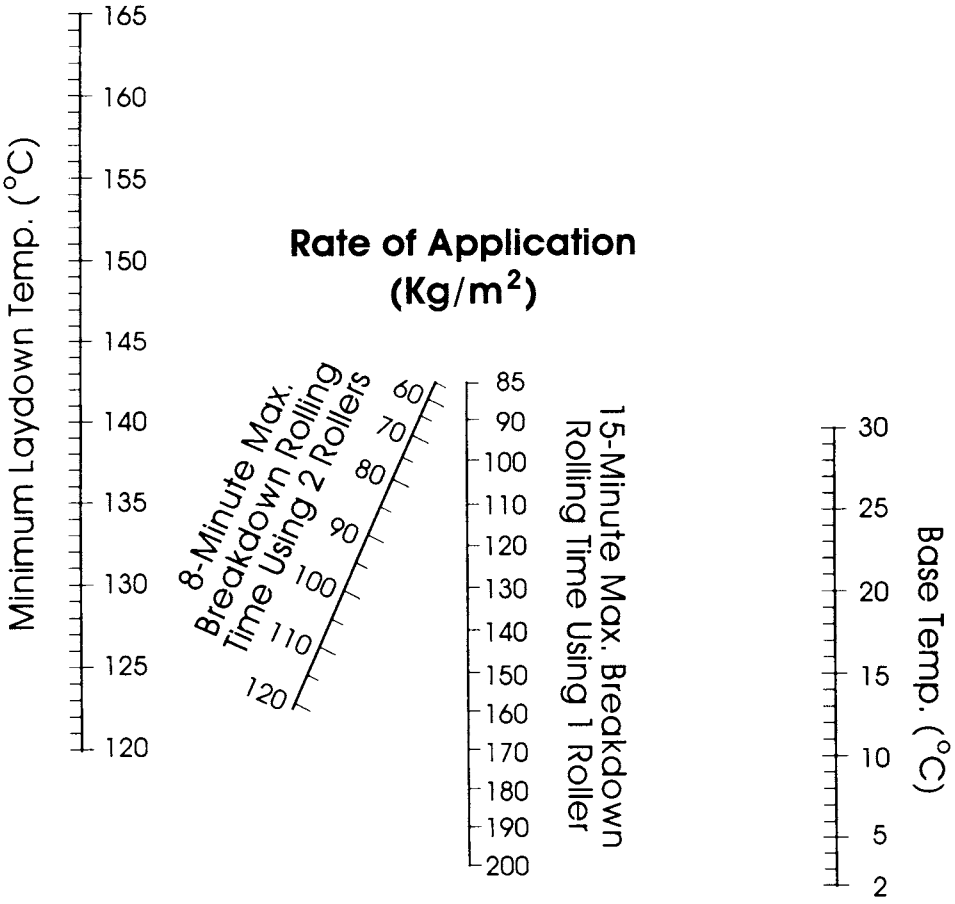
2. When the base temperature is between 1 °C and 25 °C, the Nomograph, Table III-2, shall be used to determine the minimum laydown temperature of the asphalt concrete provided the temperature of the mixture conforms to Section 211. The base temperature shall be at least 4 °C for surface mixes with a Marshall design of 50 blows and shall be at least 10 °C for surface mixes with a Marshall design of 75 blows.

3. When the laydown temperature is between 149 °C and 163 °C, the number of compaction rollers will be the same number as required for 148 °C.

Intermediate and base courses that are placed at rates of application which exceed the application rates shown in Table III-2 shall conform to the requirements for the maximum application rate shown for 8-minute and 15-minute compaction rolling as per number of rollers used.

Should the Contractor be unable to complete the compaction rolling within the applicable 8-minute or 15-minute period, the placing of asphalt mixture shall cease either until sufficient rollers are used or other corrective action is taken to complete the compaction rolling within the specified period.

TABLE III-2
Cold Weather Paving Limitations
Asphalt Concrete Paving Limitations



All compaction rolling shall be completed prior to the mat cooling down to 80 °C. Finish rolling may be performed at lower mat temperature.

The final asphalt pavement finish course shall not be placed until construction pavement markings are no longer required.

315.05—Procedures.

(a) **Base Course:** The subgrade or subbase upon which the base course is to be placed shall be prepared in accordance with the requirements of the applicable provisions of these specifications for such course.

(b) **Conditioning Existing Surface:** When the surface of the existing pavement or base is irregular, it shall be brought to a uniform grade and cross section as directed by the Engineer. The surface on which the asphalt concrete is to be applied shall be prepared in accordance with the requirements of the applicable specifications.

When specified, prior to placement of asphalt concrete, longitudinal and transverse joints and cracks in hydraulic cement concrete shall be sealed by the application of an approved joint sealing compound.

Contact surfaces of curbing, gutters, manholes, and other structures projecting into or abutting the pavement and cold joints of asphalt shall be painted with a thin, uniform coating of asphalt prior to asphalt placement.

1. **Priming existing surface:** A tack or prime coat of asphalt shall be applied between the existing surface and each asphalt course placed thereafter. The tack or prime coat shall conform to the applicable requirements of Sections 310 and 311.

   Asphalt classed as cutbacks or emulsions shall be applied ahead of the paving operations, and the time interval between applying and placing the paving mixture shall be sufficient to ensure a tacky residue providing maximum adhesion of the paving mixture to the base. The mixture shall not be placed on tack or prime coats that have been damaged by traffic or contaminated by foreign material. Traffic shall be excluded from such sections.

   On rich sections or those that have been repaired by the extensive use of asphalt patching mixtures, the tack coat shall be eliminated when directed by the Engineer.

   When asphalt concrete to be placed has a total thickness of 100 millimeters or more, priming with asphalt material will not be required on aggregate subbase or base material.

2. **Removing depressions and elevating curves:** Where irregularities in the existing surface would result in a course more than 75 millimeters in thickness after compaction, the surface shall be brought to a uniform profile by patching with asphalt concrete and thoroughly tamping or rolling until it conforms with the surrounding surface. The mixture used shall be the same as that specified for the course to be placed.

   When the Contractor elects to conduct operations to eliminate depressions, elevate curves, and place the surface course simultaneously, he shall furnish such additional spreading and compacting equipment as required to maintain the proper interval between the operations.

(c) **Placing and Finishing:** Asphalt concrete shall not be placed until the surface upon which it is to be placed has been approved by the Engineer.

The edge of the pavement shall be marked by means of a continuous line placed and maintained a sufficient distance ahead of the paving operation to provide proper control of the pavement width and horizontal alignment.

An asphalt paver shall be used to distribute asphalt concrete over the widest pavement width practicable. Wherever practicable and when the capacity of sustained production and delivery is such that more than one paver can be operated, pavers shall be used in echelon to place the wearing course in adjacent lanes. Crossovers, as well as areas containing manholes or other obstacles that prohibit the practical use of mechanical spreading and finishing equipment, may be constructed using hand tools. However, care shall be taken to obtain the required thickness, jointing, compaction, and surface smoothness.

The longitudinal joint in one layer shall offset that in the layer immediately below by approximately 150 millimeters. However, the joint in the wearing surface shall be at the center line of the pavement if the roadway comprises two traffic lanes or at lane lines if the roadway is more than two lanes in width. Offsetting layers will not be required when adjoining lanes are paved in echelon and the rolling of both lanes occurs within 15 minutes after laydown.

The Contractor shall have a certified Asphalt Concrete Paving Technician present during paving operations. Immediately after placement and screeding, the surface and edges of each layer shall be inspected and straightedged by the technician and necessary corrections performed prior to compaction. The finished pavement shall be uniform and smooth.

The placement of asphalt concrete shall be as continuous as possible and shall be scheduled such that the interruption occurring at the completion of each day's work will not detrimentally affect the partially completed work. Material that cannot be spread and finished in daylight shall not be dispatched from the plant unless the use of artificial lighting has been approved. When paving is performed at night, sufficient light shall be provided.

During compaction of asphalt concrete, the roller shall not pass over the end of freshly placed material except when a construction joint is to be formed. Edges shall be finished true and uniform.

Asphalt concrete pavement courses shall be placed in layers not exceeding 4.0 times the nominal maximum size aggregate in the asphalt mixture. The maximum thickness may be reduced if the mixture cannot be adequately placed in a single lift and compacted to required uniform density and smoothness. The minimum thickness for a pavement course shall be no less than 2.5 times the nominal maximum size aggregate in the asphalt mixture with the exception of BM-2 and BM-3 mixes, which shall be 2.0 times. Nominal maximum size aggregate for each mix shall be the largest sieve size on which aggregate can be retained as indicated in the design range shown in Section 211.03, Table II-14. Base courses to be placed in irregular shaped areas of pavement, such as transitions, turn lanes, crossovers, and entrances, may be placed in a single lift.

Overlays in excess of 90 kg/m^2 or a milled depth greater than 38 millimeters shall be squared up at the completion of each day's work.

The milled roadway areas that are opened to placement of an asphalt concrete overlay, excluding curb and gutter sections, shall have drainage outlets cut through the shoulder at locations designated by the Engineer. The Contractor shall plan and prosecute the milling operation to avoid the trapping of water on the roadway. Drainage outlets shall be restored to original grade, unless otherwise directed by the Engineer. All cost for cutting and restoring the drainage slots in the roadway shoulder shall be included in the price bid for other items of work.

The Contractor shall plan and prosecute a schedule of operations so that milled roadways will be overlayed with asphalt concrete as soon as possible, and, in no instance, shall the time lapse exceed ten days after the milling operations, unless specified herein. The milled areas of the roadway shall be kept free of irregularities and obstructions that may create a hazard or annoyance to traffic in accordance with Section 104.

A short ski or shoe shall be used to match the grade of the newly overlayed adjacent travel lane on all primary, interstate, and designated

secondary routes. Unless otherwise directed by the Engineer, a 9-meter minimum automatic grade control ski shall be used on all asphalt mixtures on all divided highways, with the exception of less than full width overlays and the first course of asphalt base mixtures over aggregate subbases. Care shall be exercised when working along curb and gutter sections to ensure a uniformed grade and joint.

The Contractor shall construct the final riding surface to tie into the existing surface by an approved method, which shall include the cutting of a notch into the pavement. In addition to notching, the Contractor may use an asphalt design containing a fine graded mix to achieve a smooth transition from the new asphalt concrete overlay to the existing pavement, with the approval of the Engineer. The material shall be of a type to ensure that raveling will not occur. All cost for constructing tie-ins in the asphalt concrete overlay shall be included in the price bid for asphalt concrete.

(d) **Compacting:** Immediately after the asphalt mixture is placed and struck off and surface irregularities are corrected, the mixture shall be thoroughly and uniformly compacted by rolling.

The surface shall be rolled when the mixture is in the proper condition. Rolling shall not cause undue displacement, cracking, or shoving.

The number, mass, and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The sequence of rolling operations and the selection of roller types shall provide the specified pavement density.

Immediately after the hot mixture is placed, it shall be sealed with rollers. Thereafter, rolling shall be a continuous process, insofar as practicable, and all parts of the pavement shall receive uniform compaction.

Rolling shall begin at the sides and proceed longitudinally parallel to the center of the pavement, each trip overlapping at least one-half the roller width, gradually progressing to the crown of the pavement. When abutting a previously placed lane, the longitudinal joint shall be rolled first, followed by the regular rolling procedure. On superelevated curves, rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the center line.

Displacements occurring as a result of reversing the direction of a roller, or from other causes, shall be corrected at once by the use of rakes or lutes and addition of fresh mixture when required. Care shall be taken in rolling not to displace the line and grade of the edges of the asphalt mixture.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with a very small quantity of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls, and other places not accessible to rollers, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons, or mechanical tampers. On depressed areas, a trench roller may be used or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Edges of asphalt pavement surfaces shall be true curves or tangents. Irregularities shall be corrected.

The surface of the compacted course shall be protected until the material has cooled sufficiently to support normal traffic without marring.

(e) **Density:** Density shall be determined in accordance with the following:

1. **Surface and intermediate courses:** Density testing shall be performed by the Contractor in accordance with VTM-76.

   Density shall be determined by the backscatter method of testing using a thin-lift nuclear gauge with printer, conforming to the requirements of VTM-81. The Contractor shall furnish and operate the nuclear gauge, which shall have been calibrated within the previous 12 months by an approved calibration service. In addition, the Contractor shall maintain documentation of such calibration service for a 12 month period. The required density of the compacted course shall be no less than 98.0 percent and not more than 102.0 percent of the control strip density.

   Nuclear density roller pattern and control strip density testing will be performed on asphalt concrete overlays placed directly on surface treatment roadways and when overlays are placed with depths less than 25 millimeters (nominal application rate of 68 kg per m^2) on any surface. In these situations, sawed plugs or core samples will not be required and the minimum control strip densities as shown in Table III-3 will be waived. The required density of the compacted course shall be not less than 98.0 percent and not more than 102.0 percent of the control strip density.

   The project will be divided into "control strips" and "test sections" by the Engineer for the purpose of defining areas represented by each series of tests.

a. **Control strip:** Construction of control strips shall be accomplished in accordance with the requirements of these specifications and VTM-10.

The term *control strip density* is defined as the average of 10 nuclear determinations selected at stratified random locations on the control strip.

One control strip shall be constructed at the beginning of work on each roadway and shoulder course and on each lift of each course. An additional control strip shall be constructed when a change is made in the type or source of materials, or compactive equipment, or whenever a significant change occurs in the composition of the underlying pavement structure or the composition of the material being placed from the same source. Either the Department or the Contractor may initiate an additional control strip at any time. During the evaluation of the initial control strip, paving operations may continue. However, paving and production shall be discontinued during construction and evaluation of the additional control strips.

The length of the control strip shall be approximately 100 meters regardless of the width of the course being placed. On the first day of construction or beginning of a new course, the control strip shall be started between 150 and 300 meters from the beginning of the paving operation. The thickness of the control strip shall be the same as the course of which it is to be a part. The control strip shall be constructed using the same paving and rolling equipment and procedures as will be used on the remainder of the course being placed. Every control strip shall remain in place and become a portion of the completed roadway. One nuclear reading shall be taken at each stratified random location. No determination will be made within 0.3 meter from the edge of any application width. The average of these 10 determinations will be the control strip density read to the nearest 1.5 kilograms per cubic meter. The minimum control strip density shall be determined in accordance with the requirements of VTM-76.

If the control strip density conforms to the requirements of Table III-3, the control strip will be acceptable and the control strip density shall become the target nuclear control strip density. If the density does not conform to the requirements of Table III-3, the Contractor shall change compactive efforts to produce a higher density. The Engineer will evaluate the foundation conditions when an acceptable control strip density

cannot be obtained. If it is determined that the required density cannot be obtained because of the condition of the existing pavement structure, the target nuclear control density will be determined from the roller pattern that achieves the optimum density and will be used on the remainder of roadway that exhibits similar pavement conditions.

TABLE III-3
Density Requirements

Mixture Type	Min. Control Strip Density (%)[1]
SM-1	96.0
SM-2A	95.0
SM-2B	94.0
SM-2C	94.0
SM-3A	95.0
SM-3B	94.0
SM-3C	94.0
IM-1A	95.0
IM-1B	94.0

[1]The control strip density requirement is the percentage of the compacted unit mass of the mixture, at the job-mix asphalt content, as established in the Marshall design for the mixture or as established by the Engineer based on two or more field Marshall tests.

b. **Test section (lot):** For the purpose of acceptance, each day's production shall be divided into lots (test section). The standard size of a lot shall consist of 1,500 meters of any pass made by the paving train regardless of the width of the pass or the thickness of the course. Pavers traveling in echelon will be considered as two passes. Each lot shall be divided into five sublots of equal length. When a partial lot occurs at the end of a day's production or upon completion of the project, the lot size shall be redefined as follows: If the partial lot contains one or two sublots, the sublots will be added to the previous lot. If the partial lot contains three or four sublots, the partial lot will be redefined to be an entire lot. Each lot shall be tested for density by taking a nuclear density reading from two random locations selected by the Engineer within each sublot. Readings shall not be taken within 0.3 meter of the edge of any application width. The average of the sublot nuclear density readings will be compared to the target

nuclear control strip density to determine the acceptability of the lot. Once the average nuclear density of the lot has been determined, the Contractor will not be permitted to provide additional compaction to raise the average. If two consecutive sublots produce nuclear density results less than 98 or greater than 102 percent of the target nuclear control strip density, the Contractor shall immediately notify the Engineer and institute corrective action. By the end of the day's operations, the Contractor shall furnish the test data developed during the day's paving to the Engineer.

The metric tonnage of each lot will be based on the lot's width and length and the mixture application rate as designated in the Contract or as revised by the Engineer. Payment will be made in accordance with the requirements of Table III-4.

TABLE III-4
Payment Schedule for Lot Densities

% of Target Nuclear Control Strip Density	% of Payment
Greater than 102.0	95
98.0 to 102.0	100
97.0 to less than 98.0	95
96.0 to less than 97.0	90
Less than 96.0	75

2. **Base courses**: Density determinations will be performed by the Department using their nuclear moisture density gauge with a density control strip as specified in Section 304 and VTM-10.

3. **Surface, intermediate, and base courses** not having sufficient quantity of material to run a nuclear density roller pattern and control strip shall be compacted to a minimum density of 90.0 percent of the theoretical maximum density as determined by VTM-22. The Contractor shall be responsible for cutting cores or sawing plugs for testing by the Department.

   Any section having a depth less than 25 millimeters (68 kg per m^2) and not having sufficient quantity to run a nuclear density roller pattern and control strip shall be compacted by rolling a minimum of 3 passes with an approved roller. No density testing will be required.

(f) **Joints:** Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. When directed by the Engineer,

a brush coat of asphalt shall be applied to contact surfaces of transverse joints just before additional mixture is placed against the previously rolled material.

Joints adjacent to curbs, gutters, or adjoining pavement shall be formed by hand placing sufficient mixture to fill any space left uncovered by the paver. The joint shall then be set up with rakes or lutes to a height sufficient to receive full compression under the rollers.

315.06—Pavement Samples.

The Contractor shall cut samples from the compacted pavement for testing for depth and density. Samples shall be taken for the full depth of the course at the locations selected by the Engineer. The removed pavement shall be replaced with new mixture and refinished. No additional compensation will be allowed for furnishing test samples and reconstructing areas from which they were taken.

315.07—Pavement Tolerances.

(a) **Surface Tolerance:** Pavement smoothness will be determined by a profilograph on designated lanes having a design speed of 65 kilometers per hour or higher as specified herein. Intersections, urban areas, transition lanes, and pavement within 10 meters of bridge approach slabs will be tested by a straightedge.

Corrective actions shall be performed at the Contractor's expense and shall be completed prior to determining the pavement thickness. Corrections shall consist of cold milling/grinding, overlaying, or removing and replacing. Cold milling and grinding shall be performed until the required surface tolerance is achieved and shall produce a uniform cross section. Milled areas shall be neat and of uniform surface appearance. Only one overlay will be permitted.

On those sections where corrections are made, pavement will be retested to verify that corrections have produced an acceptable profile, limited to one retest. Additional testing required will be performed by the Department at the Contractor's expense.

1. **Profile indexes:** Profile indexes will be determined in accordance with the requirements of VTM-83.

2. **Profilograph test:** The Contractor shall employ paving methods that produce a riding surface having a profile index of 160 millimeters or less per kilometer except as otherwise provided herein.

The profile will terminate 10 meters from preexisting pavement that is joined by new pavement. Pavement profiles will be run 0.9 meter from and parallel to each edge of each travel lane. Additional profiles may be taken only to define the limits of an out-of-tolerance surface.

During initial paving operations, both when first begun and after a shutdown period, the pavement surface will be tested with the profilograph as soon as practicable after final rolling. Initial testing may be used by the Contractor and Engineer to evaluate paving methods and equipment.

If initial pavement smoothness, paving methods, and paving equipment are acceptable, the Contractor may proceed with the paving operation. After initial testing, profiles of each day's paving will be run as soon as practicable and in every case prior to opening pavement to public traffic.

Average profile indexes will be determined for each day's paving. A *day's paving* is defined as a minimum of 0.1 kilometer of full-width pavement placed in a day. If less than 0.1 kilometer is paved, the day's production will be grouped with the next day's production.

For determining pavement sections where corrective work or pay adjustments will be necessary, the pavement will be evaluated in 0.1-kilometer sections using the profilogram. Within each 0.1-kilometer section, deviations in excess of 10 millimeters in 7.6 meters or less shall be corrected as directed by the Engineer.

Additionally, any 0.1-kilometer section having an initial profile index in excess of 240 millimeters per kilometer shall be corrected to an acceptable profile index.

Corrective efforts shall not be made for surfaces having an index of 160 millimeters per kilometer or less per 0.1 kilometer except for deviations in excess of 10 millimeters in 7.6 meters or less.

Surface defects such as, but not limited to, segregated areas, visual and ride discernible cyclic roughness, voids, and flushed areas shall be corrected as directed by the Engineer.

3. **Straightedge test:** Areas excluded from testing by the profilograph will be tested by using a 3-meter straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall be not more than 6 millimeters. Humps and depressions exceeding the specified tolerance shall be corrected, or the defective work shall be removed and replaced with new material.

4. **Payment adjustments:** When the profile index is more than 110 millimeters per kilometer but not more than 160 millimeters per kilometer per 0.1-kilometer section, payment will be made at the contract unit price. When the profile index exceeds 160 millimeters per kilometer per 0.1-kilometer section but does not exceed 240 millimeters per kilometer per 0.1-kilometer section, the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index. When the profile index is less than or equal to 110 millimeters per kilometer per 0.1-kilometer section, the Contractor will receive an incentive payment.

   Contract unit price adjustments will be made in accordance with the following schedule:

Profile Index (mm/km/ 0.1 km section)	**Contract Unit Price Adjustment (% of pavement unit price)**
50 or less	105
Over 50 to 65	104
Over 65 to 80	103
Over 80 to 95	102
Over 95 to 110	101
Over 110 to 160	100
Over 160 to 175	98
Over 175 to 190	96
Over 190 to 205	94
Over 205 to 220	92
Over 220 to 240	90
Over 240	Corrective work required

   Incentive price adjustments will be based only on the initial measured profile index, prior to any corrective work. If the profile index is more than 160 millimeters per kilometer and the Contractor performs corrective action, payment will be based on the profile index determined after corrective action. In no case will payment exceed 100 percent if the initial profile index exceeds 160 millimeters per kilometer.

   This contract unit price adjustment will apply to the total theoretical tonnage representing the total thickness of the asphalt pavement structure of the 0.1-kilometer section for the lane width represented by the profilogram.

(b) **Thickness Tolerance:** The thickness of the base course will be determined by the measurement of cores as described in VTM-32B.

Acceptance of asphalt concrete base course for depth will be based on the mean result of measurements of samples taken from each lot of material placed. A *lot* of material is defined as the quantity being tested for acceptance except that the maximum lot size will be 1 kilometer of 7.2-meter width base course.

A lot will be considered acceptable for depth if the mean result of the tests is within the following tolerance of the plan depth for the number of tests taken except that each individual test shall be within ±15 millimeters of the plan depth; mean of two tests, ±11 millimeters; mean of three tests, ±9 millimeters; mean of four tests, ±8 millimeters.

If an individual depth test exceeds the ±15 millimeters tolerance, that portion of the lot represented by the test will be excluded from the lot. If an individual test result indicates that the depth of material represented by the test is more than 15 millimeters, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If an individual test result indicates that the depth of the material represented by the test is deficient by more than 15 millimeters, correction of the base course represented by the test shall be made as specified hereinafter.

If the mean depth of a lot of material is excessive, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the tests.

If the mean depth of a lot of material is deficient by more than the allowable tolerance, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot.

For excessive depth base courses, the rate of deduction from the metric tonnage allowed for payment as base course will be calculated at a mass of 2.4 kilograms per square meter per millimeter of depth in excess of the tolerance. For sections of base course that are deficient in depth by more than 15 millimeters and less than 40 millimeters, the Contractor shall furnish and place material specified for the subsequent course to bring the base course depth within the tolerance. This material will be measured on the basis of metric tonnage actually placed, determined from weigh tickets, and paid for at the contract unit price for the base course material. Such material shall be placed in a separate course. If the deficiency is more than 40 millimeters, the Contractor shall furnish and place base course material to bring the base course thickness within the tolerance. Corrections for deficient base course depth shall be made in a manner to provide a finished pavement that is smooth and uniform.

When the Contract provides for the construction or reconstruction of the entire pavement structure, the surface and intermediate courses shall be placed at the rate of application shown on the plans within an allowable tolerance of ± 5 percent of the specified application rate for application rates of 50 kilograms per square meter or greater and within 2.5 kilograms per square meter for application rates of less than 50 kilograms per square meter. The amount of material exceeding the allowable tolerance will be deducted from the pay quantities.

When the Contract provides for the placement of surface or intermediate courses over existing pavement, pavements constructed between combination curb and gutter, or in the construction or reconstruction of shoulders, such courses shall be placed at the approximate rate of application shown on the plans. However, the specified rate of application shall be altered where necessary to produce the required riding quality.

315.08—Measurement and Payment.

Asphalt concrete base will be measured in metric tons and paid for at the contract unit price per metric ton. This price shall include preparing and shaping the subgrade or subbase, constructing and finishing shoulders and ditches, and removing and replacing unstable subgrade or subbase.

Asphalt concrete will be measured in metric tons and paid for at the contract unit price per metric ton. Net mass information shall be furnished with each load of material delivered in accordance with the requirements of Section 211. Batch masses will not be permitted as a method of measurement unless the Contractor's plant is equipped in accordance with the requirements of Section 211, in which case the cumulative mass of the batches will be used for payment.

Asphalt used in the mixtures, when a pay item, will be measured in metric tons in accordance with the requirements of the provisions of Section 109.01 except that transporting vehicles shall be tared prior to each load. The mass shall be adjusted in accordance with the percentage of asphalt indicated by laboratory extractions.

Tack coat shall be included in the price for other appropriate pay items.

Asphalt curb backup material will be measured in metric tons and will be paid for at the contract unit price per metric ton. This price shall include placing, tamping, and compacting.

Liquid asphalt cement, when a pay item, will be measured in metric tons and will be paid for at the contract unit price per metric ton.

These prices shall include heat stabilization additive, furnishing samples, and maintaining traffic.

Payment will be made under:

Pay Item	Pay Unit
Asphalt concrete base course (Type)	Metric ton
Asphalt concrete (Type) (Class)	Metric ton
Asphalt concrete curb backup material	Metric ton
Liquid asphalt cement	Metric ton

SECTION 316—HYDRAULIC CEMENT CONCRETE PAVEMENT

316.01—Description.

This work shall consist of constructing pavement and approach slabs composed of hydraulic cement concrete, with or without reinforcement as specified, or a continuously reinforced pavement on a prepared subgrade or base course in accordance with the requirements of these specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or as established by the Engineer.

316.02—Materials.

(a) **Concrete** shall be central mixed and shall conform to the requirements of Table II-17 for Class 20 paving concrete except that the slump shall be not more than 50 millimeters for placement by the slipform method. Concrete for placement by the slipform method shall be sufficiently cohesive to prevent detrimental sloughing at the pavement edges as the forms advance. Transit mixture concrete may be furnished for use in constructing approach slabs, ramps, transitions, connections, crossovers, and other miscellaneous pavement. Aggregate used in concrete for pavement and approach slabs that are used as riding surfaces shall be nonpolishing aggregate.

(b) **Reinforcing steel dowels, tie bars, hook bolts, and welded wire fabric** shall conform to the requirements of Section 223.

(c) **Wide flange beams** used in the anchor slab of continuously reinforced pavement shall conform to the requirements of ASTM A36.

(d) **Joint sealer and filler** shall conform to the requirements of Section 212.

(e) **Load transfer devices** shall be fabricated of steel and shall be of an approved type and design.

(f) **Curing materials** shall conform to the requirements of Section 220.

316.03—Equipment.

Equipment and tools necessary for handling materials and performing the work shall be subject to the approval of the Engineer.

The Contractor shall provide the equipment and tools specified herein, or their approved equivalent, and they shall be of such capacity that the rate of placing concrete and finishing pavement will be continuous. If any piece of equipment does not have sufficient capacity to keep pace with the other operations, the Contractor shall limit the size of the batch or otherwise limit the rate of production to preclude poor workmanship or frequent delays.

(a) **Forms:** Straight side forms shall be made of metal at least 5.5 millimeters in thickness and shall be furnished in sections at least 3 meters in length. Forms shall have a depth at least equal to the prescribed edge thickness of the concrete, without horizontal joints, and a base width equal to at least the depth of the forms. Flexible or curved forms of proper radius shall be used for curves with a radius of 30 meters or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure placement so that when set they will withstand the impact and vibration of consolidating and finishing without visible springing or settlement. Flange braces shall extend outward on the base at least 2/3 the height of the form. Forms that are bent, twisted, or broken or that have battered top surfaces shall be removed. Repaired forms shall not be used until inspected and approved. Built-in forms shall not be used except where the total area of pavement on the project is less than 2,000 square meters. The top face of the form shall not vary from a true plane more than 3 millimeters in 3 meters, and the vertical side shall not vary from a true plane more than 6 millimeters in 3 meters. Forms shall contain provisions for locking the ends of abutting form sections together tightly and for secure setting.

(b) **Subgrade Machine:** The machine shall be of an approved mechanical type, capable of preparing the subgrade to within 5 millimeters of the grade shown on the plans or established by the Engineer.

(c) **Subgrade Roller:** The roller shall be of an approved type and capable of obtaining the required density.

(d) **Bulkheads:** Bulkheads for construction joints shall be of sufficient strength to prevent deformation of the joint and shall be constructed to permit dowels or other reinforcement to extend through the joint.

(e) **Work Bridges:** Work bridges shall be provided by the Contractor.

(f) **Mechanical Spreader:** The mechanical spreader shall be a self-powered, self-propelled unit capable of placing the concrete mechanically on the subgrade over the full width and depth of the pavement.

The spreader shall be equipped with a hopper or other type of spreading equipment that will distribute the concrete over the subgrade without segregation. The concrete shall not be placed directly on the subgrade from the hauling equipment except in areas where hand labor must be performed.

(g) **Vibrators:** Vibrators for full-width vibration of concrete pavements shall be internal vibrators with multiple spuds. They may be attached to the spreader or mounted on a separate carriage operating directly behind the spreader. The frequency of vibrators shall be at least 7,000 impulses per minute.

When spud internal vibrators, either hand operated or attached to spreaders, are used adjacent to forms, they shall have a frequency of at least 3,500 impulses per minute.

Vibration shall be controlled by the forward movement of the spreader so that vibration automatically ceases when the forward movement of the spreader is stopped.

(h) **Spraying Equipment:** When liquid membrane-forming compound is used for curing concrete pavement, the Contractor shall provide mechanical spraying equipment mounted on movable bridges. The equipment shall be the full atomizing type equipped with a tank agitator and a gage to measure the quantity of material applied. The equipment shall be capable of continuously agitating the membrane during application.

(i) **Concrete Saw:** When sawing joints is elected or specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate with a water-cooled, diamond-edged saw blade or an abrasive wheel.

(j) **Slipform Paver:** The paver shall be designed to consolidate, screed, and float finish the freshly placed concrete in one complete pass of the machine and in a manner so that a minimum of hand finishing will be

necessary to provide a dense and homogeneous pavement. The paver shall be equipped to vibrate the concrete thoroughly for the full width and depth of the strip of pavement being placed.

316.04—Procedures.

(a) **Concrete Base Course:** The subgrade or subbase upon which the base course is to be placed shall be prepared in accordance with the requirements of the applicable provisions of these specifications for such course.

The construction of a hydraulic cement concrete base course shall conform to the requirements of these specifications except for floating and final finishing of the surface. The surface shall be finished so that there will be no deviation of more than 5 millimeters between any two contact points when tested with a 3-meter straightedge placed parallel to the center line. A heavy broomed texture shall be applied.

(b) **Preparing Grade:** The subgrade shall be prepared as specified in Section 305. The course upon which the concrete pavement will rest, including the area that will support the paving equipment, shall be graded and compacted to the required profile.

Before or after side forms have been securely set to grade, the subgrade or subbase course shall be brought to the proper cross section. The finished grade shall be maintained in a smooth and compacted condition until pavement is placed.

The subgrade or subbase course shall be uniformly moist when concrete is placed. However, the method of moistening shall not be such as to form mud or pools of water.

(c) **Placing Reinforcing Steel for Continuously Reinforced Pavement:** At each location where five or more consecutive days will elapse between placement operations, a "leave out" joint shall be installed as detailed on the plans. Longitudinal bars shall be positioned in the finished pavement within ±13 millimeters of the specified vertical position and ± 25 millimeters of the specified horizontal position with a cover of at least 50 millimeters.

Prebent deformed tie bars, Grade 300 or 400, may be used in the joint between the mainline and ramp pavement to facilitate the use of the slipform paver. Bars shall be prebent with equipment designed especially for fabricating 90-degree bends in 16-millimeter deformed bars without damage to the bars. Side forms of the slipform paver shall be designed in a manner so that the prebent tie bars can be

inserted in an appropriate slot and will pass between the edge of the pavement and the inside face of the trailing forms as the paver advances.

When reinforced concrete pavement is placed in two layers, the entire width of the bottom layer shall be vibrated and struck off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly on the concrete, after which the top layer of concrete shall be placed, struck off, and screeded. Any portion of the bottom layer of concrete that has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or placed by approved mechanical or vibratory means in fresh concrete after spreading.

Reinforcing steel shall be straight, and its surface condition shall conform to the requirements of Section 406.03(b).

(d) **Setting Forms:** The foundation under forms shall be compacted to grade so that forms, when set, will be firmly in contact for their entire length and at the specified grade. Any foundation grade that is found to be low shall be filled to grade with granular material in lifts of 13 millimeters or less for a distance of 450 millimeters on each side of the base of the form and thoroughly compacted. Imperfections or variations above grade shall be corrected by tamping or cutting as necessary.

Forms shall be set at least 150 meters in advance of concrete placement. Where local conditions make this requirement impracticable, it may be waived. After the forms have been set, the grade shall be thoroughly tamped at the inside and outside edges of the base of forms. Forms shall be staked into place with a sufficient number of pins of sufficient length for any section to hold the form at the correct line and grade. Form sections shall be tightly locked, free from play or movement. The top of the form, when tested with a 3-meter straightedge, shall not deviate more than 3 millimeters and the longitudinal axis of the vertical face shall not vary more than 5 millimeters from the straightedge. No excessive settlement or springing of forms under the finishing machine will be allowed. Forms shall be cleaned and oiled prior to concrete placement.

The alignment and grade elevation of forms shall be checked and corrections made by the Contractor immediately before concrete placement. If any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

(e) **Placing Concrete:** Concrete shall be placed on the grade in a quantity that will provide a uniform and adequate supply for the finishing equipment. Spreading shall be accomplished with a mechanical spreader. Necessary hand spreading shall be performed using square-faced shovels. The use of rakes or hoes will not be permitted. Workers shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with soil or foreign substances.

Where concrete is placed adjoining a previously constructed lane and mechanical equipment will be operated from the existing lane, the concrete in that lane shall have attained a modulus of rupture strength of at least 3 megapascals. Test specimens for this purpose shall conform to the requirements of AASHTO T23 and shall be tested in accordance with the requirements of AASHTO T177. Equipment that will damage the surface of the existing pavement will not be permitted.

Concrete shall be thoroughly consolidated against forms and joint assemblies by means of full-width vibration. Vibrators will not be permitted to come in contact with a joint assembly, reinforcement, or side forms. The vibrator shall not be operated for more than 15 seconds in any one location. When fabric or bar mat reinforcement is placed by mechanical equipment that uses vibration or a tamping action, other vibratory equipment may be eliminated except in areas adjacent to side forms.

Concrete shall be placed as close to expansion and contraction joints as is possible without disturbing the joints. Concrete shall be placed over and around dowels in a manner so that dowels are fully embedded without displacement.

Concrete for continuously reinforced pavement shall be placed through the openings in the steel in one lift and vibrated with an internal vibrator for the entire width and depth. Special attention shall be given to the consolidation of the concrete in the immediate vicinity of construction joints and other areas where the performance of vibrators mounted on the paving equipment is questionable.

Following concrete placement, concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be reasonably close to the elevation shown on the plans or as established by the Engineer.

If concrete operations are permitted to extend after sunset, adequate lighting shall be provided.

(f) **Test Specimens:** The Contractor shall furnish the concrete necessary for casting test beams in accordance with the requirements of Section

316.04 (o). Beams shall be cured by a designated method as specified for the pavement in accordance with the requirements of AASHTO T23.

(g) **Jointed Pavement:** Joints shall be installed in a manner and at such time to prevent random or uncontrolled cracking. If random or uncontrolled cracking occurs, sufficient concrete shall be removed and replaced on each side of the cracking to form a slab at least 3 meters long. Transverse construction joints shall be constructed at each end of the slab in accordance with the requirements of applicable provisions of 4. herein.

1. **Longitudinal joints:** Deformed tie bars of the specified length, size, spacing, and material shall be placed perpendicular to the longitudinal joints. They shall be placed by approved mechanical equipment and rigidly secured by chairs or other approved supports to prevent displacement or by the insertion of bars with an approved hand tool. When adjacent lanes of pavement are constructed separately, approved two-piece connectors shall be used.

   Longitudinal joints shall be sawed, formed, or created using a strip insert. Longitudinal center joints shall be installed in a manner so that full contact is made at intersections with transverse joints.

   a. **Formed joints:** Formed joints shall consist of a groove extending downward from, and normal to, the surface of the pavement and shall be formed by an approved nonmetallic or removable device that consistently demonstrates its ability to produce in fresh concrete a joint having the dimensions and line indicated on the plans. The groove shall be sealed with a premolded or poured joint material as required.

   b. **Strip insert joints:** A longitudinal weakened plane joint may be furnished at traffic lane lines in multilane monolithic concrete pavement in lieu of forming or sawing such joints. Strip insert joints shall be formed by placing a continuous strip of plastic or other approved material. The insert strip shall be of sufficient width to form a weakened plane to the depth shown on the plans. The thickness of the insert material shall be at least 0.5 millimeter. Strip insert joints shall not be sawed.

      The insert strip shall be inserted with a mechanical device that places the material in a continuous strip. Splices will be permitted provided they are effective in maintaining the continuity of the insert strip. The top edge of the insert strip shall be positioned flush with the finished surface. The insert strip shall not be deformed from a vertical position during installation or in subsequent finishing operations performed

on the concrete. The alignment of the finished joint shall be uniformly parallel with the center line of the pavement and free from local irregularities in alignment that are more than 13 millimeters in 3 meters. The mechanical installation device shall vibrate the concrete during the insertion of the strip in a manner to cause the disturbed concrete to return evenly along the sides of the strip without segregating or developing voids.

If the Contractor is unable to furnish a satisfactory strip insert joint consistently, he shall, upon being notified by the Engineer, discontinue furnishing such joints and furnish other approved formed or sawed joints without additional compensation.

c. **Sawed joints:** Longitudinal sawed joints shall be cut by approved concrete saws. Suitable guidelines or devices shall be used to ensure cutting the longitudinal joint on the true line as shown as soon as the concrete has hardened sufficiently to permit sawing without chipping, spalling, or tearing. Concrete faces of the saw cut shall be protected from drying until the end of the specified curing period. Sawed joints shall be thoroughly cleaned and dried prior to being sealed.

2. **Transverse expansion joints:** Transverse expansion joints shall be formed in accordance with the requirements of 1.a. herein and shall be sealed using Type D material. Expansion joint filler shall be continuous from form to form, shaped to the subgrade. Preformed joint filler shall be furnished in lengths equal to the pavement width or the width of one lane. Damaged or repaired joint filler shall not be used.

Expansion joint filler shall be held in a position perpendicular to the subgrade. An approved installing bar, or other device, shall be used, if required, to secure preformed joint filler at the proper grade and alignment during placing and finishing of concrete. Finished joints shall not deviate more than 5 millimeters in the horizontal alignment from a straight line. If joint filler is assembled in sections, there shall be no offsets between adjacent units.

3. **Transverse contraction joints:** Transverse contraction joints shall consist of planes of weakness created by cutting grooves in the surface of the pavement and, when shown on the plans, shall include load transfer assemblies.

Edges of concrete adjacent to the joint may be rounded or beveled to a radius or length approved by the Engineer. Any joint having insufficient opening shall be resawed or ground to the proper size. Where a joint opening is larger than that specified, the Contractor may be required to build up the joint with epoxy mortar or to

furnish a larger size seal as determined by the Engineer. The cost of any such additional work or material shall be borne by the Contractor.

4. **Transverse construction joints:**

   a. **Jointed pavement:** Unless specified expansion joints occur at the same points, transverse construction joints shall be constructed at the end of each day's work or when there is an interruption of more than 30 minutes in the concreting operations. A transverse construction joint shall not be constructed within 3 meters of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 3 meters long, the excess concrete back to the last preceding joint shall be removed and disposed of as directed. An approved header board, cut to the required cross section, shall be used to form joints. Deformed dowel bars shall be used in transverse construction joints whose location does not coincide with the specified location of a transverse expansion or contraction joint.

   b. **Continuously reinforced concrete pavement:** Transverse construction joints shall be formed by the use of an approved header board in accordance with the requirements of 4.a. herein. The header shall consist of two sections, one being placed above and one being placed below the reinforcing mat, and shall be furnished with openings to accommodate the longitudinal steel and additional reinforcement required.

      At any location where a "leave out" is necessary for a detour, at least 30 meters shall be maintained between transverse construction joints.

5. **Load transfer devices:** Plain dowels shall be held in position parallel to the surface and center line of the slab by a metal device that is left in the pavement.

   The entire free end of each dowel shall be painted with one coat of approved paint. When the paint has dried and immediately before dowels are placed in position, the free end shall be thoroughly coated with an approved lubricant. A metal or plastic dowel cap of approved design to cover 50 millimeters, ±5 millimeters, of the dowel, with a closed end and with a suitable stop to hold the end of the sleeve at least 25 millimeters, from the end of the dowel bar, shall be furnished for each dowel bar used in expansion joints. Caps or sleeves shall fit the dowel bar tightly, and the closed end shall be mortartight. Dowels, plastic coated in accordance with

the requirements of Federal Specification L-C-530 C or epoxy coated in accordance with the requirements of AASHTO M284, may be used in lieu of painted and lubricated dowel bars.

In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the full thickness of pavement by an approved device.

6. **Isolation joints at structures:** Isolation joints shall be formed by placing a strip of 13-millimeter preformed expansion joint filler around each structure that extends into or through the pavement before concrete is placed at that location.

(h) **Final Striking Off, Consolidating, and Finishing:** The sequence of operations shall be as follows: (1) striking off, (2) consolidating, (3) floating, (4) removing laitance, (5) straightedging, and (6) finishing. If the application of moisture to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.

1. **Finishing at joints:** Concrete adjacent to joints shall be mechanically vibrated to prevent voids and segregation from occurring against the joint material, also under and around load transfer devices, joint assembly units, and other features designed to extend into the pavement.

   a. **Machine finishing:** Concrete shall be spread as soon as placed, struck off, and then screeded by an approved finishing machine. Vibration for the full width of the paving slabs shall be provided in accordance with the requirements of Section 316.03(g). The machine shall be operated over each area of pavement as many times and at such intervals as necessary to result in proper consolidation and develop a surface of uniform texture. Excessive manipulation of a given area shall be avoided.

   During the first pass of the finishing machine, a uniform roll of concrete shall be maintained ahead of the front screed for its entire length.

   If a uniform and satisfactory density of concrete is not obtained at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and use methods that will produce pavement conforming to the requirements specified herein.

   b. **Hand finishing:** Hand finishing will be permitted only under the following conditions: (1) to finish concrete already deposited on the grade in the event of a breakdown of

mechanical equipment; and (2) to finish narrow widths, approach slabs, or other areas of irregular dimensions where the operation of mechanical equipment is impractical.

Concrete shall be struck off as it is placed and screeded with an approved portable screed. If reinforcement is required, the bottom of concrete shall be screeded prior to placement of reinforcement.

Consolidation shall be attained by the use of an approved vibrator or other approved equipment.

Hand finishing shall be kept to the absolute minimum necessary to attain a surface that has a uniform texture, is true to the approximate grade and cross section, and has a closed surface.

2. **Floating:** After concrete has been struck off and consolidated, it shall be further smoothed and made true by means of a float using one of the following methods as specified or permitted:

   a. **Mechanical method:** A mechanical float shall be adjusted so that its full length will be in continuous contact with the surface of the pavement.

   If necessary, long-handled floats having blades at least 1500 millimeters in length and 150 millimeters in width may be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing, the prescribed method of floating.

   b. **Hand method:** This method will be permitted only in those instances specified in 1.b. herein. Following strike off by an approved screed, concrete shall be smoothed with a darby to level raised spots or fill depressions. Long-handled floats or hand floats of wood or metal, as the area dictates, may be used in lieu of darbies to smooth and level the concrete surface. Excessive bleed water shall be wasted over the side forms after each pass of the float.

3. **Straightedge testing and surface correction:** After floating has been completed and excess water removed, but while concrete is still fresh, the surface of the concrete shall be tested for trueness with a 3-meter straightedge. The Contractor shall furnish and use an accurate 3-meter straightedge swung from handles 0.9 meter longer than 1/2 the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the pavement center line, and the entire area shall be gone over

from one side of the slab to the other as necessary. Advancement along the pavement shall be in successive stages of not more than 1/2 the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, stuck off, consolidated, refinished, and retested. High areas shall be cut down and refinished. Special attention shall be given to ensure that the surface across joints conforms to the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

4. **Final finish (texture):** Prior to grooving, multi-ply damp fabric shall be dragged over the pavement surface to provide a gritty texture on ridges between grooves. The roadway pavement riding surface shall be textured with (1) uniformly pronounced grooves approximately 3 millimeters in depth and 3 millimeters in width on approximately 20-millimeter centers and transverse to the pavement center line, or (2) a combination of uniformly pronounced grooves approximately 3 millimeters in depth and 3 millimeters in width on approximately 20-millimeter centers and longitudinal to the pavement center line and additional grooves 3 millimeters in depth and 3 millimeters in width on approximately 75-millimeter centers and transverse to the pavement center line.

(i) **Stenciling Station Numbers and Dates:** Before concrete takes its final set and after finishing operations are completed, the Contractor shall stencil station numbers and dates into the pavement in accordance with the Standard Drawings. The dies for numbering and dating will be furnished by and remain the property of the Department. Dies or numerals lost or damaged by the Contractor shall be replaced at his expense.

(j) **Curing:**

1. **Membrane-forming compounds:** The entire surface of the pavement shall be sprayed uniformly with a white pigmented membrane-forming compound immediately following the texturing operation.

The compound shall be applied under constant pressure at the rate of 2.5 to 3.5 square meters per liter by mechanical sprayers mounted on movable bridges. On textured surfaces, the rate shall be as close to 2.5 square meters per liter as possible. Application shall be such that an even, continuous membrane is produced on the concrete surface. At the time of use, the compound shall be in a thoroughly mixed condition, with the pigment uniformly dispersed throughout the vehicle. During

application, the compound shall be continuously and effectively agitated. Hand spraying of odd widths or shapes and concrete surfaces exposed by removing forms and sawing joints will be permitted.

The membrane shall harden 30 minutes after application. Personnel and equipment shall be kept off the freshly applied material to prevent damage to the seal. If the membrane becomes damaged within the initial 72 hours, damaged portions shall be repaired immediately with additional compound.

Upon removal of side forms, sides of exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.

If the slipform method of paving is used, edges of pavement shall be cured in the same manner and at the same time as the surface.

2. **PE film:** When PE film is used for curing, it shall be white. However, from November 1 to April 1, clear or opaque PE film will be permitted.

3. **Protection in cold weather:** The Contractor shall prevent the temperature at the surface of the concrete from falling below 4 °C during the first 72 hours immediately following concrete placement. Protective material shall be left in place for an additional 48 hours if freezing air temperatures are expected to continue. Such protection shall be furnished in addition to the curing material required elsewhere in these specifications. The Contractor shall be responsible for the quality of the concrete placed during cold weather. Concrete damaged by the action of frost or by freezing shall be removed and replaced at the Contractor's expense.

4. **Curing in hot, low-humidity, or windy weather:** Care shall be taken in hot, dry, or windy weather to protect the concrete from shrinkage cracking by applying the curing medium at the earliest possible time after finishing operations and after the sheen has disappeared from the surface of the pavement.

(k) **Rideability:**

1. **Surface test methods:** Pavement smoothness will be determined by a profilograph on designated lanes having design speeds of 60 kilometers per hour or higher as specified herein. Lanes with a design speed of less than 60 kilometers per hour, intersections, urban areas, transition lanes, and pavement within 10 meters

from the end of bridge approach slabs will be tested by a straightedge.

2. **Profile indexes:** Profile indexes will be determined in accordance with the requirements of VTM-83.

3. **Profilograph test:** The Contractor shall use paving methods that produce a riding surface having a profile index of 160 millimeters or less per kilometer except as otherwise provided herein. Profiles up to 240 millimeters per kilometer may be accepted with applicable price adjustments.

   The profile will terminate 10 meters from preexisting pavement. Pavement profiles will be run 0.9 meter from and parallel to each edge of each travel lane. Additional profiles may be taken only to define the limits of an out-of-tolerance surface variation.

   During initial paving operations, both when starting up and after a shutdown period, the pavement surface will be tested with the profilograph as soon as practicable after concrete has cured sufficiently to allow testing. Membrane damaged during the testing operation shall be repaired by the Contractor as directed by the Engineer at the Contractor's expense. Initial testing may be used to help the Contractor and Engineer evaluate the paving methods and equipment.

   If initial pavement smoothness, methods, and equipment are acceptable, the Contractor may proceed with paving operations. After initial testing, profiles of each day's paving will be run as soon as practicable and prior to opening to public traffic.

   Average profile indexes will be determined for each day's paving. A *day's paving* is defined as at least 0.1 kilometer of the full width of pavement placed in a day. If less than 0.1 kilometer is paved, the day's production will be grouped with the next day's production.

   For determining pavement sections where corrective work or pay adjustments will be necessary, pavement will be evaluated in 0.1-kilometer sections using the profilogram.

   Within each 0.1-kilometer section, deviations in excess of 10 millimeters in 8 meters or less shall be corrected as directed by the Engineer. Individual deviations in excess of 10 millimeters in 8 meters shall be corrected prior to other corrections. Any 0.1-kilometer section having an initial profile index in excess of 240 millimeters per kilometer shall be corrected to an acceptable profile index.

Any area or section removed shall be not less than 3 meters in length or less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 3 meters in length shall also be removed and replaced.

On sections where corrections are made, pavement will be tested to verify that corrections have produced an acceptable profile index, limited to one retest. Other required testing will be performed by the Department at the Contractor's expense.

Corrective efforts shall not be made for surfaces having an index of 160 millimeters per kilometer or less per 0.1 kilometer, except for deviations in excess of 10 millimeters in 7.6 millimeters or less.

Corrections shall be made using an approved profiling device or by removing and replacing the pavement as directed by the Engineer. Bush hammers or other impact devices will not be permitted. Corrective work shall be done at the Contractor's expense. Where surface corrections are made, the Contractor shall reestablish the surface texture to a uniform texture equal to the surrounding uncorrected pavement.

Corrective work shall be completed prior to determining pavement thickness.

Surface defects such as but not limited to segregated areas, visual and ride discernible cyclic roughness, voids, and flushed areas shall be corrected as directed by the Engineer.

4. **Straightedge test:** As soon as concrete has hardened sufficiently, the pavement surface will be tested by the Engineer with a 3-meter straightedge. Areas showing high spots of more than 5 millimeters on mainline pavement and approach slabs but not exceeding 13 millimeters in 3 meters shall be marked and, after the concrete has attained the design compressive strength, cut down with an approved cutting tool to an elevation where the area or spot will not show surface deviations in excess of 5 millimeters. Areas showing high spots of more than 10 millimeters on ramps when tested with a 3-meter straightedge shall be marked and, after the concrete has attained the design compressive strength, corrected to within the 10-millimeter tolerance by removing and replacing or by cutting as specified herein. If the slipform method of paving is used, a straightedge tolerance of ± 5 millimeters in 3 meters will be permitted for the area within 150 millimeters of the slipformed edge except for pavement adjacent to connections and ramps. Equipment for cutting shall be designed to cut the surface of the

pavement in a longitudinal direction parallel to the center line and in a uniform planing action. However, the cutting operation shall not produce a polished pavement surface. The equipment shall be adjustable so as to vary the depth of the cut as required. Bush hammering, rubbing with carborundum stone, or hand grinding will not be permitted. Where the departure from correct cross section exceeds 13 millimeters on mainline pavement, the pavement shall be removed and replaced by and at the expense of the Contractor.

5. **Payment adjustments:** When the profile index is more than 110 millimeters but not more than 160 millimeters per kilometer per 0.1-kilometer section, payment will be made at the contract price for the completed pavement. When the profile index is more than 160 millimeters per kilometer but not more than 240 millimeters per kilometer per 0.1-kilometer section, the Contractor may elect to accept an adjusted price in lieu of reducing the profile index. When the profile index is less than or equal to 110 millimeters per kilometer per 0.1-kilometer section, the Contractor will receive an increased contract unit price.

   Price adjustments will be made in accordance with the following schedule:

Profile Index (mm/km/ 0.1 km section)	**Price Adjustment (% of pavement contract unit price)**
50 or less	105
Over 50 to 65	104
Over 65 to 80	103
Over 80 to 95	102
Over 95 to 110	101
Over 110 to 160	100
Over 160 to 175	98
Over 175 to 190	96
Over 190 to 205	94
Over 205 to 220	92
Over 220 to 240	90
Over 240	Corrective work required

   Incentive price adjustments will be based only on the profile index measured prior to corrective work. If the profile index is more than 160 millimeters per kilometer and the Contractor performs corrective action, payment will be based on the profile index determined after corrective action. In no case will payment exceed 100 percent for any pavement on which corrective action has been performed.

The adjusted contract unit price will apply to the total area of the 0.1-kilometer section for the width represented by the profilogram.

(l) **Removing Forms:** Forms shall not be removed from freshly placed concrete until it has set for at least 12 hours. Forms shall be removed carefully to avoid damage to the pavement. After forms are removed, the sides of the slab shall be cured as specified by one of the methods described herein. Major honeycombed areas will be considered defective work and shall be removed and replaced. Any area of section removed shall be not less than 3 meters in length or less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 3 meters in length shall also be removed and replaced.

(m) **Sealing Joints:** Before pavement is opened to traffic, including the Contractor's equipment, and as soon after completion of the curing period as practicable, joints required to be sealed shall be filled with joint-sealing material. Just prior to sealing or resealing, each joint shall be thoroughly cleaned by brushing, routing, sawing, grinding, blast cleaning, or any combination thereof to eliminate oil, grease, existing joint material, membrane-forming compound, laitance, protrusions or hardened concrete, dirt, or other foreign material that cannot be removed by means of compressed air to a depth at which the sealer and backup material, if required, are to be installed. Dust and loose material shall be removed from the joint with oil-free and water-free compressed air delivered at a minimum of 3.4 cubic meters of air per minute and a nozzle pressure of at least 620 kilopascals. Existing joint material extending outside the joint shall be removed.

Joint material shall be installed in accordance with the manufacturer's recommendations. However, in the absence of specific recommendations or plan details, the following provisions shall apply.

1. Preformed seals shall be installed by machines that are designed especially for such installation and shall not damage the seal. Type A and D material shall be installed by machine. The seal shall be installed with its vertical axis parallel to the interfaces of the joint.

2. The method of installing preformed seals shall be such that the seal is not stretched more than 5 percent of the length of the joint.

   The method of installation shall be checked for stretching, using transverse joint sealer. The check shall consist of installing sealer in five joints, the full width of the pavement, and removing the sealer immediately after installation and checking the length. If

the measured length of any of the five sealers is less than 95 percent of the minimum theoretical length required to seal the joint, the installation method shall be modified so that stretching greater than 5 percent no longer occurs. Once sealing operations have started, 1 joint per every 100 shall be removed and checked for stretch in excess of 5 percent. If a stretched condition is detected, the joint sealers on either side shall be removed until the condition disappears. Affected joints shall be resealed in a satisfactory manner at the Contractor's expense.

3. For rounded or beveled joints, seal or sealant shall be installed at a depth of at least 3 millimeters but not more than 6 millimeters below the bottom edge of the rounding or bevel. For joints with vertical sides, seals or sealant shall be installed at a depth of 6 millimeters, ± 2 millimeters, below the level of the pavement surface.

4. Hot-poured sealer shall be applied to a completely dry joint. The ambient air temperature shall not be below 4 °C. The joint shall be filled with hot-poured sealer by means of a sealing device that will not cause air to be entrapped in the joint. Sufficient passes shall be made to achieve the filled joint requirement.

5. Material for hot-poured sealer shall be stirred during heating so that localized overheating does not occur.

6. Sealer shall not be placed directly on the filler but shall be prevented from bonding to the filler by a carefully placed strip of waxed or silicone paper, plastic tape, aluminum foil, or other suitable material placed over the filler before sealer is applied. Masking tape or other means shall be used to avoid spilling sealer onto adjacent concrete surfaces. Excess sealer on such surfaces shall be cleaned off before the material has set without damaging the material in the joint.

7. Silicone sealer shall not be applied when the air temperature is below 4 °C. Sealer shall fill the joint and shall be applied inside the joint from the bottom up by means of an application device that will not cause air to be entrapped. Immediately after application, sealer shall be tooled to form a recess below the pavement surface in accordance with the standard drawings. The use of soap, water, or oil as a tooling aid will not be permitted. Primer, if used with silicone sealer, shall be applied to the joint faces prior to installation of backup material. Backup material shall be approximately 25 percent larger than the joint width and shall be installed in the joint such that it is not displaced during the sealing application.

Sealing material shall be applied in a manner so that it will not be spilled on the exposed surfaces of the concrete. Excess material on the surface of the concrete pavement shall be removed immediately, and the pavement surface cleaned. The use of sand or similar material as a cover for the seal will not be permitted.

(n) **Protecting Pavement:** The Contractor shall protect the pavement and its appurtenances against public traffic and traffic caused by his employees and agents. This shall include furnishing watchpersons and flaggers to direct traffic and erecting and maintaining warning signs, lights, pavement bridges, or crossovers.

In order that the concrete may be properly protected against the effects of rain before it has attained final set, the Contractor shall have covering material available at the work site, such as burlap, cotton mats, curing paper, or plastic sheeting.

If the slipform method of paving is used, the Contractor shall also have material available at all times for protecting the edges of unhardened concrete. Protective materials shall consist of standard metal forms or wood planks having a nominal thickness of at least 50 millimeters and a nominal width of at least the thickness of the pavement at its edges.

When rain appears imminent, concrete placement operations shall be halted and available personnel shall assist in covering the surface of unhardened concrete.

A layer of coarse burlap shall be applied to the surface of fresh concrete prior to the application of PE film or other protective coverings that tend to "wipe out" or reduce the texture upon contact.

The Engineer will carefully consider any damage to the pavement occurring prior to final acceptance and may allow the Contractor to repair such damage or require the damaged pavement to be replaced.

(o) **Opening to Traffic:** Pavement shall not be opened to traffic until specimen beams conforming to the requirements of Section 316.04(f) have attained a modulus of rupture strength of 4 megapascals when tested by the center point loading method in accordance with the requirements of AASHTO T177. In the absence of such tests, pavement shall not be opened to traffic until 14 days after concrete is placed. Prior to opening to traffic, pavement shall be cleaned and joints sealed and trimmed.

316.05—Tolerances.

The thickness of pavement will be determined by average caliper measurements of cores taken therefrom, as described in VTM-26, and tested in accordance with the requirements of AASHTO T148.

Areas found to be deficient in thickness by more than 25 millimeters will be evaluated by the Engineer, and if in his judgment the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness specified on the plans. The deficient area shall be the product of the full width of the slab or lane of pavement multiplied by the sum of the distances in each direction from the deficient core along the center line of the pavement to the first actual cores found not deficient in thickness by more than 25 millimeters.

The Contractor shall fill test holes with the same type of concrete as in the pavement.

316.06—Measurement and Payment.

Hydraulic cement concrete pavement will be measured in square meters of concrete pavement, complete-in-place, and will be paid for at the contract unit price per square meter. This price shall include furnishing and placing materials, including dowels, reinforcement, and joint material, provided that for any pavement found deficient in average thickness, as described in VTM-26, by more than 5 millimeters but not more than 25 millimeters only the reduced price stated herein will be paid. The width of measurement will be the width of the pavement shown on the typical cross section of the plans and additional widening where called for or as otherwise directed in writing by the Engineer. The length will be measured horizontally along the center line of each roadway or ramp.

Concrete entrance pavement, concrete launching ramps, and anchor slabs will be measured in square meters of surface area, complete-in-place, and will be paid for at the contract unit price per square meter.

Bridge approach slabs, when a pay item, will be measured in cubic meters of concrete and kilograms of reinforcing steel, complete-in-place, and will be paid for at the contract unit price per cubic meter of concrete and per kilogram of reinforcing steel.

Bridge approach expansion joints will be measured in meters of transverse measure, complete-in-place, and will be paid for at the contract unit price

per meter. This price shall include subslab excavating and furnishing and placing materials.

No additional payment over the contract unit price will be made for any pavement that has an average thickness in excess of that specified on the plans.

Resealing joints, when a pay item, will be paid for at the contract unit price per meter. This price shall include joint preparation, furnishing and placing sealer, and removing and disposing of debris.

Price adjustments: Where the average thickness of pavement is deficient by more than 5 millimeters but not more than 25 millimeters, payment will be made at an adjusted price as specified by the following:

Deficiency in Thickness (mm)	Percent of Contract Unit Price Allowed
0-5.0	100
5.1-7.5	80
7.6-10.0	72
10.1-12.5	68
12.6-20.0	57
20.1-25.0	50

When the thickness of pavement is deficient by more than 25 millimeters and the Engineer determines that the area of such deficiency should not be removed and replaced, there will be no payment for the area retained.

Payment will be made under:

Pay Item	Pay Unit
Hydraulic cement base course (Depth)	Square meter
Plain hydraulic cement concrete pavement (Depth)	Square meter
Reinforced hydraulic cement concrete pavement (Depth)	Square meter
Continuously reinforced hydraulic cement concrete pavement (Depth)	Square meter
Concrete, Class 30, bridge approach slab	Cubic meter
Reinforcing steel, bridge approach slab	Kilogram
Bridge approach expansion joint	Meter
Concrete entrance pavement (Depth)	Square meter
Concrete launching ramp (Standard)	Square meter
Anchor slabs (Type)	Square meter
Resealing (Type) joints (Material)	Meter

Division IV

BRIDGES AND STRUCTURES

SECTION 401—STRUCTURE EXCAVATION

401.01—Description.

This work shall consist of excavating and backfilling or disposing of material necessary for constructing substructures and superstructures of new bridges and altering existing bridges in accordance with the requirements of these specifications and in reasonably close conformity with the lines and grades shown on the plans or as established by the Engineer.

401.02—Materials.

(a) **Backfill** shall be approved by the Engineer and shall be free from large or frozen lumps, wood, or rocks more than 75 millimeters in their greatest dimension or other extraneous material. Porous backfill shall conform to the requirements of Section 204.

(b) **Pipe underdrains** shall conform to the requirements of Section 232.

401.03—Procedures.

Excavated material shall generally be used for backfilling and constructing embankments over and around the structure. Surplus or unsuitable material shall be disposed of in a place and manner such that it will not affect or re-enter streams or otherwise impair the hydraulic efficiency or appearance of the structure or any part of the roadway.

Where practicable, substructures shall be constructed in open excavation and, where necessary, the excavation shall be sheeted, shored, braced, or protected by other means. If footings can be placed in the dry without the use of sheeting or cofferdams, forms may be omitted with the approval of the Engineer and the entire excavation filled with concrete to the required elevation of the top of the footing. When forms are eliminated, measurement and payment for structure excavation and concrete will be on a plan quantity basis wherein no adjustments will be made.

Unless tremie placement of concrete is specified, foundations for footings shall be kept free from standing or surface water until concrete and backfill operations have been completed. However, if the foundation is rock or the footing is supported on piles, other than for shelf abutments, dewatering need be performed only during concrete and backfill operations.

(a) **Preserving the Channel:** Excavation shall not be performed outside caissons, cribs, cofferdams, or sheet piles. The natural stream bed

adjacent to the structure shall not be disturbed. Material deposited in the stream area because of the Contractor's operations shall be removed, and the stream area shall be freed from obstructions caused by the Contractor's operations.

Prior to beginning work, the Contractor shall submit a plan that shall include the specific location of temporary structures or other obstructions that will constrict the stream flow, a description of construction activities that will contribute to constricting the stream flow, the dimensions and number of temporary structures and constrictions that are to be placed in the stream at any one time, and a dimensional elevation view of the stream and proposed temporary structures and constrictions.

(b) **Depths of Foundations:** Elevations denoting the bottom of footings shown on the plans shall be considered approximate only. Foundations shall not be considered satisfactory until approved by the Engineer.

When requested, the Contractor shall explore foundations by rod soundings or drillings to determine, to the satisfaction of the Engineer, the adequacy for the foundations to support the structure. If explorations indicate that satisfactory foundations can be obtained, variations from plan depths to foundations of open column abutments and solid or column piers shall be made only by adjusting stem lengths. Footing depths shown on the plans shall be considered minimum depths. Plan depths of concrete for footings may be increased not more than 600 millimeters at points of local irregularity over solid rock foundations.

Variations from plan depths to foundations of solid or deep curtain-wall abutments shall be made only by adjusting the depths of footings. Plan depths shall be considered minimum depths and shall not be exceeded by more than 0.9 meter.

If explorations reveal that foundations or subfoundations are inadequate for the structure, or are not within the limits of permissible variation from the bottom of footing elevations, the Engineer shall be consulted for instructions for further action or redesign.

(c) **Preparing Foundations for Footings:** Hard foundation material shall be freed from loose material, cleaned, and cut to a firm surface, either level, stepped, or serrated as directed by the Engineer. Seams shall be cleaned out and filled with concrete as directed by the Engineer.

When concrete is to rest on an excavated surface other than rock, the bottom of the excavation shall not be disturbed. The final removal

of foundation material to grade shall not be performed until just prior to concrete placement.

When the elevation of the bottom of a footing is above the level of the original ground, the footing shall not be placed until the approach embankment has been placed and compacted to the elevation of the top of the footing and excavation has been performed through the embankment to the elevation of the bottom of the footing. When a footing is to be placed over material subject to movement because of pressure from overlying or adjacent fill, the footing or piles for the footing shall not be placed until after the fill has been placed and compacted. Excavation for shelf abutment footings shall be limited to a perimeter extending not more than 450 millimeters outside the neat lines at the bottom of the footing.

When the material on which a foundation is to be placed using piles is declared unsatisfactory by the Engineer, the excavation shall be undercut for a depth of 150 to 300 millimeters as directed and backfilled with crusher run aggregate, select borrow, or other material approved by the Engineer.

(d) **Holes for Drilled-In Caissons:** Foundation bearing areas shall be cut to an approximately level surface except that they may be stepped or serrated on hard rock. If material is encountered that is not sufficiently cohesive to maintain the proper diameter of the hole, casing shall be used.

(e) **Cofferdams:** Cofferdams for foundation construction shall be as watertight as practicable and carried to a depth that will allow them to function properly without displacement. The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and inspection of their exteriors and permit pumping from outside the forms. Cofferdams that are tilted or moved laterally during sinking shall be realigned to provide the required clearance.

If conditions are encountered that render it impracticable to dewater the foundation, the Contractor may be required to construct a concrete foundation seal of the dimensions necessary to ensure that the balance of the concrete can be placed in the dry. When massed cofferdams are employed and the mass is used to overcome the hydrostatic pressure acting against the bottom of the foundation seal, anchorage, such as dowels or keys, shall be provided to transfer the entire mass of the cofferdam into the foundation seal. Cofferdams that are to remain in place shall be ported at the low water level.

Cofferdams shall be constructed in a manner to prevent damage to fresh concrete from a sudden rising of the stream and prevent damage

to the foundation by erosion. Timber or bracing left in cofferdams shall not extend into the substructure concrete.

Cofferdams, including sheeting and bracing, shall be removed after completion of the substructure in a manner that will not disturb or damage the finished concrete.

(f) **Pumping:** Pumping from the interior of a foundation enclosure shall be performed in a manner to preclude the possibility of water moving through any fresh concrete. Pumping will not be permitted during concrete placement or for at least 24 hours thereafter unless it is performed from a suitable sump separated from the concrete work.

(g) **Protecting Existing Structures or Utilities:** When foundations are located such that excavation may endanger or interfere with an existing structure or utility, the location of bracing and method of protection shall be subject to approval by the owner of the structure or utility.

(h) **Inspection:** After each excavation has been completed, the Contractor shall notify the Engineer and request his inspection and approval. Concrete shall not be placed until the depth of the excavation and the character of the foundation material have been approved.

(i) **Backfilling:** Excavated spaces that are not occupied by abutments, piers, or other permanent work shall be backfilled with soil to the surface of the surrounding ground. Backfill shall be uniformly compacted, and the top surface shall be neatly graded.

The fill around the perimeter of abutments, wing walls, and retaining walls shall be placed in horizontal layers not more than 150 millimeters in loose thickness and compacted at ± 20 percent of optimum moisture to a density of at least 95 percent as compared to the theoretical maximum density as defined in Division II. Tests for compliance with density requirements will be performed in accordance with the requirements of VTM-12. As the work progresses, backfill in front of units shall be placed and compacted in horizontal layers to the same elevation as the layers behind units until the final elevation in front is reached. Backfill shall be placed in a manner to prevent wedging action against the concrete. Slopes bounding excavation for abutments, wingwalls, or retaining walls shall be destroyed by stepping or serrating. Jetting of the fill behind abutments, wingwalls, or retaining walls will not be permitted.

Fills and backfills around piers not included in the roadway prism shall be constructed in uniformly compacted layers and placed alternately to maintain a uniform elevation on both sides of the structure. However, the density requirement will be waived.

Provision shall be made for drainage of backfill. Fifty-millimeter crusher run aggregate, conforming to the requirements of Section 205, shall be placed at the back of weep holes to extend 450 millimeters behind the entrance to the hole, 450 millimeters above the elevation of the bottom of the hole, and 450 millimeters laterally on each side of the center line of the hole.

Backfill shall not be placed against abutments or wingwalls until concrete has been in place 14 days, exclusive of days on which the average high-low air temperature is below 4 °C in the shade or until test cylinders have attained a compressive strength equal to 93 percent of the required 28-day design compressive strength.

Backfill shall be placed as soon as practicable following attainment of the required compressive strength or lapse time specified in Table IV-2 for removal of formwork but not later than 30 days after concrete placement. Excavation openings shall be maintained as dry as practicable at the time of backfilling. Backfill shall be placed in a manner to deter impoundment of water and facilitate existing drainage.

(j) **Filled Spandrel Arches:** Fill for spandrel arches within 1 1/2 times the height of the arch shall be placed in a manner to load the ring uniformly and symmetrically. Fill material shall be homogeneous soil and shall be placed in horizontal layers not more than 150 millimeters in loose thickness, compacted in accordance with the requirements of Section 303.04(h), and brought up simultaneously from both haunches. Wedge-shaped sections of fill material against spandrels, wings, or abutments will not be permitted.

(k) **Approach Embankment:** Approach embankment shall be constructed in accordance with the requirements of Section 303.04(h).

401.04—Measurement and Payment.

Structure excavation will be measured in cubic meters of material removed from the limits of vertical planes within 450 millimeters outside the neat lines of footings or of neat work that does not have footings directly beneath it, such as curtain walls or cantilevered wing walls. It will be measured from the surface of the original ground or approach roadway down to the bottom of the foundation shown on the plans or such foundation as the Engineer may approve, or down to 450 millimeters below the bottom of the neat work not directly over footings, or to the top of existing concrete where excavation is to permit placing new concrete over existing concrete.

When specified on the plans, structure excavation will include material removed outside the limits specified for the substructure, in the vicinity of the substructure on which a superstructure rests, and to a depth of 450

millimeters below the lowest beam or bottom of the slab of the superstructure, or to such depth as shown on the plans. The width of such excavation shall be limited to 450 millimeters outside the exterior beams or edges of the slab or as shown on the plans.

Excavation above the bottom of a proposed channel change or roadway template or an overpassed road will not be included as structure excavation.

Structure excavation will be paid for at the contract unit price per cubic meter. This price shall include clearing and grubbing, sheeting, shoring, bracing, placing and compacting backfill, dewatering, furnishing and placing aggregate for weep holes, disposing of unsuitable or surplus material, and clearing the channel of obstructions caused by construction operations.

Excavation for drilled-in caissons will be measured in meters of drilled hole from the existing ground to the bottom of the finished hole as measured along the center line of the hole and will be paid for at the contract unit price per meter. This price shall include drilling, underreaming, casing, and preparing the hole.

Furnishing and placing backfill will be included in the price for structure excavation and will not be measured for separate payment unless specific material is required by the Engineer and no suitable material is available within the construction limits. When specific material is required for backfill by the Engineer, measurement and payment will be in accordance with the requirements of Section 104.03.

Porous backfill, when a pay item, will be measured in cubic meters of material within the limits shown on the plans or as otherwise directed by the Engineer and will be paid for at the contract unit price per cubic meter.

Pipe underdrains, when a pay item, will be measured in meters and will be paid for at the contract unit price per meter.

Unsuitable materials removed below the plan foundation will be measured and paid for as structure excavation.

Foundation seals required by the Engineer and that are properly placed for structural adequacy as a part of the planned footing will be accepted as part of the permanent footing. Measurement and payment will be in accordance with the requirements of Section 404.08. Foundation seals that are not required by the Engineer will be included in the price for structure excavation.

Clearing and grubbing within the area defined by lines connecting the extremities of the substructure units, regardless of whether excavation is involved, shall be included in the price for structure excavation unless otherwise specified in the Contract.

Cofferdams will be measured in units of each per foundation and will be paid for at the contract unit price per each. This price shall include furnishing, erecting, maintaining, and removing.

Payment will be made under:

Pay Item	Pay Unit
Structure excavation	Cubic meter
Drilled holes	Meter
Porous backfill	Cubic meter
Pipe underdrain (Size)	Meter
Cofferdams	Each

SECTION 402—SHEET PILES

402.01—Description.

This work shall consist of furnishing and installing the type of sheet piles shown on the plans or specified by the Engineer to be left in place or removed as part of the finished structure. Other sheet piles used by the Contractor shall be considered incidental nonpay items.

402.02—Materials.

(a) **Timber sheet piles** shall conform to the requirements of Section 236 and may be of any species of wood that can be driven satisfactorily. Piles shall be free from worm holes, loose knots, wind shakes, decayed or unsound portions, or other defects that might impair their strength or tightness.

(b) **Concrete and reinforcing steel for concrete sheet piles** shall conform to the requirements of Sections 217 and 223.

(c) **Steel sheet piles** shall conform to the requirements of Section 228.

402.03—Procedures.

(a) **Timber Sheet Piles:** Piles shall be sawed with square corners and provided with tongues and grooves of ample proportions, either cut from the solid material or made with three planks securely fastened together. Piles shall be drift sharpened at the lower ends to wedge the adjacent piles tightly together.

The top of piles shall be cut off to a straight line. Piles shall be braced with waling strips that are lapped and joined at splices and corners. Wales shall be in one length between corners and bolted near the top of the piles.

(b) **Concrete Sheet Piles:** Concrete sheet piles shall be manufactured in accordance with the requirements of Section 403, 404, or 405, as applicable. Installation shall be in accordance with the requirements of Section 403.

(c) **Steel Sheet Piles:** When assembled in place, pile sections shall be practically watertight at the joints. Painting of steel sheet piles shall be performed in accordance with the requirements of Section 403. Piles shall be provided with tongues and grooves of ample proportions for securely fastening together. Wales and structural supports shall be provided as necessary to ensure structural integrity.

(d) **Temporary Sheet Piling:** When shown on the plans or directed by the Engineer, temporary sheet piling will be measured in square meters. The horizontal dimensions will be measured continuously along the outer face of the sheet piling. The bottom limit will be the bottom of the excavation shown on the plans or as authorized. The top limit will be original ground line or in areas adjacent to traffic, 1 meter above original ground line, or as otherwise shown on the plans.

402.04—Measurement and Payment.

Sheet piles will be measured in square meters of piles remaining in place and will be paid for at the contract unit price per square meter. The horizontal dimensions will be measured continuously along the outer face of the piling. For steel sheet piles, the horizontal dimension used shall be not more than the sum of the laying widths or driving dimensions of the individual piles.

Payment for temporary sheet piling will be made at the contract unit price per square meter, which price shall be full compensation for furnishing, driving, and removing the piling.

Payment will be made under:

Pay Item	Pay Unit
Sheet piles (Type)	Square meter
Temporary sheet piling	Square meter

SECTION 403—BEARING PILES

403.01—Description.

This work shall consist of furnishing, driving, cutting off, and, when required, load testing piles of the type and dimensions specified on the plans.

403.02—Materials.

(a) **Timber piles** shall conform to the requirements of Section 236.

(b) **Steel piles** shall conform to the requirements of Section 228.

(c) **Steel shells for cast-in-place piles** shall conform to the requirements of Section 228.

(d) **Concrete** shall conform to the requirements of Section 217. Concrete exposed to tidal water shall contain slag or silica fume.

(e) **Reinforcing steel,** Grade 300 or 400 for use in precast or cast-in-place piles, shall conform to the requirements of Section 223.

403.03—Pile Types.

(a) **Timber Piles:**

1. **Storing and handling:** Care shall be taken to avoid breaking the surface of treated piles. Cant hooks, dogs, or pike poles shall not be used. Cuts or breaks in the surface of treated piles shall be given three brush coats of the preservative used to treat the pile. Preservative shall be poured into bolt holes.

2. **Cutoffs:** The tops of piles shall be cut off at the elevation shown on the plans or as directed by the Engineer. Piles that support timber caps or grillage shall be cut off to conform to the plane of the bottom of the superimposed structure. In general, the length of pile above the elevation of the cutoff shall be sufficient to permit removing material damaged by driving. Piles driven to or near the cutoff elevation shall be trimmed or otherwise freed from splintered or damaged material.

(b) **Precast Concrete Piles:** Precast concrete piles with conventional reinforcement shall be furnished in accordance with the requirements of these specifications. Prestressed concrete piles shall be furnished

in accordance with the requirements of Section 405. Piles shall be manufactured to conform to the requirements of Section 404. Class 20 concrete shall be used.

1. **Casting:** Forms shall conform to the requirements of Section 404 and shall be accessible for vibrating, tamping, and consolidating concrete. Care shall be taken to place concrete to produce a satisfactory bond with the reinforcement and avoid segregation of components, honeycomb, or other defects.

   Concrete shall be continuously placed in each pile form and consolidated by vibrating. Forms shall be overfilled, the surplus concrete screeded off, and the top surface finished to a uniform, even texture similar to that produced by forms.

2. **Curing:** As soon as piles have set sufficiently, side forms shall be removed and the piles moist cured for at least 7 days. Piles shall not be driven until the concrete has reached the minimum 28-day compressive strength specified in Section 217. Concrete piles for use in brackish or tidal water or alkali soils shall be moist cured for at least 30 days before use.

3. **Finishing:** As soon as forms are removed, piles shall be pointed with mortar that conforms to the requirements of Section 218. Trestle piles exposed to view shall be finished above the ground line with a Class I finish in accordance with the requirements of Section 404.07(a). Foundation piles, that portion of trestle piles that will be below the ground surface, and piles for use in tidal water or alkali soils shall not be finished except by pointing as specified herein. Piles to be used in tidal water shall be protected in accordance with the requirements of Section 404.03(i).

4. **Storing and handling:** Storing, transporting, and handling shall be performed in a manner to prevent bending stresses, cracking, spalling, or other damage. The method of handling shall not induce stresses in the reinforcement of more than 8 megapascals or a concrete stress of more than 0.4 f'_c, where f'_c is equal to the compressive strength of a control test cylinder at the time of handling. Concrete stress shall be not more than 8 megapascals.

   Piles shall be supported or picked up only at pickup points shown on the plans or at a greater number of properly spaced pickup points as may be necessary to comply with stress requirements.

5. **Splicing:** Splicing will not be permitted unless deemed necessary by the Engineer. When splicing is permitted, it shall be performed as specified herein. Splicing shall be performed only with the

piles in their normal driving position. The final locations of splices shall be below the ground line.

Splices shall be made by providing dowels cast into the upper section of the pile. Dowels shall have a total area of at least 1 1/2 percent of the gross cross-sectional area of the pile and extend at least 30 bar diameters on each side of the splice. At least four dowels shall be used. Dowels shall be bonded into holes drilled or formed into the lower section of the pile. Holes shall be serrated to provide a mechanical bond. At least one dowel hole shall be provided with a bleeder vent near the bottom.

Ends of both sections shall be prepared to ensure that the concrete adjacent to the splice is sound material free from material that would interfere with the action of the bonding agent.

The bonding agent shall be a plasticized cement or other approved compound that can be placed or otherwise forced into the spaces around dowels and between ends of pile sections. The bonding agent shall have a compressive strength equal to that of the concrete and an adhesive strength equal to the shear and tensile strength of the concrete. The agent shall be able to withstand impact and driving stresses and shall have the same resistance as concrete to damaging water and soil conditions. These properties shall be obtained within a time limit consistent with the driving requirements. If compounds require heating, the manufacturer's recommendations shall be followed. The temperature of the concrete and the ambient temperature shall be not less than 10 °C at the time the splice is made.

Pile sections shall be held in such a manner that there will be a space of approximately 13 millimeters between the ends to permit free flow of the bonding agent. A splice form extending approximately 450 millimeters on each side of the splice shall be placed around the ends of the pile sections. The form shall have at least four ports for pouring of the bonding agent and allowing the escape of air. The bonding agent shall be poured simultaneously through two opposing ports. Driving may be resumed after sufficient time has elapsed to permit the bonding agent to develop its required properties.

6. **Build-ups:** When necessary, build-ups shall be made as follows: After driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel or strand exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel, and the necessary forms shall be placed, with care taken to

prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to concrete placement, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement or other suitable bonding material. Forms shall remain in place at least 7 days and then carefully removed. The exposed surface of the pile shall be finished as specified for precast concrete piles.

(c) **Cast-in-Place Concrete Piles:**

1. **Construction:** Piles shall be cast in previously driven metal shells that shall remain permanently in place. The diameter shown on the plans shall be the nominal diameter of the uppermost section of shell. Shells shall be classified into the following types:

   a. **For driving without mandrels:** Type A, fluted, uniform taper; Type B, straight pipe

   b. **For driving with mandrels:** Type C, corrugated, step taper; when conditions require its use, the lower section may consist of pipe conforming to the requirements for Type B; Type D, corrugated, straight, or uniform taper

   The shell, including the tip, shall be of a design and thickness that are adequate to hold the original shape and prevent distortion of the shell resulting from driving it and any adjacent shell.

   The Contractor shall determine whether self-supporting or mandrel-driven shells will be used and the necessary shell thickness.

   If the steel shells collapse, the Contractor shall increase the shell thickness or furnish prestressed concrete piles as shown on the plans at his own expense.

   Concrete shall be Class 20.

2. **Reinforcement:** Reinforcement shall consist of a cage of No. 20 longitudinal bars tied with a 6-millimeter or greater spiral bar having a 150-millimeter pitch. If the thickness of the shell wall is less than 3 millimeters, six longitudinal bars shall be used. If the thickness of the shell wall is 3 millimeters or greater, four longitudinal bars shall be used. The depth to which the reinforcement is extended below the top of the shell at the cutoff elevation shall be at least 1/3 the length of the shell, 3 meters below the elevation of material providing firm lateral support, or, in any case, 3 meters, except for shells less than 4.5 meters in

length. The reinforcement shall not extend closer than 1.5 meters to the tip. If the thickness of the shell is 5 millimeters or more, the length of longitudinal reinforcement required herein may be reduced to 1.5 meters below the top of the shell provided any splices occurring within the length are made sufficient to develop the full strength of the pile shell. In all cases, the longitudinal reinforcement shall extend 375 millimeters above the top of the shell and shall be provided with standard hooks.

3. **Inspection of metal shells:** The Contractor shall have available a light suitable for the inspection of each shell throughout its entire length. Improperly driven, broken, or otherwise defective shells shall be removed and replaced. No shell will be accepted whose diameter at any section is altered by more than 25 percent.

4. **Placing concrete:** Concrete shall not be placed until all driving within a radius of 4.5 meters is completed unless this is not practicable, in which case driving shall be discontinued until the concrete in the last cast pile has been in place at least 7 days.

   Concrete shall be placed continuously and consolidated by vibrating. Accumulations of water in shells shall be removed before concrete is placed.

(d) **Steel Piles or Steel Pile Shells:**

1. **Cutoffs:** The use of cutoffs will be permitted as extensions to driven or undriven piles, or as complete piles in themselves, provided the length of each cutoff is equal to or greater than the length of the extension or full-length pile required.

2. **Welding:** Splices, points, or point reinforcement shall be welded in accordance with the requirements of Section 407.04(a) except that welder certification will be required only for the particular welds performed as required for H-pile splices, built-up point reinforcement, and shell splices that require the full strength of the shell to be developed.

3. **Splicing:** For locations requiring pile lengths of 12 meters or less, one splice per pile will be permitted. For lengths over 12 meters, up to and including 24 meters, two splices will be permitted. For lengths exceeding 24 meters, one splice per 12 meters will be permitted. Sections less than 3 meters in length shall not be spliced except as a final (top) section of the pile.

   Splices on steel H-piles shall be made by means of butt joints with full penetration welds. Piles spliced in a vertical position shall receive a single-bevel groove weld. Piles spliced in a

horizontal position shall receive a single vee or V-groove weld. Abutting ends of piles to be spliced shall be properly prepared for welding, including removing damaged material and squaring the two ends. The two sections of pile shall be securely clamped in proper position and alignment prior to welding.

Each splice between abutting pile shell sections shall be welded or adequately connected by mechanical means approved by the Engineer to give a complete seal and shall be of adequate strength to withstand handling, driving, and design stresses. If the diameters of abutting shell sections to be spliced are not the same, the shells shall be telescoped at least 150 millimetes at splices. When splices are required to develop the full strength of the shell, the top of the outside shell at the splice shall be scalloped to provide sufficient fillet welds. Sections of shell less than 1.5 meters in length shall not be spliced to another shell except as a build-up after driving is completed. More than one splice shall not be used within any 4.5-meter length of completed pile.

4. **Protection by painting:** When steel piles or steel pile shells extend above the ground or water surface, they shall be protected in accordance with the requirements of System A as specified in Section 411. Protection shall extend from an elevation 0.6 meter below the lowest ground or water surface up to a level 50 millimeters into the concrete in which their tops are to be embedded.

5. **Variations in length:** Where steel H-piles are driven in limestone areas or where extreme variations in length are likely to be encountered, the following procedure shall be used: Wherever a pile has been driven to a depth requiring a length exceeding by 30 percent or 4.5 meters, whichever is greater, the length determined in accordance with the requirements of Section 403.04 or as indicated by the borings or piles already driven, the pile shall not be driven further until all other piles in the pier, abutment, or retaining wall have been driven or until a sufficient number has been driven to indicate clearly the trend of lengths. The Engineer will then determine the method to be used.

403.04—Determination of Pile Lengths.

For cast-in-place piles, the Contractor shall determine the type, thickness, and driving criteria of the steel pile shell. Lengths shall be determined by performing driving tests.

A driving test shall be performed by driving a pile of the same type and size as that required or proposed for the specific structure at each location shown on the plans or otherwise approved by the Engineer.

Driving test piles that are not to be load tested or dynamically analyzed shall be driven their full length or until practical or absolute refusal is reached.

403.05—Order List.

The Contractor shall submit to the Engineer for approval an itemized list for precast concrete and timber piles prior to placing the order with the supplier. The list shall include the lengths required for each pile location and the corresponding full or partial lengths of piles to be ordered.

Driving tests, dynamic pile tests, loading tests, and refined wave equation analyses shall be completed for a substructure element prior to submission of an order list for the substructure element.

403.06—Procedures.

(a) **Suitability of Foundation:** If there is any indication that piles cannot be driven in accordance with the requirements of these specifications or if the foundation material appears to be capable of supporting footings without piles, the foundation shall be explored in accordance with the requirements of Section 401.03(b) and the results of the exploration submitted to the Engineer for review to determine whether piles will be omitted and the substructure adjusted to give adequate bearing on a firm foundation.

(b) **Preparation for Driving:** Piles shall not be driven until excavation is complete. Material forced up between piles shall be removed to correct the foundation elevation before concrete for the foundation is placed.

Piles for supporting abutments on very soft or swampy original ground or on newly placed fill shall not be driven until the approach embankment, including any fill in front of the abutment, has been completed to the elevation of the top of the earthwork and compacted as specified in Section 303.

Piles shall not be driven in proximity to uncured concrete.

(c) **Protection During Driving:** Heads of concrete piles shall be protected by caps of an approved design, with a suitable cushion equivalent to at least 100 millimeters of plywood or a sufficient amount as site-specific conditions dictate, next to the pile head and fitting into a casing that supports a shock block. During driving, the cap block and cushion shall be changed if compressed more than 50 percent or as required to prevent damage to the pile. When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the cross section of the pile.

For special types of piles, driving heads, mandrels, or other devices shall be used in accordance with the requirements of the manufacturer's recommendations so that the pile may be driven without damage.

For steel piles, heads shall be cut squarely and a driving cap provided to hold the axis of the pile in line with the axis of the hammer.

Timber piles that are not enclosed in concrete shall be protected as specified in Section 418.03(d). Collars, bands, or other devices to protect timber piles against splitting and brooming shall be provided when specified by the Engineer.

Tips for timber piles shall be sharpened. When specified, timber piles shall be provided with steel or cast iron points conforming to the requirements of Section 236.02(b). When points are used, the tips of the piles shall be carefully shaped to secure an even and uniform bearing on the points.

When specified, steel H-piles shall be provided with cast steel points. Points shall be welded as recommended by the manufacturer, but the length of the weld shall be not less than twice the width of the flange.

If during the driving of a precast concrete pile a reduction in blow count indicates that the point of the pile has passed from a harder material into a softer material that offers little or no resistance to penetration, the energy per blow shall be reduced to an amount specified by the Engineer. When firm bearing material is reached, the energy per blow shall be returned to normal.

Steel piles and steel pile shells shall be painted as specified in Section 403.03(d)4.

(d) **Driving:** The capability of the hammer to drive piles properly will be verified from records of the test piles. If the required penetration is not obtained in the driving test by the use of a hammer complying with the requirements, the Contractor shall provide a heavier hammer or use other approved means at his own expense. The method of driving shall not produce deformed piles. Where it is determined necessary by the Engineer in order to obtain the required tip elevation, design bearing capacity, or minimum penetration, driving shall be supplemented by jetting or preboring. After driving is completed, voids existing as a result of preboring, soil consolidation, or movement shall be filled with dry sand and consolidated to provide adequate lateral pile support. Damaged piles shall be removed and replaced.

1. **Hammers for timber and steel H-piles:** Hammers may be either gravity or power hammers. Striking parts of gravity hammers

for driving timber piles shall have a mass of at least 900 kilograms and for driving steel piles at least 1,360 kilograms. In no case shall the mass of the striking parts of gravity hammers be less than the combined mass of the pile and any device used on the pile head for protection during driving. The hammer fall shall be regulated to avoid damage to piles. The fall shall be not more than 4.5 meters.

Power hammers shall be capable of developing at least 9,500 newtonmeters of energy per blow when driving timber piles and at least 20,300 newtonmeters of energy per blow when driving steel piles.

2. **Hammers for concrete piles:** Precast concrete piles or shells for cast-in-place piles shall be driven with a power hammer that shall develop an energy per blow of at least 0.0610 joule per newton of the design bearing capacity of the pile being driven. Power hammers shall develop an energy (E) in newtonmeter per blow of at least 0.3048 joule per newton of pile mass (W) for piles having a mass up to 11,350 kilograms. For piles having a mass of more than 11,350 kilograms, E shall be at least $11,350 + 0.6\ (W - 11,350)$. The value of E shall be at least 20,300 newtonmeters per blow.

3. **Leads:** Pile driver leads shall be constructed in a manner that will afford freedom of movement of the hammer and shall be held in position by guys or stiff braces to ensure support of the pile during driving. Except where piles are driven through water, leads shall be of sufficient length so that a follower will not be necessary.

   Inclined leads shall be used in driving battered piles.

4. **Followers:** Followers shall be used only with the written permission of the Engineer. When followers are used, 1 pile from every group of 10 shall be a long pile driven without a follower and shall be used as a test pile to determine the average bearing capacity of the group.

5. **Water jets:** The volume and pressure of water at the jet nozzles shall be sufficient to erode freely the material adjacent to the pile. A pressure of at least 690 kilopascals shall be delivered at the nozzles. At least two jet nozzles, having a diameter of at least 19 millimeters, shall be used and placed symmetrically about the circumference of the pile. Before the desired penetration is reached, the jets shall be withdrawn and the piles driven at least 1.5 meters or to the depth determined by the Engineer to be necessary to secure the final penetration.

6. **Preboring:** The area of each prebored hole shall be approximately 10 percent more than the area of the pile but not more than 20 percent of the area.

(e) **Penetration:** In general, the penetration for any pile shall be at least 3 meters. In soft material, the penetration shall be at least 6 meters. Where piles are driven through fills, they shall penetrate at least 1.5 meters into undisturbed original ground under the fill. Friction piles, other than steel H-piles, in fills shall be driven through prebored holes extending to the elevation of the original ground.

(f) **Accuracy of Driving:** Piles shall be driven to within the tolerances specified in Table IV-1 for positions at cutoff elevations.

Piles shall not be driven with a variation of more than 20 millimeters per meter from the vertical or batter specified. Steel and concrete piles shall not be subjected to force in order to place them in correct alignment or a horizontal position. The position of a timber pile that lies within the tolerance allowed for the driven position as specified in Table IV-1 under pile type No. 4, Condition (a) or (b), shall be corrected to the tolerance given for pile type No. 5, Condition (a) or (b), respectively, by the application of horizontal force wherever conditions will permit such corrective work without damage to the pile.

If the distances between the actual and theoretical pile centers or centers of gravity are more than the specified tolerances, the piles will be considered unacceptable unless the Contractor submits a satisfactory working plan showing the corrective work proposed. Such work shall not proceed until the plan has been approved by the Engineer.

The clear distance between the heads of piles and edges of footings shall be at least 150 millimeters. Additional concrete and reinforcement required to maintain the required minimum clear distance shall be placed only with the prior approval of the Engineer and shall be furnished at the Contractor's expense.

Timber piles driven below the cutoff elevation specified on the plans or by the Engineer or otherwise driven outside the limits for the driven position specified herein shall be withdrawn, and a replacement pile driven in the correct position at the Contractor's expense. Other types of piles driven to below the required elevation may be spliced or built up as otherwise provided for in these specifications.

(g) **Bearing Capacities:** Piles shall be driven to the following capacity:

1. **Steel H-piles** shall be point bearing and shall be driven to practical or absolute refusal. Steel H-piles designated as friction

TABLE IV-1
Pile Tolerance Criteria

Pile Type	Condition	Tolerance for Position of Single Pile (mm)	Center of Gravity for Pile Group[1]	
			Direction	Tolerance
1. Steel and concrete	Column supports for bent caps	±75	About long axis of footing	3% of distance between extremes[2] or 40 mm, whichever is greater
2. Steel and concrete	(a) Footing supports for box culverts	±150		
	(b) Footing supports for column piers	±150	About both major axes	3% of distance between extremes[2] or 40 mm, whichever is greater
	(c) Footing supports for abutments, retaining walls, and piers other than column piers	±150	About long axis of footing	3% of distance between extremes[2] or 40 mm, whichever is greater
3. Timber	Footing supports for box culverts	±175		
4. Timber	(a) Footing supports for column piers driven through material that will permit correction of position without damage to pile	±175	About both major axes	4 1/2% of distance between extremes[2] or 60 mm, whichever is greater
	(b) Footing supports for abutments, retaining walls, and piers other than column piers	±175	About long axis of footing	4 1/2% of distance between extremes[2] or 60 mm, whichever is greater
5. Timber	(a) Footing supports for column piers driven through material that will not permit correction of position	±150	About both major axes	4 1/2% of distance between extremes[2] or 60 mm, whichever is greater
	(b) Footing supports for abutments, retaining walls, and piers other than column piers driven through material that will not permit correction of position	±150	About long axis of footing	4 1/2% of distance between extremes[2] or 60 mm, whichever is greater
6. Timber	Fender systems and other uses requiring requiring non-load bearing piles	As required for proper attachment of wales, bracing, etc. or tying of groups for dolphins		

[1]Piles under a separate footing of individually constructed units shall be considered a separate group. The tolerances expressed as a percentage of "distance between extremes" will be allowed only about the axis for which it is computed.

[2]If the group consists of a single row of piles, the distance shall be measured from the center line of the row to the center line of the footing.

piles shall be driven to a safe bearing capacity of at least 120 kilograms per millimeter of nominal size.

2. **Timber piles** shall be driven to a safe bearing capacity of at least 20 metric tons per pile.

3. **Precast concrete piles and shells for cast-in-place concrete piles** shall be driven to a safe bearing capacity of at least 140 kilograms per millimeter of the nominal diameter or side dimension.

(h) **Disposing of Pile Cutoffs:** Upon completion of pile driving operations for structures on the project, pile cutoffs left in storage, including precast concrete and timber cutoffs, shall become the property of the Contractor and shall be disposed of off the project.

403.07—Determination of Bearing Capacities.

(a) **Loading Tests:** When required, the safe bearing capacities of piles shall be determined in accordance with 72-hour or quick load tests as specified herein. The loading test shall commence no sooner than 5 days after the pile to be tested has been driven. Telltales consisting of steel rods 13 millimeters in diameter shall be lubricated and inserted in plastic pipe 19 millimeters in inside diameter. Individual sections of telltales shall be joint coupled flush so that each rod is of uniform diameter throughout its length.

Where necessary, the unsupported length of the test pile shall be braced to prevent buckling without influencing the test results.

The clear distance from the reaction frame to the test pile shall be at least 5 times the maximum diameter of the test pile or as approved by the Engineer.

Loading shall be applied through a hydraulic jack with spherical bearings jacked against a platform load. The loading apparatus shall have a capacity of at least that required for the test. If more than one jack is used, the jacks shall have the same piston diameter, be connected to a common manifold and pressure gage, and be operated by a single hydraulic pump.

The method of determining test loads shall be by using a pressure gage or load cell. The pressure gage, hydraulic ram, and hydraulic pump shall be calibrated as a unit to an accuracy of at least 5 percent of the applied load. If a multiple jacking system is used, each jack shall be fitted with a pressure gage in addition to the master gage. Load-measuring devices shall have been calibrated not more than 3

months prior to the loading test and shall be recalibrated when directed by the Engineer.

Loads shall be applied uniformly with no impact. The load cell or pressure gage shall be continuously monitored, and the jacking pressure adjusted to maintain a constant load.

The load shall be applied to a steel test plate of appropriate thickness for the loads involved and of a size not less than the size of the pile butt and not less than the area covered by the base(s) of the hydraulic jack rams. The plate shall be set in high-strength, quick-setting grout to ensure uniform bearing. Provision shall be made for the telltale rod to extend through the test plate.

Movement of the pile butt and telltale relative to the pile butt shall be measured with dial gages to an accuracy of 0.03 millimeter. Dial gages shall have a travel of at least 50 millimeters, and gage blocks shall be provided to record measurements as required. The pile butt shall be measured by dial gages attached to an independently supported frame. Movement shall be measured by a secondary system consisting of a scale, mirror, and piano wire. The scale and mirror shall be attached parallel to the longitudinal axis of the pile. The wire shall be properly tensioned and supported so that it passes within 25 millimeters of the face of the scale. The scale shall have gradations of 0.25 millimeters.

Supports for dial gage frames and wires shall be more than 2.1 meters clear of the pile and as far from anchor piles or reaction supports as is practicable. Support and frames shall be checked by a surveyor's level.

Gages and measuring devices shall be protected from the weather, including direct sunlight. Adequate ventilation shall be provided to prevent fogging or frosting of the gages.

The Contractor shall provide the Engineer reasonable access to and from the site of the test pile. The Contractor shall assist the Engineer in recording load, settlement, and rebound measurements throughout the test and shall furnish complete information on the driving equipment used and the pile driving record.

Other piles of the same type and size that are not load tested shall be driven to the safe bearing capacity of at least that required for the satisfactory load-tested pile(s).

1. **The 72-hour loading test** shall be 200 percent of the design capacity applied in increments of 25 percent of the design capacity. Each load increment shall be maintained until the rate of settlement is not greater than 0.25 millimeter per hour or until

2 hours have elapsed, whichever occurs first. The test load shall be applied fully and continuously for at least 72 hours and shall produce no measurable settlement during the last 24 hours. After the required holding time, the test load shall be removed in decrements of 25 percent of the total test load with at least 1 hour between decrements.

Permanent settlement of the pile after completion of the specified loading test shall be not more than 6 millimeters. If the permanent settlement is more than 6 millimeters, the Contractor shall redrive and test load the same pile or drive and test load additional piles until the loading test is satisfactory.

Proven safe bearing capacity for piling from the 72-hour loading test is defined as 1/2 the test load for a satisfactory loading test.

2. **The quick load test** shall be 300 percent of the design capacity applied in increments of 10 percent of the design capacity, with a constant time interval between increments of 5 minutes. Load increments shall be added until continuous jacking is required to maintain the test load or until the specified capacity of the loading apparatus is reached, whichever occurs first. After a 10-minute interval, the full test load shall be removed in four approximately equal decrements with 5 minutes between decrements.

   The Contractor shall record readings of time, load, and settlement for the pile and telltale immediately before and after applying each load increment. When the maximum load has been applied, the Contractor shall record when jacking is stopped. Readings shall be repeated after 5 minutes and again at 10 minutes after jacking has stopped. Readings of time, load, and rebound shall also be recorded after each decrement during load removal and repeated 5 minutes and 10 minutes after the load has been removed.

   The ultimate bearing capacity of a pile tested under an axial compressive load is that load which produces a settlement of the pile head equal to the following:

$$S_f = S + (0.15 + 0.008D)$$

   where S_f = settlement at failure in millimeters; D = pile diameter or width in millimeters; S = elastic deformation of pile length in millimeters = $P_t L/AE$; P_t = load on pile in kilograms; L = length of pile in millimeters; A = area of pile in square millimeters; and E = the modulus of elasticity of the pile [$w^{1.5}$ (0.0428) $\sqrt{f'_c}$ for concrete; $2(10^8)$ kilopascals for steel].

Proven safe bearing capacity for piling is defined as 1/2 the ultimate bearing capacity obtained and shall be at least the required design capacity. If the proven safe bearing capacity is less than the required design capacity, the Contractor shall redrive and test load the same pile or drive and test load additional piles until the loading test is satisfactory.

(b) **Timber Piles:** If timber piles are not required to be driven to practical refusal or if their safe bearing capacity is not required to be determined by loading tests, their theoretical safe bearing capacity shall be determined by the following formulas:

$$P = \frac{2MH}{S + 0.1} \text{ for single-acting steam hammers}$$

$$P = \frac{2H\,(M + Ap)}{S + 0.1} \text{ for double-acting steam hammers}$$

$$P = \frac{2MH}{S + 1.0} \text{ for gravity hammers}$$

$$P = \frac{1.6E}{S + 0.1} \text{ for diesel hammers}$$

where P = theoretical safe load carrying capacity in kilograms; M = mass in kilograms of striking part of hammer; H = height of fall in meters; S = average penetration in millimeters per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for power hammers; A = area of piston in square millimeters; p = steam pressure in kilopascals at the hammer; and E = equivalent energy in joules as determined by a gage attached to the hammer for hammers with enclosed rams or the mass in kilograms of the ram multiplied by the length of travel in meters for hammers without enclosed rams. The value of E shall be not more than the manufacturer's rating for developed energy.

These formulas are applicable only when (1) the hammer has a free fall, (2) the head of the pile is not broomed or crushed, (3) the penetration is reasonably quick and uniform, or (4) a follower is not used.

If there is an appreciable bounce, twice the height of the bounce shall be deducted from H to determine its value in the formula.

If the Engineer determines that energy losses attributable to pile rebound exceed the nominal values assumed in these formulas, safe bearing capacity shall be reevaluated by wave equation analysis or

substantiated pile formulas that rationally consider energy losses in the cap, pile, and soil.

When water jets are used in connection with driving, the capacity shall be determined by the formulas from the results of driving after the jets have been withdrawn or by application of a test load.

Theoretical safe bearing capacity for piling from the timber pile formulas shall be no less than the required design capacity.

(c) **Bearing Value of Piles:** Bearing values for concrete and steel piles shall be determined by the loading tests specified in (a) herein. In the absence of loading tests, safe bearing capacities may be determined using a dynamic pile analyzer during pile driving or results of wave equation analysis. In the absence of loading tests, wave equation analysis, or a dynamic pile analyzer, the safe bearing capacity may be approximated by using substantiated pile formulas or the timber pile formulas given in (b) herein. The character of the soil penetrated; conditions of driving; followers; size, length, and mass of the piles; and computed load per pile shall be given due consideration in determining the safe bearing capacity.

Bearing piles shall be driven until the blow count determined to produce the required design capacity has been continuously maintained for 1 meter or to practical or absolute refusal, whichever occurs first. *Practical refusal* is defined as twice the blow count required to produce a safe bearing capacity when maintained for 300 millimeters. *Absolute refusal* is defined as 4 times the blow count required to produce a safe bearing capacity when maintained for 25 millimeters.

A pile shall not be driven above the blow count if wave equation analysis indicates that maximum stress levels will be exceeded.

The following are the maximum allowable driving stresses (attributable to hammer impact only):

1. **Prestressed concrete piles:**

   a. **Compression:** $0.85\ f'_c$ – Unit prestress (after losses)

   b. **Tension:** $3\sqrt{f'_c}$ + Unit prestress (after losses)

2. **Steel piles:**

   a. **Compression:** $0.9\ F_y$

   b. **Tension:** $0.9\ F_y$

At the Contractor's option, piles reaching bearing value with heads above the cutoff grade may be driven to the cutoff grade provided driving is less than practical refusal and no damage to the pile occurs.

When required by the Engineer, a pile shall be restruck with the same hammer and cushion system used for the initial driving. Pile restrike shall be at least 24 hours after initial driving. A cold hammer shall not be used for the restrike. The hammer shall be warmed up prior to restrike by striking at least 20 blows on a pile that is at least 7.5 meters from the pile to be restruck. The maximum amount of penetration required during restrike shall be 150 millimeters or the maximum total number of hammer blows required will be 50, whichever occurs first.

403.08—Measurement and Payment.

Piles will be measured in meters from the tip (excluding any added pile point) to the head of the pile remaining in place in the completed structure and will be paid for at the contract unit price per meter. This price shall include furnishing piles; driving piles; splices; obtaining safe bearing capacity, tip elevation, or minimum penetration; performing wave equation analysis; disposing of piling cutoffs; concrete and reinforcing steel required for steel shell piles, including reinforcing steel that extends into the structure footing; painting; and waterproofing.

Precast concrete and timber cutoffs will be measured in meters of pile excluding that portion of the precast concrete pile the Contractor elects to furnish to facilitate driving. Only precast concrete and timber cutoffs will be paid for. Payment will be limited to the invoice price plus 15 percent, not to exceed the contract unit price per meter of pile.

Pile points for timber and steel H-piles will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include furnishing and attaching to the pile.

Driving tests shown on the plans or required by the Engineer will be measured in meters and will be paid for at the contract unit price per meter. Piles used in driving tests will be measured from the tip (excluding any added pile point) to the head of the pile. When a pile used in a driving test is incorporated in the completed structure at the required location, no separate measurement of the pile will be made for payment. This price shall include performing the test; furnishing, removing, and disposing of piles; and restoring the pile hole when the pile is not incorporated in the structure.

Driving tests not specified on the plans or required by the Engineer but performed to determine lengths or other required properties will not be measured as driving tests. However, when piles used for the tests are

incorporated in the completed structure, they will be measured and paid for the same as other piles of the same type.

Loading tests will be measured in units of each and will be paid for at the contract unit price per each. This price shall include performing the loading test. If a loading test is terminated by the Engineer because of insufficient bearing capacity, the test will be measured for payment. If a loading test is terminated because of malfunction of the Contractor's equipment or other reasons that are the fault of the Contractor, the test will not be measured for payment.

The length of pile driven to the cutoff grade after obtaining required bearing will be measured in meters and will be paid for as cutoff.

Preboring fills in accordance with the requirements of Section 403.06(e) will not be measured for separate payment. The cost thereof shall be included in the price for pile.

Jetting when specified by the Engineer in accordance with the requirements of Section 403.06(d) will be measured in meters and will be paid for per meter at 30 percent of the contract unit price per meter for the particular size and type of pile for which the jetting was ordered. This price shall include disposing of surplus material and erosion, siltation, and water quality controls required as a result of the jetting operations.

Preboring when specified by the Engineer in accordance with the requirements of Section 403.06(d) will be measured in meters for the particular size and type of pile for which the preboring was ordered in accordance with the requirements of Section 104.03 and Section 109.05. This price shall include disposing of surplus material and erosion and siltation controls when required as a result of the preboring operations.

Pile restrike will be measured in meters of pile from the tip, excluding any added pile point, to the head of the pile remaining in the structure. Payment will be made at the contract unit price for the driving test for the same size and type pile less the invoice price per meter for the pile. This price shall include the equipment and driving effort required for the restrike.

Payment will be made under:

Pay Item	Pay Unit
Pile (Type and size)	Meter
Pile point for (Size and type) pile	Each
Driving test for (Size and type) pile	Meter
Loading test for (Size and type) pile	Each

SECTION 404—HYDRAULIC CEMENT CONCRETE OPERATIONS

404.01—Description.

This work shall consist of furnishing and placing hydraulic cement concrete in accordance with these specifications and in reasonably close conformity with the dimensions, lines, and grades shown on the plans or as established by the Engineer.

404.02—Materials.

(a) **Concrete** shall conform to the requirements of Section 217. Aggregate used in concrete for bridge decks shall be nonpolishing.

(b) **Curing materials** shall conform to the requirements of Section 220.

(c) **Concrete admixtures** shall be used as specified in Section 217.

(d) **Corrugated metal bridge deck forms** shall be galvanized steel conforming to the requirements of ASTM A446, Grade C, D, or E, and shall be coating designation G165. Supports, closures, and other fabricated parts shall conform to the requirements of ASTM A446, Grade A, C, D, or E, and shall be coating designation G165.

(e) **Prestressed concrete deck panels** shall conform to the requirements of Section 405 except as specified herein.

(f) **Anchor bolts** shall conform to the requirements of Section 226.

(g) **Reinforcing steel** shall conform to the requirements of Section 223.

(h) **Waterstops** shall conform to the requirements of Section 212.

404.03—Procedures.

(a) **Forms:** On concrete beam bridges, the Contractor shall have the option of using corrugated metal bridge deck forms, prestressed deck panels, or wood forms to form that portion of bridge decks between beams unless otherwise specified on the plans. On steel beam bridges, the Contractor shall have the option of using corrugated metal bridge deck forms or wood forms to form that portion of bridge decks between beams or girders unless otherwise specified on the plans. However, corrugated metal forms and prestressed deck panels shall

not be used to form overhangs or portions of slabs where a longitudinal joint occurs between beams or girders.

Devices for supporting forms of any type shall not be welded to steel beams or girders unless specified on the plans.

Formwork shall be mortartight and of sufficient rigidity to prevent distortion attributable to the pressure of the concrete and other loads incidental to construction operations.

Forms for exposed surfaces shall have a form liner of an approved type and shall be mortartight. Forms for exposed surfaces below the bottom of slabs of bridges, including substructures, and on endwalls and wing walls of culverts down to an elevation of 300 millimeters below low water or 0.6 meter below the final ground line above water shall be faced with metal, plyboard, or other approved smooth-faced material constructed to provide a minimum of joints and prevent leakage. Concrete shall present a uniform and smooth surface without requiring touch-up or surface finishing upon removal of forms. Uneven joint protrusions of more than 3 millimeters shall be removed. Forms shall be filleted 19 millimeters at sharp corners and given a bevel or draft in the case of projections, such as girders and copings, to ensure easy removal.

Metal ties or anchorages within the form shall be constructed to permit their removal to a depth of at least 25 millimeters from the face without damage to the concrete. If ordinary wire ties are permitted, wires shall be cut back at least 6 millimeters from the face of the concrete with chisels or nippers upon removal of forms. Fittings for metal ties shall be of such design that cavities left upon their removal will be the smallest size possible. Cavities shall be filled with cement mortar, and the surface left sound, smooth, even, and uniform in color.

Forms shall be set and maintained true to line. When forms appear to be unsatisfactory, either before or during concrete placement, the Engineer may order the work stopped until defects have been corrected.

The shape, strength, rigidity, watertightness, and surface smoothness of reused forms shall be maintained at all times. Warped or bulged lumber shall be resized before being reused.

For narrow walls and columns where the bottom of the form is inaccessible, the lower form boards shall be left loose so that they may be removed for cleaning immediately before concrete placement.

Forms shall be treated with an approved oil or form-coating material or thoroughly wetted with water immediately before concrete

placement. For rail or other units with exposed faces, forms shall be treated with an approved oil or form-coating material to prevent adherence of concrete. Material that will adhere to or discolor concrete shall not be used.

Forms shall be maintained at a temperature that will not adversely affect curing of concrete.

Formed voids in concrete shall be of accurate dimensions and locations so that the thickness of surrounding concrete shall not be reduced from plan dimensions.

Methods of positioning void forms and placing surrounding concrete shall be subject to the approval of the Engineer prior to their use.

Bridge deck slabs shall be constructed in a manner so that the thickness of the finished slab shall be not less than the thickness shown on the plans or more than the thickness plus 13 millimeters.

1. **Corrugated metal bridge deck forms:** If the Contractor elects to use corrugated metal bridge deck forms, he shall submit details of the forms, including fabrication and erection details, to the Engineer for approval in accordance with the requirements of Section 105.02. Forms shall be designed and erected in accordance with the following:

    a. **Design:** The thickness of forms shall be at least 0.9 millimeter (20 gage). The unit working stress in the sheet metal and supporting units shall be not more than 0.725 of the specified minimum yield strength of the material furnished. In no case shall it be more than 250 megapascals. The maximum stress under a design load equal to the mass of the forms and plastic concrete plus a construction live load of 245 kilograms per square meter shall be not more than the unit working stress for the material furnished. Deflection of forms under the mass of the form, plastic concrete, and reinforcement shall be not more than 1/180 of the span of the forms or 13 millimeters, whichever is less. In no case shall the loading be less than 590 kilograms per square meter total.

        When the actual dead load attributable to the use of metal bridge deck forms is more than the design allowance for construction tolerances and methods shown on the plans, the Contractor shall strengthen the beams or girders to the extent necessary to maintain the design live load rating of the bridge and shall submit supporting information and calculations to the Engineer for review.

b. **Erection:** Forms shall be installed in accordance with reviewed fabrication and erection plans. Field cutting of forms, supports, and closures at expansion joints, diaphragms, and abutments in skewed areas or in any area where girders or beams are not parallel shall be performed with saws or shears. The outstanding leg of the support angle, channel, or other device shall be not more than 75 millimeters.

Form sheets shall not rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 25 millimeters at each end. Form supports shall be placed in direct contact with the stringer or floor beam flange by hangers or clips. Attachment of the forms to the form supports shall be made by permissible welds, screws, clips, or other approved means. Fasteners along the ends and edges of form sheets shall be spaced at intervals not to exceed 450 millimeters.

Welding and welds shall conform to the requirements of Section 407.04 except that 3-millimeter fillet welds will be permitted.

Permanently exposed form metal whose galvanized coating has been damaged shall be repaired in accordance with the requirements of Section 233.

Corrugated metal forms shall be positioned such that the specified cover for the reinforcing steel and minimum design slab thickness are maintained above crests of the corrugation.

Transverse construction joints shall be located at the bottom of a flute, and 6-millimeter weep holes shall be field drilled at not more than 300 millimeters on center along the line of the joint.

Closures at edges of forms parallel to beams or girders shall be made by crimping corrugations. Closures at skewed ends may be of the serrated or channel type.

The design span of the sheet shall be the clear span of the form plus 50 millimeters measured parallel to form flutes.

The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits.

Physical design properties shall be computed in accordance with the requirements of AISI's specifications for the design of cold-formed steel structural units.

c. **Inspection:** After concrete has been in place for at least 2 days, the Contractor shall sound at least 50 percent of the area of at least 25 percent of the individual form panels using a moderate blow administered with a carpenter's hammer. Individual form panels to be sounded will be selected randomly by the Engineer. Areas of questionable soundness shall be exposed by removing forms. The amount of sounding and form removal required will be adjusted as the work progresses according to conditions detected by the investigation. When procedures, materials, or equipment used during placement of concrete warrant additional inspection of the underside as determined by the Engineer, the Contractor shall remove at least one form panel at each location selected by the Engineer. If the initial inspection reveals inferior workmanship or unsatisfactory material as determined by the Engineer, additional panels shall be removed to ascertain the extent of the deficiency. The Contractor will not be required to replace metal forms at locations where sections of forms are removed for inspection purposes. However, adjacent metal forms and supports shall be repaired to the extent necessary to render their attachment secure.

The Contractor shall provide facilities required for the safe and convenient conduct of the Engineer's inspection.

2. **Prestressed deck panel forms:** If the Contractor elects to use prestressed deck panel forms, he shall redesign the deck slab in accordance with the requirements of AASHTO's *Standard Specifications for Highway Bridges* and the interim specifications as modified by the Department and shall submit the redesign of the deck slab, reinforcing steel schedule, design calculations, and working drawings to the Engineer for acceptance in accordance with the requirements of Section 105.02. Working drawings shall show the permissible construction live load. The Contractor's submittal shall be made at least 60 days prior to the time necessary for ordering materials for the work.

a. **Design:** The following conditions shall apply to the redesign of the cast-in-place deck slab:

1. The size, spacing, and area of transverse reinforcing steel in the top of deck slabs shall be not less than that shown on the plans. The transverse reinforcing steel shown on the plans in the bottom of the deck slab shall be eliminated.

2. Longitudinal reinforcing steel shown on the plans in the bottom of the deck slab shall be replaced by reinforcing bars having the identical size and spacing as the main transverse reinforcing bars in the deck slab. These bars shall be placed 13 millimeters clear above the top of the deck panels. Longitudinal reinforcing steel shown on the plans in the top of the deck slab may be eliminated, except over intermediate supports of continuous spans, provided adequate tie bars having no more than 600 millimeters spacing are used for securing top transverse steel. The distance from the face of the concrete to the center of the top layer of main reinforcing steel shall be 70 millimeters.

3. Shear connectors on steel beams or girders and vertical reinforcement in prestressed concrete beams may be adjusted to facilitate placing prestressed deck panels.

4. The design for deck panels shall provide for the same total slab thickness as shown on the plans.

5. When epoxy-coated steel is specified on the plans, reinforcing steel in the cast-in-place section of the slab shall be epoxy coated.

6. The depth of intermediate diaphragms for prestressed concrete beams shall be modified to provide clearance between the panel and diaphragm.

7. Lifting devices installed in panels for handling may be left in place provided they do not project closer than 50 millimeters to the finished deck surface.

8. Panels will not be allowed over the end supports for bridges skewed more than 15 degrees. End sections of slabs shall be cast the full depth shown on the plans.

9. Panels shall be roughened in the direction parallel to the strands.

The following conditions shall apply to the design of the deck panels:

1. The strand size shall be not more than 10 millimeters.

2. A cover of at least 40 millimeters shall be provided on the bottom of deck panels for prestressing strands and reinforcing steel.

3. The cracking load a unit can sustain shall be at least $1.2(D) + 1.5(L + I)$ without the concrete tensile stress exceeding $7.5\ \sqrt{f'_c}$ where D = dead load; $L + I$ = live load + impact; and f'_c = the 28-day design compressive strength of concrete in kilopascals.

4. At least 23 square millimeters per meter of reinforcing steel transverse to strands shall be provided in panels.

5. The length of the panel in the direction of strands shall be at least 1.6 meters.

6. Strands shall project at least 75 millimeters from the concrete at both ends of the panel.

7. Mild reinforcing steel in the deck panel, including tie bars and reinforcing bars used for panel-lifting purposes, shall be epoxy coated. Bar supports shall conform to the requirements of Section 406.03(d).

   Panel sides that are parallel to the strands may be cast to provide full-depth contact with the adjacent panel or cast with angular sides that, when installed with an adjacent panel, will form a V-shaped joint, which shall be mortartight at its base.

b. **Erection:** Precast bridge deck panels shall be erected in accordance with the accepted working drawings and with the strands transverse to the longitudinal direction of the beams. Panels shall be tightly butted together and shall be mortartight, with panel joints staggered on each side of the supporting beam. Panel joints that are not in full contact or that are not mortartight shall be sealed by epoxy mortar or other approved method at the Contractor's expense.

   Prior to placement of the deck surface concrete, foreign material detrimental to achieving a bond shall be removed by sandblasting, waterblasting, or other approved methods. The top surface of deck panels shall be thoroughly and continuously water soaked for at least 1 hour prior to placement of deck surface concrete. Puddles of standing water shall be removed prior to placement of deck surface

concrete. Panels shall be supported by one of the following methods to provide the same total slab thickness as shown on the plans:

1. nonshrink cement mortar bed 75 ± 6 millimeters in width with a thickness of at least 13 millimeters conforming to the requirements of Section 218 except that the compressive strength shall be 35 megapascals. When shims are used to construct the mortar bed, they shall be removed prior to placement of the deck concrete.

2. galvanized steel support angles having an outstanding leg width of at least 25 millimeters and a thickness of at least 3 millimeters or 10 gage. The unit working stress shall be not more than 72 1/2 percent of the specified minimum yield strength of the material furnished but in no case more than 250 megapascals. A strip of 3-millimeter asphalt felt the same width as the angle shall be placed between the support angle and the deck panel. When cast-in-place slab concrete is to be used to provide permanent support for panels, concrete shall be placed in continuous strips over the girders and consolidated to ensure concrete penetrates under the panels, prior to placing concrete on top of the panels. Slab overlay concrete shall penetrate under the panels to a width of 75 ± 6 millimeters and a thickness of at least 40 millimeters to provide the rigid support for the panels. If this method of support is used, bridge seat elevations shall be adjusted as necessary at the Contractor's expense.

Welding and welds shall conform to Section 407.04, except that 3-millimeter fillet welds will be permitted. Welding to beam or girder flanges will not be permitted.

Regardless of the method of support used, the Contractor shall ensure the stability of the deck panels until the slab overlay concrete has set.

(b) **Falsework and Centering:** The Contractor shall have a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia inspect the completed falsework assembly supporting a bridge superstructure prior to placing loads. The Professional Engineer shall provide a certification, based upon visual inspection of the completed falsework assembly, that the falsework assembly conforms to the approved working drawings.

However, such certification shall not require an exhaustive inspection or testing or make the Professional Engineer liable for any deficiencies in workmanship or materials by the Contractor or for such conditions that cannot be ascertained from a visual inspection.

Falsework shall be designed and constructed to provide the necessary rigidity and support the loads without appreciable settlement or deformation. The Contractor may be required to employ screw jacks or hardwood wedges to take up settlement in the formwork either before or during concrete placement. A design mass of 2,400 kilograms per cubic meter shall be assumed for fresh concrete.

Falsework that cannot be founded on a satisfactory footing shall be supported on piles that are spaced, driven, and removed in a manner approved by the Engineer.

Falsework shall be set in a manner so that after its removal the finished structure will have the finished grade specified or indicated on the plans. Correction for dead-load deflection of cast-in-place concrete beams and slab spans shall be provided for by applying an upward parabolic camber having an ordinate at midspan of 3 millimeters per 3 meters of span length.

Falsework-supporting elements shall remain in place until concrete in the element has attained at least the minimum 28-day design compressive strength.

Arch centering shall be constructed according to centering plans approved by the Engineer. Provision shall be made by means of suitable wedges, sand boxes, or other devices for gradual lowering of centers and rendering the arch self-supporting. When directed by the Engineer, centering shall be placed on approved jacks to take up and correct settlement that may occur after concrete placement has begun.

(c) **Placement and Consolidation:** Individual placements of more than 20 cubic meters of concrete shall be at the following rate:

Quantity (m^3)	**Min. Placement Rate**
20-60	25%/hr
Over 60	20 m^3/hr

If corrugated metal bridge deck forms are used in lieu of removable forms, concrete placement shall proceed in the direction opposite that of form placement.

Concrete shall be placed as soon as practicable after forms are prepared and excavation is completed. Water shall be removed from excavations before concrete is placed. Flowing water within the excavation shall be diverted outside concrete areas to a sump.

Before concrete is placed, sawdust, chips, dirt, and other debris and temporary struts and braces shall be removed from the space to be occupied by concrete. Removable forms shall be thoroughly wetted, oiled, or treated with an approved form-coating material. The depth and character of foundations and the placing of reinforcing steel shall have been approved by the Engineer.

Concrete shall be placed in forms immediately after mixing. Concrete that does not reach its final position in forms within the time specified in Section 217 shall not be used. The method of placement shall be such as to avoid the possibility of segregating ingredients and displacing reinforcement or void forms.

The use of long chutes for conveying concrete from the mixing plant to forms will be permitted only with the written permission of the Engineer. If chutes are allowed and the quality of concrete as it reaches the forms or the methods of placing it therein are not satisfactory, the Contractor shall, upon direction from the Engineer, discontinue the use of chutes and re-equip his operation for placing concrete in a satisfactory manner.

Where steep slopes are required, chutes shall be equipped with baffle boards. When pipes are used, they shall be kept full of concrete and have their lower ends buried in fresh concrete where necessary to prevent an excessive flow rate. Chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thorough flushing with water after each run. Water used for flushing shall be discharged clear of concrete in place and filtered prior to entry into state waters. Open troughs and chutes shall be metal or lined with metal and shall extend as nearly as possible to the point of deposit. When discharge must be intermittent, a hopper or other device for regulating discharge shall be provided.

Dropping concrete a distance of more than 1.5 meters or depositing a large quantity at any point and running or working it along forms will not be permitted. However, the 1.5-meter limitation will not apply to dropping concrete into forms for walls of box culverts, catch basins, drop inlets, or end walls unless there is evidence of segregation.

Concrete placement shall be regulated so that pressures caused by fresh concrete shall be not more than those used in the design of forms.

Embedded materials shown on the plans shall be installed during each stage of concrete operations and suitably supported and maintained in the correct position. Reinforcement shall be placed in accordance with the requirements of Section 406.03(d).

Care shall be taken to fill each part of a form by placing concrete as near its final position as possible, working coarse aggregates back from forms, and moving concrete under and around reinforcing bars without displacing them. After concrete has taken its initial set, care shall be taken to avoid jarring forms or placing strain on ends of projecting reinforcement.

Concrete shall be thoroughly consolidated during and immediately following placement. Consolidation shall be accomplished by mechanical vibration subject to the following provisions:

1. Vibration shall be internal to the concrete but not applied directly to reinforcement or formwork.

2. Vibrators shall be of a type and design approved by the Engineer.

3. The intensity of vibration shall visibly affect a mass of concrete over a radius of at least 450 millimeters.

4. The Contractor shall provide a sufficient number of vibrators to consolidate each batch immediately after it is placed in forms.

5. Vibrators shall be manipulated to work concrete thoroughly around reinforcement and embedded fixtures and into corners and angles of forms. Vibration shall be applied at the point of deposit and in the area of the freshly placed concrete. Vibrators shall not be pulled through concrete and shall be inserted and withdrawn slowly and maintained nearly vertical at all times. Vibration shall be of sufficient duration and intensity to consolidate concrete thoroughly but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.

6. Vibration shall not be applied directly or indirectly to sections or layers of concrete that have hardened to the degree that it ceases to be plastic under vibration. Vibration shall not be used to make concrete flow in forms, and vibrators shall not be used to transport concrete in forms.

7. Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations inaccessible to vibrators.

8. These specifications shall apply to filler concrete for steel grid floors except that vibration shall be applied to the steel.

9. These specifications shall apply to precast piling, concrete cribbing, and other precast units except that the manufacturer's methods of vibration may be used if approved by the Engineer.

When vibrating is not practicable, concrete shall be consolidated and its faces well spaded by continuous working with a suitable tool in a manner acceptable to the Engineer.

Concrete shall be placed in continuous horizontal layers not more than 300 millimeters in thickness. However, slabs shall be placed in a single layer. When it is necessary in an emergency to place less than a complete horizontal layer in one operation, the layer shall terminate in a vertical bulkhead. In any given layer, separate batches shall follow each other so closely that each one shall be placed and consolidated before the preceding one has taken initial set. Each layer of concrete shall be left rough to secure efficient bonding with the layer above. A succeeding layer placed before the underlying layer has become set shall be consolidated in a manner to prohibit the tendency to produce a construction joint between layers.

Layers placed at the end of one day's work or prior to temporarily discontinuing operations shall be cleaned of laitance and other objectional material as soon as the surface has become sufficiently firm to retain its form. The top surface of concrete adjacent to forms shall be smoothed with a trowel.

Horizontal layers located to produce a construction joint at a location wherein a feather edge might be produced in the succeeding layer shall be formed by inset formwork so that the succeeding layer will end in a body of concrete having a thickness of at least 150 millimeters.

The work on any section or layer shall not be stopped or temporarily discontinued within 450 millimeters below the top of any face unless the details of the work provide for a coping having a thickness of not more than 450 millimeters, in which case the construction joint may be made at the underside of the coping at the option of the Engineer.

Care shall be taken when placing concrete to avoid coating reinforcing steel, structural steel, forms, and other items that extend into areas to be involved in a subsequent placement. If coating of steel does occur,

no attempt shall be made to remove the mortar until after the concrete steel bond of the earlier placement has developed sufficiently to withstand a cleaning operation. Any coating of mortar on deformed bars that cannot be removed by hand brushing with a wire bristle brush or a light chipping action will not have to be removed.

The method and manner of placing concrete shall be regulated so as to place construction joints across regions of low shearing stress and in locations that will be hidden from view to the greatest extent possible.

Placing and consolidating concrete shall be conducted to form a compact, dense, impervious mass of uniform texture that will show smooth faces on exposed surfaces. Any section of concrete found to be defective shall be removed or repaired as directed by the Engineer.

If concrete operations are permitted to extend after sunset, the work area shall be brightly lighted so that all operations are plainly visible.

1. **Culverts:** Sidewalls of box culverts shall be carefully bonded to the base slab in accordance with (h) herein. Each wing shall be constructed as a monolith if possible. Construction joints, where unavoidable, shall be horizontal.

2. **Girders, slabs, and columns:** Concrete shall be placed by beginning at the center of the span and working toward the ends. Concrete in girders shall be placed uniformly for the full length of the girder and brought up evenly in horizontal layers.

   The concrete floor and girders for each span of concrete through girder spans and concrete in T-beams, slab spans, and deck girders shall be placed monolithically.

   If the finished top surface of a concrete unit being placed is not level, care in the method of vibration, the use of low slump concrete, or other means shall be taken to prevent downgrade movement of newly placed concrete. Special attention shall be given to sloping slabs.

   Concrete in columns shall be placed in one continuous operation. If cap forms are supported by falsework independent of columns or column forms or are otherwise designed so that no load is placed on columns, concrete may be placed in caps after concrete in columns has set for at least 12 hours. Otherwise, the requirements of Table IV-2 for columns carrying a load shall have been conformed to before concrete is placed in caps.

Concrete shall not be placed in the superstructure until column forms have been stripped sufficiently to determine the character of concrete in columns.

(d) **Pneumatic Placement:** Pneumatic concrete placement will be permitted only when authorized by the Engineer and the method is approved by the Engineer. When permitted, placement shall be in accordance with the requirements of Section 412.

(e) **Pumping:** Placing concrete by pumping will be permitted only when authorized by the Engineer and provided concrete is pumped through a conduit system that is not aluminum. Equipment shall be arranged such that no vibrations that might damage freshly placed concrete will occur. Equipment shall be thoroughly cleaned prior to use. The operation of the pump shall be such that a continuous stream of concrete without air pockets is delivered. If concrete remaining in the pipe line is to be used, it shall be ejected in such a manner that there will be no contamination of concrete or separation of ingredients.

(f) **Depositing Concrete Under Water:** Concrete shall not be deposited in water except with the approval of the Engineer.

Concrete placed in water shall be Class 20T. Concrete shall be carefully placed in a compact mass in its final position by means of a tremie or another approved method and shall not be disturbed after being deposited except as specifically provided herein. Still water shall be maintained at the point of placement.

A tremie shall consist of a tube having a diameter of at least 250 millimeters, constructed in sections having flanged couplings fitted with gaskets. The discharge end shall be closed at the start of work and entirely sealed at all times. The tremie tube shall be kept full to the bottom of the hopper. When a batch of concrete is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the placed concrete. Concrete seal shall be placed continuously from start to finish. Concrete shall be placed at a rate of at least 0.3 vertical meter per hour over the entire area of the seal course. The surface of concrete shall be maintained in a horizontal plane within a tolerance of 150 millimeters at all times during placement. The tremie shall be supported so that its discharge end is freely movable over the entire work area, or multiple tremies shall be used. Vibration shall be used only when deemed necessary by the Engineer. Supports for tremies shall permit rapid lowering of discharge ends when necessary to retard or stop the flow of concrete. The method of placing the seal shall be subject to the approval of the Engineer prior to concrete placement.

TABLE IV-2
Requirements for Removing Formwork and Constructing Superimposed Elements

Structural Element	Removing Formwork		Forming for Superimposed Elements		Placing Concrete in Superimposed Elements	
	Time (days)	Strength (% f'_c)[1]	Time (days)	Strength (% f'_c)	Time (days)	Strength (% f'_c)
T-beam (centering)	14	93	18	90	21	95
T-beam (side forms)	2	30	—	—	—	—
Deck slab	7	60	10	70	14	93
Wall carrying load[2]	7	60	10	70	14	93
Column carrying load[2]	7	60	10	70	14	93
Footing	2	30	3	40	5	50
Pier or abutment cap	7	60	10	70	14	93
Part not carrying load[2]	2	30				

[1]Minimum 28-day design compressive strength as specified in Table II-15.

[2]The load referred to is the immediate load that will be transmitted to the structural element as a result of removing falsework and bracing, not the load that will eventually be placed on the structural element.

Note: Curb and parapet face forms may be removed as soon as concrete has attained sufficient set to stand without slumping. When mineral admixtures are used in the concrete mixture, requirements for removing formwork and constructing superimposed elements shall be based on percentage of strength only.

Removal of water from cofferdams or other structures may proceed when the concrete seal has attained final set. Laitance or other unsatisfactory material shall be removed from the exposed surface by scraping and chipping with pneumatic or hand tools to an extent that will expose the aggregate for good bond with the footing to be cast upon it but not to an extent that will damage the concrete.

(g) **Construction Joints:** Construction joints that are not detailed on the plans shall be placed as directed or approved by the Engineer. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together. Joints shall be constructed so that featheredging does not occur.

For construction joints in deck slabs, a 50 by 40 millimeter shear key shall be provided between mats of reinforcing steel.

Construction joints against which earth fill is placed shall be protected by a heavy coat of asphalt conforming to the requirements of Section 213, applied for a distance of 75 millimeters on each side of the joint and continuous throughout its length.

In construction joints exposed to view, a waterstop conforming to the requirements of Section 213 shall be inserted. The waterstop shall be placed at least 75 millimeters from the face of concrete and shall extend at least 50 millimeters into each section of concrete.

Longitudinal or transverse construction joints may be used to facilitate placing concrete in continuous slab spans. Longitudinal joints shall be spaced so that each concrete placement will be at least 3 meters in width. Transverse joints shall be placed at the center lines of piers provided they are located infrequently, permitting simultaneous longitudinal screeding of as many spans as possible. Concrete shall be placed in one continuous operation between construction joints. The volume of concrete in any one placement shall be not less than the volume of concrete in one end span.

(h) **Bonding Construction Joints:** In joining fresh concrete to set concrete, the work already in place shall have its surface roughened thoroughly. Shavings, sawdust, and other loose and foreign material shall be removed. The surface shall be washed and scrubbed with wire brooms when necessary to remove substances that will interfere with bonding. Concrete of the preceding placement shall be thoroughly wetted prior to placement of the next unit of fresh concrete.

For construction joints in deck slabs, the vertical face shall be sandblasted to expose the coarse aggregate. When epoxy-coated reinforcing steel is used, the epoxy coating shall be protected during

sandblasting operations. Damaged areas of coated bars shall be repaired in accordance with the requirements of Section 223. Prior to placement of adjoining concrete, the vertical face shall be coated with epoxy, Type EP-4. After the concrete in the second placement has set, a V groove shall be formed along the top of the joint by sandblasting to a depth of at least 6 millimeters and shall be sealed with epoxy, Type EP-5, low viscosity, conforming to the requirements of Section 243.

To bond successive courses, suitable keys shall be formed at the top of the upper layer of each day's work and at other levels where work is interrupted. Keys shall be formed by inserting and subsequently removing beveled wood strips, which shall be saturated with water to induce swelling prior to insertion in fresh concrete. At the discretion of the Engineer, rough stone or steel dowels may be used in lieu of keys. Dowels shall extend an equal distance on each side of the construction joint. Prior to the inserting or driving of dowels into predrilled or preformed holes, holes shall be filled with hydraulic cement grout in the proportion of 1 part cement to 2 parts sand. The size and spacing of keys and dowels shall be determined by the Engineer.

(i) **Concrete Exposed to Tidal Water:** Concrete structures other than box culverts subject to the action of tidal water shall not have construction joints located within a zone 1.5 meters above to 1.5 meters below the elevation of the mean tide.

Concrete within 1.5 meters of the mean tide shall be cured in forms for 48 hours and allowed to dry for 5 days after forms are stripped. After drying, one coat of primer and four coats of asphalt, conforming to the requirements of Section 213, shall be applied during a period of 48 hours. Each coat shall be allowed to set before the succeeding one is applied. In lieu of primer and asphalt, the coating may consist of one coat of epoxy, Type EP-3B, followed by one coat of epoxy, Type EP-3T, and shall have a total thickness of at least 0.50 millimeter.

For precast concrete, protective coatings shall be applied in the same manner, but the seal coat shall be allowed to dry 4 days, or as long as necessary to harden, before handling.

Requirements for protective coating shall also apply to inside surfaces of box culverts that are subject to the ebb and flood of tidal water.

Concrete exposed to the action of ice, drift, or other forces producing shock and abrasion shall be protected by encasing that portion of the exposed surface with a special sheathing or protective armor.

Provision shall be made in the size of the original cofferdam for sufficient clearance to permit access to the concrete surface for the installation and effective anchorage of the sheathing.

(j) **Removing Formwork and Constructing Superimposed Elements:** In the determination of the time for removing formwork and constructing superimposed elements, consideration shall be given to the location and character of the structure, the weather, other conditions influencing setting of concrete, and material used in the mixture. Formwork shall include forms, braces, ties, guy wires, and other instruments of stabilization.

If removing formwork and forming for and placing concrete in superimposed elements are controlled by cylinder tests, the Contractor will be permitted to perform these operations when cylinder strengths reach the values specified in Table IV-2. Cylinders shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portions of concrete the cylinders represent. The Contractor shall furnish molds, labor, and material; make sufficient test specimens; and transport specimens to the testing facility. Single-use waxed paper, plastic, or light-gage metal molds, conforming to the requirements of AASHTO M205, may be used for making control cylinders. Control cylinders shall be molded under the observation of the Engineer. Tests for compressive strength will be performed by or under the observation of the Engineer.

The periods given in Table IV-2, exclusive of days when any portion of the concrete element surface is below 4 °C, shall be used if the control cylinder test is not used. The period of time shall be counted from the completion of concrete placement. These strengths and periods are intended only for indicated construction operations and shall not apply to the use of equipment or other live loads on the structure. Stockpiling materials or using unauthorized equipment on the structure will not be permitted until conformance to the requirements of (m) herein has been attained.

Methods of form removal that will overstress concrete shall not be used. Formwork and its supports shall not be removed without the approval of the Engineer. Supports shall be removed in a manner to permit the concrete to take, uniformly and gradually, the stresses caused by its own mass.

(k) **Curing Concrete:** The method of curing concrete shall be subject to the approval of the Engineer prior to mixing or placing concrete. When the atmospheric temperature is above 4 °C in the shade, concrete surfaces that are not protected by formwork and surfaces from which forms have been removed shall be cured using approved

materials applied before the sheen disappears from fresh concrete or immediately upon removal of formwork. Concrete shall be cured for 7 days, regardless of the strength obtained with control cylinders. During this 7-day curing period, a curing agent or medium shall be used.

PE film used for curing shall be white except that opaque or transparent PE film may be used between November 1 and April 1.

When liquid membrane seal is used for curing grooved horizontal surfaces, the application rate shall be 2.4 to 3.6 square meters per liter. The application rate for all other surfaces shall be 3.6 to 5.0 square meters per liter. Application shall be such that an even, white, continuous membrane is produced on the concrete surface.

If the atmospheric temperature falls below 4 °C in the shade, water curing shall be discontinued except when it is accomplished by flooding as specified herein. Curing shall be immediately resumed using insulated blankets or other approved methods that will retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass above 10 °C for at least 72 hours and above 0 °C for at least 48 additional hours immediately following concrete placement.

In the event the Contractor begins masonry concrete operations when the atmospheric temperature is below 4 °C in the shade, the method of cure and protection shall retain or supply adequate moisture to promote a normal cement hydration process and shall maintain the temperature at the outermost surfaces of the concrete mass above 10 °C for 72 hours and above 0 °C for not less than 48 additional hours immediately following the placement of the concrete.

When concrete is cured by flooding with water and the temperature is below 4 °C in the shade, a depth of at least 150 millimeters shall be maintained above the surface of the mass until concrete has attained the minimum required design strength as determined by a test cylinder cured in the same water.

(l) **Protecting Concrete:** Protection of concrete shall begin immediately following concrete placement in the formwork and shall continue without interruption throughout the curing period.

1. **Weather:** The Contractor shall schedule the placement of structural concrete so that the date and hour decided upon reflect consideration of weather conditions.

   Concrete shall be protected from rain.

Concrete shall not be placed against surfaces whose temperature is below 4 °C. Concrete shall be protected from freezing by approved coverings and, when necessary, heating the surrounding air in such a manner that the concrete will not dry.

Protection shall be provided to prevent rapid drying of concrete as a result of low humidity, high wind, high atmospheric temperatures, or combinations thereof. The Contractor shall perform evaporation rate testing for bridge deck placements. If the maximum evaporation rate, as determined from Figure 1 of ACI 308-2, exceeds 0.5 kg/m^2/hr for Class 30 concrete bridge deck placements or 0.3 kg/m^2/hr for latex modified concrete overlays and other hydraulic cement overlays with a water/cement ratio of 0.40 or less, the Contractor shall use protective measures to prevent shrinkage cracking. In the event plastic shrinkage cracking occurs, the Contractor shall make repairs by epoxy injection, concrete removal and replacement, or other methods approved by the Engineer at no additional cost to the Department.

2. **Construction activities:** Care shall be taken to avoid damage to concrete from vibration created by blasting and pile driving operations, movement of equipment in the vicinity of the structure, or disturbance of formwork or protruding reinforcement.

   Concrete shall be protected from the heat of an open fire. A watchperson shall be provided at the structure throughout any period in which open-flame heaters are operated in the vicinity of the concrete.

   After concrete in finished surfaces has begun to set, it shall not be walked on or otherwise disturbed for at least 24 hours except as provided for in (j) herein.

3. **Silicone treatment:** When unpainted weathering steel is used in a structure and no other concrete waterproofing surface finish is specified, a 5 percent solids, solvent-based, clear, water-repellent silicone treatment shall be applied in two coats to the surface of the concrete substructure on exposed concrete surfaces below and including the bridge seats, within the limits of vertical planes parallel to and 0.6 meter outside the extreme edges of exterior beams or girders. The first coat shall be applied at the rate of 1.5 to 1.7 square meters of surface area per liter of treatment solution and the second coat at the rate of 2.2 to 2.7 square meters per liter. If the treatment is applied by spraying, the nozzle shall not be held further than 0.6 meter from the surface being treated. The treatment shall be applied after cleaning of

exposed substructure concrete surfaces and before any structural steel is erected.

(m) **Opening to Traffic:** Structures shall not be opened to traffic, including construction traffic, or used for storing materials before concrete has attained the 28-day design compressive strength, as specified in Table II-17. Cylinders used for control purposes shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portions of concrete the cylinders represent. When traffic is to be permitted on a partially completed slab span, falsework shall remain in place in accordance with the strength requirements specified herein. Other structures supported on falsework from the ground shall not be opened to traffic until falsework is removed.

404.04—Bridge Deck Construction.

Prior to the beginning of deck placement, screeds shall be approved by the Engineer.

When the longitudinal screed is used, the overall length shall be such as to screed independently supported spans up to and including 24 meters. The length of the screed shall be not less than the full length of the span for spans less than 24 meters. When using the longitudinal screed on independently supported spans exceeding 24 meters in length with a screed length less than the full length of the span, the center half of the span shall be completed first. Bulkheads or other substantial supports for the screed shall be placed over abutments and piers and at the terminal point of placements within the span. The surface of a previously placed section shall not be used as a bearing area for the screed track until control cylinders have attained a strength of at least 50 percent of f'_c as specified in Table II-15.

When a transverse screed is used, the screed shall be of sufficient size to finish the full width of the deck between curbs or parapets unless a longitudinal joint in the deck is specified, in which case the portion on either side of the joint shall be placed and finished separately. Wheels of the screed shall bear on temporary rails supported on and directly above the main structural units or on form supports. With continuous spans, form supports shall be fully supported by the principal structural units supporting the deck. Rails shall be sufficiently rigid and strong to permit the screed to finish the surface of the deck within specified requirements. If rails are placed within the roadway area, they shall be elevated a sufficient distance above the deck to permit simultaneous finishing by hand of any portion not finished by the screed. Rail supports extending above the roadway surface shall be fabricated and installed in a manner to permit their removal to at least 50 millimeters below the top surface of the deck slab. Where rail supports are placed in that portion of the deck under curbs or parapets, supports shall be placed so that they will

be at least 50 millimeters from the face of the curb, parapet walls, or outside edge of the slab.

An approved positive means of permitting access to the surface of the bridge shall be provided for operations requiring access to the deck surface after passing of the screed. The means of access shall not make contact with the deck surface.

Concrete for the entire span or section to be placed shall remain workable until the entire operation of placing, screeding, patching, rescreeding, finishing, and testing is completed. Excess water or soupy material collected by a screeding operation shall be immediately removed from the deck.

If the concrete in the deck of a continuous beam or girder span group cannot be placed in one operation, the location of construction joints and sequence of placement shall be in accordance with the approved placement schedule. After the initial placement has been made in any one group of continuous spans, no further placement shall be made until previously placed concrete in the deck of that group has been in place for at least 3 days or until the cylinder strength is at least 0.4 f'_c.

The deck surface shall be tested with a 3-meter straightedge and rescreeded as many times as is necessary to ensure a smooth riding surface. The straightedge shall be held in successive positions at the edges and quarter points and on the center line, parallel thereto and in contact with the surface. Advancement along the deck shall be in successive stages of not more than the length of the straightedge. The surface shall also be checked transversely at the ends, quarter points, and center of the span. Areas showing high spots or depressions of more than 3 millimeters in 3 meters in the longitudinal direction and 6 millimeters in 3 meters in the transverse direction shall be struck off or filled with freshly mixed concrete. Attention shall given to ensure that the surface across joints conforms to the requirements for smoothness.

404.05—Expansion and Fixed Joints.

(a) **Open Joints:** Open joints shall be constructed by inserting and subsequently removing wood strips, metal plates, or other approved material. Insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete.

Edges of concrete adjacent to joints shall be finished to a radius of approximately 3 millimeters or as shown on the plans.

(b) **Filled Joints:** Materials for filled joints shall conform to the requirements of Section 212 and shall be installed in accordance with the requirements of Section 316.04(g). When not specified or shown

on the plans, filler shall be preformed asphalt joint filler, and sealer shall be the hot-poured type.

Edges of concrete adjacent to joints shall be finished to a radius of approximately 6 millimeters or as shown on the plans.

When expanded rubber, PVC, or PE filler is used, it shall be attached to the first-placed side of the joint with an approved adhesive and the concrete on the other side shall then be placed against the filler. Care shall be taken not to displace or compress the filler.

Other types of premolded fillers shall be similarly placed but need not be attached by an adhesive.

Joints shall be free from cracked and spalled areas, and their faces shall be free from foreign matter, curing compounds, oil, grease, and dirt. Faces shall be sandblasted, and the joint blown out with oil-free and water-free compressed air just prior to application of primer or sealer.

(c) **Steel Joints:** Plates, angles, or other structural shapes shall be fabricated to conform to the section of the concrete floor. Fabrication and painting shall conform to the requirements of Sections 407 and 411. Care shall be taken to ensure that the surface in the finished plane is true and free from warping. Positive methods shall be employed in placing joints to keep them in the correct position during concrete placement so that the opening at expansion joints shall be that designated on the plans at normal temperature. Care shall be taken to avoid impairing the clearance in any manner. Normal temperature shall be considered as 15 °C, and correction to this temperature shall be computed using a coefficient of expansion of 0.0000118 per meter per degree Celsius.

(d) **Waterstops:** Metal waterstops shall be spliced, welded, or soldered to form continuous, watertight joints.

Nonmetal waterstops shall be furnished full length for each straight portion of the joint, without field splices. Manufacturer's shop splices shall be fully vulcanized.

Field splices for neoprene waterstops shall be vulcanized; mechanical, using stainless steel parts; or made with a splicing union of the same stock as the waterstop. Finished splices shall have a full-size tensile strength of 17.5 newtons per millimeter of width.

Field splices for PVC waterstops shall be made by heat sealing adjacent surfaces in accordance with the requirements of the manufacturer's recommendations. A thermostatically controlled

electric source of heat shall be used to make splices. The heat shall be sufficient to melt but not char the material.

When being installed, waterstops shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distorting the web or flange.

If waterstops are out of position or shape after concrete is placed, the surrounding concrete shall be removed, the waterstop reset, and the concrete replaced, all at the Contractor's expense.

404.06—Bridge Seat Bearing Areas.

Bridge seat bearing areas shall be finished plane and level and shall not deviate more than 1.5 millimeters from plane or more than 2.6 millimeters per meter from level or from the slope specified on the plans. These limits of tolerance do not necessarily represent fully acceptable construction but are the limits at which construction may become unacceptable. In general, workmanship on bearing areas shall be at a level of quality that will be well within the tolerance limits. Bearing area roughness for elastomeric pads shall conform to the requirements of Section 408.03(g).

Bearing areas shall be cleaned and tested for planeness and levelness prior to placement of bearing pads or preparation for bearing plates. Preparation of bearing areas for placing bearing plates and setting anchor bolts shall be in accordance with the requirements of Section 408.03(g) and (h).

404.07—Finishing Concrete Surfaces.

Following replacement or satisfactory repair of defective concrete, surface defects produced by form ties, honeycombing, spalls, or broken corners or edges shall be cleaned, wetted, filled with a mortar conforming to the requirements of Section 218, and troweled or struck off flush with the surrounding surface. If the surface cannot be repaired immediately following removal of forms or before the concrete surface has become dry, the surface shall be kept wet for 1 to 3 hours, as directed by the Engineer, prior to application of mortar. Repaired areas shall be cured in accordance with the requirements of Section 404.03(k).

The formed face of the following concrete items shall be given a Class 1 finish: (1) bridge items: wheel guards, the inside and outside faces of parapet walls and concrete posts and rails; and (2) other items: curbs, raised medians, steps, and retaining walls that lie within 9 meters of the edge of the pavement.

(a) **Class 1, Ordinary Surface Finish:** Following removal of forms, fins and irregular projections shall be removed from exposed surfaces and surfaces to be waterproofed.

Immediately following removal of forms, surfaces that contain cavities having a diameter or depth greater than 6 millimeters shall be cleaned, wetted, filled with a mortar conforming to the requirements of Section 218, and rubbed with burlap. If the surface cannot be finished immediately following removal of forms or before the concrete surface has become dry, the surface shall be kept wet for 1 to 3 hours, as directed by the Engineer, prior to application of mortar. The finished surface shall be cured in accordance with the requirements of Section 404.03(k).

Construction and expansion joints in the completed work shall be left free from mortar and concrete. Joint filler shall be left exposed for its full length.

(b) **Class 2, Rubbed Finish:** Rubbing of concrete shall be started immediately after forms are removed. Immediately before this work, concrete shall be kept wet for at least 3 hours. Sufficient time shall elapse before wetting to allow mortar used in the pointing of rod holes and defects to set thoroughly. Surfaces to be finished shall be rubbed with a medium-coarse carborundum stone with a small amount of mortar on its face. Mortar shall be composed of cement and fine aggregate mixed in the proportions used in the concrete being finished. Rubbing shall be continued until form marks, projections, and irregularities are removed; voids are filled; and a uniform surface is obtained. Paste shall be left in place.

The final finish shall be obtained by rubbing with a fine carborundum stone and water. Rubbing shall be continued until the entire surface has a smooth texture and uniform color.

After final rubbing is completed and the surface has dried, the surface shall be rubbed with burlap and left free from unsound patches, paste, powder, and objectionable marks.

(c) **Class 3, Tooled Finish:** This finish shall be produced by the use of a brush hammer, pick, crandall, or other approved tool. Tooling shall not be done until concrete has set for at least 14 days and as much longer as may be necessary to prevent aggregate particles from being picked out of the surface. The finished surface shall show a grouping of broken aggregate particles in a matrix of mortar, with each aggregate particle in slight relief.

(d) **Class 4, Sandblasted Finish:** The thoroughly cured concrete surface shall be sandblasted to produce an even, fine-grained surface in which mortar has been cut away, leaving the aggregate exposed.

(e) **Class 5, Wire Brushed or Scrubbed Finish:** This finish shall be produced by scrubbing the surface of the plastic concrete with stiff wire or fiber brushes, using a solution of muriatic acid in the proportion of 1 part acid to 4 parts water. As soon as forms are removed and while concrete is comparatively plastic, the surface shall be scrubbed thoroughly and evenly until the cement film or surface is removed and aggregate particles are exposed, leaving an even, pebbled texture presenting an appearance grading from that of fine granite to coarse conglomerate, depending on the size and grading of aggregate used. As soon as scrubbing has progressed sufficiently to produce the texture desired, the entire surface shall be thoroughly washed with water to which sufficient ammonia has been added to remove all traces of acid.

(f) **Class 6, Bridge Deck Finish:** Methods, procedures, and equipment shall conform to the requirements of Section 404.03 and shall not result in segregating ingredients of the concrete and shall ensure a smooth riding surface.

Hydraulic cement concrete bridge deck surfaces shall be textured with uniformly pronounced grooves sawed transversely to the center line. After final screeding of the deck, a multi-ply damp fabric shall be dragged over the deck surface to provide a gritty texture. The deck concrete shall not be grooved until it has reached an age of 14 days or 85 percent of the 28-day design compressive strength. Grooves shall be sawed approximately 5 ± 1.5 millimeters in depth and 3 millimeters in width (nominal) on 19-millimeter (nominal) centers. Grooves shall terminate 300 ± 25 millimeters from the parapet wall or curb line. Grooves shall not be sawed closer than 50 or further than 75 millimeters from the edge of any joint. When the width of the cutting head on the grooving machine is such that grooves cannot be practically sawed to within the required tolerance for a skewed transverse joint, grooving shall not be closer than 50 millimeters or more than 1 meter from the edge of the joint. On curved decks, each pass of the grooving machine shall begin on the side of the deck having the smaller radius, and the nominal spacing of grooves at the starting point shall be 19 millimeters on center.

Bridge decks should be grooved prior to opening to traffic. However, the Contractor will be permitted to delay grooving up to 6 months. The Contractor shall provide the Engineer with a plan for traffic control when working under traffic.

If a single pass of the grooving machine cannot be made across the width of the bridge, the mating ends of subsequent passes shall not overlap previous grooves or leave more than 25 millimeters of surface ungrooved.

After concrete has set and prior to placement of other slabs, the deck surface will be tested by the Engineer. Areas showing high spots or depressions of more than the specified tolerances will be marked as failing to conform to smoothness requirements. Levels may also be run over the surface to determine if there is any deviation from grade and cross section. Decks that do not conform to thickness and surface smoothness requirements will not be accepted until deficiencies have been corrected as directed by the Engineer. Sections that cannot be satisfactorily corrected shall be removed and replaced at the Contractor's expense.

Bridge decks that are to receive an asphalt concrete overlay of 25 millimeters or more in thickness shall be finished to a tolerance of 6 millimeters in 3 meters in both longitudinal and transverse directions except at expansion joints, where the finished tolerance shall be 3 millimeters in 3 meters.

(g) **Class 7, Sidewalk Finish:** After concrete has been placed, it shall be consolidated and the surface struck off with a strike board and floated with wooden or cork floats. Light metal marking rollers may be used if desired after the initial set. An edging tool shall be used on edges and at joints. The surface shall not vary more than 6 millimeters under a 3-meter straightedge and shall have a granular texture that will not be slick when wet.

404.08—Measurement and Payment.

Concrete will be measured in cubic meters within the neat lines of the structure as shown on the plans and will be paid for at the contract unit price per cubic meter, complete-in-place. Deductions will not be made for chamfers 25 millimeters or less in width or for grooves less than 25 millimeters in depth. The volume of reinforcing steel or any other material or internal voids within the concrete will be deducted.

The volume of bridge deck slab concrete allowed for payment will be computed using the actual thickness of the slab, not to exceed the plan thickness plus 13 millimeters, for the area between faces of sidewalks or curb lines. The area beneath sidewalks, curbs, or parapets will be based on plan thickness. If prestressed concrete deck panel forms are used, the volume they displace will be computed using plan dimensions and the volume of the cast-in-place portion will be measured as provided herein.

Unless designated as pay items, this price shall include waterstops, waterproofing, damp-proofing, anchor bolts, drain assemblies, silicone treatment, protective coating for concrete exposed to tidal waters, and trial batches.

If corrugated metal bridge deck forms are used in lieu of removable forms, the price for concrete shall include furnishing and placing metal forms, additional concrete required to fill corrugations, work necessary to facilitate inspection of the underside of the deck, repairing deficiencies, and strengthening beams or girders to maintain the design live-load rating of the bridge. If prestressed deck panel forms are used in lieu of removable forms, the price shall include casting, furnishing, and placing forms.

Bridge-deck grooving will be measured in square meters of deck surface area from the faces of parapets, sidewalks, or curb lines and will be paid for at the contract unit price per square meter. No deduction will be made for drainage items and joints.

Payment will be made under:

Pay Item	Pay Unit
Concrete (Class) item	Cubic meter
Bridge-deck grooving	Square meter

SECTION 405—PRESTRESSED CONCRETE

405.01—Description.

These specifications cover the use of prestressed or post-tensioned hydraulic cement concrete when called for on the plans.

405.02—Materials.

(a) **Concrete** shall conform to the requirements of Section 217, Class 35, with the following exceptions:

1. Concrete for piles, beams, and slabs shall contain 17.3 liters per cubic meter of calcium nitrite conforming to Section 215, unless granulated iron blast-furnace slag (min. 40% by mass) or silica fume (min. 7% by mass) conforming to Section 215 is used.

2. Concrete for structures over tidal water, beams and slabs within 4.5 meters of mean high tide, and all exposed piles shall contain either 26.7 liters per cubic meter of calcium nitrite conforming

to Section 215 or 9.9 liters per cubic meter of calcium nitrite with granulated iron blast-furnace slag (min. 40% by mass) or silica fume (min. 7% by mass) conforming to Section 215.

(b) **Concrete admixtures** shall conform to the requirements of Section 215.

(c) **Epoxy-resin compounds** shall conform to the requirements of Section 243.

(d) **Steel reinforcement and prestressed tendons** shall conform to the requirements of Section 223 and Section 406, respectively.

(e) **Epoxy-coated reinforcing steel** shall conform to the requirements of Section 223.

(f) **Structural steel** shall conform to the requirements of Section 226.

(g) **Bedding materials and bearing pads** shall conform to the requirements of Sections 237 and 408.

(h) **Waterproofing** shall conform to the requirements of Section 416.

(i) **Hydraulic cement mortar and grout** shall conform to the requirements of Section 218.

405.03—Plant Review.

Plants that manufacture precast, prestressed concrete elements shall have PCI certification for applicable product groups and categories except that plants supplying only deck panels and piles will not be required to be certified. PCI inspection reports shall be on file at the plant and available for review by the Department. Plants that have not previously produced products for the Department will be inspected by the Engineer prior to commencement of production. The Contractor shall provide suitable office space for use by the Engineer's representatives.

The request for plant inspection shall be made by the Contractor to the Engineer at least 3 weeks prior to the start of production. As a part of the plant inspection, a meeting will be held with the producer, Contractor, Engineer, and Inspectors to discuss plant facilities, materials, production methods, drawings, and production schedules.

In order to qualify new installations for the manufacture of prestressed units other than piles, the Department may require the Contractor to test a unit that is representative of each design type and size of unit to be manufactured. The acceptance test shall be as follows: Not more than one line of units shall

be cast prior to the satisfactory completion of the acceptance test. A representative unit shall be tested in accordance with the requirements of VTM-20 in the presence of the Engineer prior to plant approval.

The unit to be tested will be selected at random by the Engineer. Jigs and load-testing equipment shall be approved by the Engineer before use. The cost of the units selected for testing and the cost of the test shall be borne by the Contractor.

405.04—Concrete Controls.

The Contractor shall provide concrete testing equipment and a Certified Concrete Technician to perform concrete acceptance tests.

During each concrete operation, at least two clusters of test cylinders shall be prepared. Each cluster shall consist of four 150 by 300 millimeter or six 100 by 200 millimeter cylinders, which shall be placed at quarter points of the casting bed and cured under the same conditions as the prestressed concrete units.

Concrete batches from which cylinders are made shall be tested for slump in accordance with the requirements of AASHTO T119 and for air content in accordance with the requirements of AASHTO T152.

The compressive strength of the concrete at strand release, as specified in Section 405.05(b), will be based on the results obtained from tests on one cylinder from each cluster.

Average values of test cylinders from each cluster will be used to determine acceptability of compressive strengths.

The Contractor shall maintain records of tensioning operations, curing temperatures, and concrete testing in a form suitable for permanent filing. Records shall be available to the Department and maintained for 10 years.

405.05—Procedures.

(a) **Forms:** Forms and centering shall be made and maintained true to the shapes and dimensions shown on the approved drawings.

Forms shall be of metal or other material that will give comparable results. Forms shall be designed and aligned so that they will not restrict the longitudinal movement of the casting when the prestressing force is transferred.

Drilled holes in bulkheads and templates shall be sized to provide for unrestricted movement of strands during tensioning.

Bulkheads may be constructed of adequately reinforced plywood. Wooden bulkheads that are warped or damaged shall not be used.

Form ties shall not be used without the approval of the Engineer.

Joints between panel forms shall be well aligned and tight, and adequate precautions shall be taken to prevent leakage of mortar. Corners or intersections of surfaces exposed in the completed structure shall be chamfered or rounded, with a width or radius of 19 millimeters. For square piles, corners shall be chamfered from 19 to 38 millimeters or rounded to a 50-millimeter radius. A smaller chamfer not less than 19 millimeters may be used if approved by the Engineer.

Void forms shall be anchored during concrete placement and secured by means other than being tied to strands.

Precast prestressed concrete box beams and flat slabs shall have one drain provided in each end of each void. The drain shall be located so that the void will drain after the unit has been installed in the structure. The device for forming the drain shall be of such material and design that the drain will not rust, stain, or otherwise disfigure the concrete and shall allow free drainage from the void.

(b) **Placing Strands and Wires and Applying and Transferring Pretension:** The Contractor may be required to submit for approval the detailed computations of gage pressures and elongations proposed.

Wires shall conform to the requirements herein for strands.

When indicated on the plans and approved by the Engineer, the Contractor may substitute low-relaxation strands for stress-relieved strands or stress-relieved strands for low-relaxation strands in prestressed units, provided the following conditions are met:

1. The unit is redesigned by the Contractor in accordance with the design specifications shown on the plans, including modifications by the Department.

2. There is no mixing of low-relaxation strands and stress-relieved strands within a superstructure, substructure, or piles.

3. In prestressed piles, the net compressive stress in the concrete, after all losses, shall equal the stress for such piles as shown on the plans, and the number and cross sectional area of the strands in each pile shall equal or exceed that as shown on the plans in addition to the requirements specified in 1. and 2. herein.

When the Contractor elects to substitute low-relaxation strands for stress-relieved strands or stress-relieved strands for low-relaxation strands, the design, camber calculations, and working drawings shall be submitted in accordance with the requirements of Section 105.02.

Strands with kinks, bends, nicks, broken wires, scales, rust, or other defects shall not be used. The failure of one wire in a seven-wire pretensioned strand or one wire in a parallel-wire post-tensioned cable may be accepted provided the wire is not more than 2 percent of the total number of wires. Slight rusting will not be cause for rejection provided it is not sufficient to cause visible pits. Strands shall be satisfactorily cleaned before concrete operations begin.

Strands shall be placed in proper position and first tensioned individually by a force of at least 5 but not more than 25 percent of the final stressing force. This force shall not vary by more than 5 percent in any group of strands.

The final stressing of strands shall be performed by applying tension to each strand individually or to all strands as a group. The strand or strand group shall be tensioned to the total pretensioning force as indicated on the plans, with a maximum applied stress of 70 percent of the ultimate strength for stress-relieved strands and 75 percent of the ultimate strength for low-relaxation strands.

During stressing, allowance shall be made for the amount of strand anchorage slipping. The proper allowance shall be determined during trial plant operations and satisfactorily checked periodically during actual stressing operations. Strand anchorage devices of each type and source shall be checked as specified herein.

During stressing, allowance shall be made in the amount of strand elongation for the loss or gain in tension resulting from the change in temperature in the strand between the time of stressing and time of the initial set of concrete. The magnitude and method of application of this allowance shall be in accordance with the requirements of the *PCI Manual for Quality Control* (MNL-116).

A manufacturer's corresponding recommended value for the average modulus of elasticity will be used for each order of strand supplied. Consideration shall be given to the stress-strain data of tests performed on the samples.

Strands shall not be spliced within units.

Pretensioned strands shall be secured by suitable anchorage devices capable of developing at least 90 percent of the ultimate strength of the strand.

When deflected strands are tensioned in their deflected position, they shall be supported by lubricated rollers with solid bushings or other low-friction rollers at hold-up and hold-down points. Provisions shall be made for a cover of at least 3 millimeters of concrete or epoxy mortar on metal parts of the hold-down devices remaining in beams.

The final position of strands and reinforcing steel shall be accurately maintained as shown on the plans.

The tensioning system shall be equipped with a pressure gage indicating the jack pressure to an accuracy of within 2 percent of the pressure corresponding to the full prestress tension in the strand. Gages shall be recalibrated at least once every 6 months and any time the gaging system appears to be giving erratic or erroneous results or if the gage indication and elongation measurements indicate materially different stresses. Gages, jacks, and pumps shall be calibrated as a system in the same manner in which they are used in tensioning operations. Calibration shall be performed by an approved testing laboratory or approved calibration service, and a certified calibration curve shall accompany each tensioning system. Load, as measured by gage pressure, shall not vary from that measured by elongation by more than 5 percent. Elongation measurements shall be taken as checks on the final pressure gage reading. Elongation shall be measured to a precision of 6 millimeters. During stressing, elongation and pressure readings shall be recorded by the Contractor.

Tension in the strands shall not be transferred to the concrete in the unit until the concrete has attained a compressive strength of at least 24.5 megapascals for piles and 27.5 megapascals for other units. When multiple-strand detensioning is used, strands shall be transferred gradually, simultaneously, and equally to the concrete.

When the single-strand release method is used, strands shall be released by heating near the end of each unit in accordance with the Contractor's sequence and schedule. Individual jack release or burning may be used for strands at the dead or live end of the bed. Strands to be released in each step of the sequence shall be burned apart between beams before the next step is begun. No more than two strands shall be included in each step of the pattern.

Strands shall not be burned quickly but shall be heated with a low-oxygen flame played along the strand at least 125 millimeters until the metal gradually loses its strength and failure of the first wire in each strand occurs after the torch has been applied for at least 5 seconds.

The schedule for single-strand detensioning of units having deflected strands shall incorporate the following:

1. Straight strands located in the upper flange of the unit shall be released first.

2. Tension in the deflected strands at the ends of bed and uplift points shall be released in sequence.

3. Hold-down devices for deflected strands shall be disengaged, and hold-down bolts shall be removed from units.

4. The remaining straight strands of the pattern to be detensioned individually shall be released in sequence.

If it is desired to release hold-down devices prior to releasing tension in deflected strands, this may be permitted (1) if the mass of the prestressed unit is more than twice the total of the forces required to hold strands in the low position, or (2) if weights or other approved vertical restraints are applied directly over the hold-down points to counteract uplifting forces, at least until the release of deflected strands has proceeded to such a point that the residual uplifting forces are less than 1/2 the mass of the unit.

Failure to follow these procedures may result in rejection of units.

(c) **Placing Concrete:** The procedure and equipment for handling, placing, and consolidating shall be such that a uniformly dense and high-grade concrete is obtained in all parts of the unit under all working and weather conditions.

When placing concrete in continuous horizontal layers in forms for precast I-beams, succeeding layers shall follow the preceding layer before any initial set takes place. Concrete in bottom slabs of precast prestressed box beams shall be placed before void forms are positioned. Concrete may be placed in forms for piling and precast slab units in one continuous horizontal layer.

The use of external vibration will be at the option of the Contractor. Improper placing and vibrating may be cause for rejection.

(d) **Removing Forms:** Forms for units being moist cured may be removed when concrete reaches a strength of 10.3 megapascals.

After forms are removed, units will be inspected to determine acceptability. Patching of any surface irregularities, especially those resulting from honeycombing, shall be performed only after inspection.

(e) **Finishing:** Holes and voids in the surface of concrete resulting from bolts, ties, or large air pockets shall be wetted and filled with mortar having the same proportion of fine aggregate and cement as in the concrete, after which exposed mortar surfaces shall be finished smooth and even with a wood float.

If finishing work is necessary, the exterior face of exterior beams shall be finished free from blemishes and then rubbed with burlap. Holes or voids having a depth or diameter greater than 13 millimeters on the interior face of exterior beams, on both faces of interior beams, or on piles shall be filled and finished.

Surfaces to be repaired and finished shall be kept wet for at least 1 hour before hydraulic cement mortar is applied. Immediately following patching work, repaired areas shall be cured for at least 48 hours. The wet cure may be accomplished by the use of steam, wet burlap, or continuous spray wetting, or liquid membrane-forming compound may be used on noncomposite surfaces. Epoxy may be used and shall be applied and cured in accordance with the requirements of the manufacturer's recommendations.

Piles specified on the plans as being subject to tidal waters shall be finished in accordance with the requirements of Section 404.03(i).

Tops of prestressed deck panels shall receive a finish having pronounced grooves. Grooves shall be approximately 3 millimeters in depth and 3 millimeters in width, with a spacing of not more than 25 millimeters. Other groove patterns proposed by the Contractor that promote bonding may be used upon approval by the Engineer.

Units that are to be made composite with subsequently placed concrete shall be finished by striking off the top of forms. As soon as the condition of the concrete permits and before it has fully hardened, dirt, laitance, and loose aggregate shall be removed from the surface by means of a wire brush, which shall leave the coarse aggregate slightly exposed or otherwise roughened. If concrete has been allowed to harden so that it is impossible to remove laitance and roughen the top surface of units by brushing, the surface shall be cleaned and prepared for bonding by chipping.

Except in piles, ends of strands shall be allowed to cool to normal temperature after cutting and then shall be covered with at least 3 millimeters of epoxy mortar or other material approved by the Engineer. After mortar is allowed to cure, the entire end of the unit shall be covered with epoxy, Type EP-3T.

Care shall be taken in cutting or burning ends of strands to prevent damaging the concrete surface.

(f) **Protecting and Curing:** Prestressed concrete shall be cured by being kept moist at temperatures that will promote hydration. Proper curing by any method requires that moisture is retained for complete hydration and the formation of surface cracks attributable to rapid loss of water is prevented while concrete is plastic. Prior to concrete placement, procedures for retaining moisture shall be approved by the Engineer. Moist curing shall continue until such time as the compressive strength of concrete reaches the strength for detensioning. Moist curing shall commence as soon as possible following the completion of surface finishing.

The Contractor shall have the option of using steam curing in lieu of moist curing in accordance with the following:

1. The design concrete mixture shall be proven adaptable for steam curing, using the same cure as proposed for the routine manufacture of prestressed concrete units.

2. The Contractor shall be responsible for the quality of concrete placed in any weather or atmospheric condition. At the time of placement, concrete shall have a temperature of 4 °C to 32 °C when concrete is moist cured. If accelerated curing is used, the temperature of the concrete at placement shall be 4 °C to 38 °C. Mixing limitations shall be in accordance with the requirements of Section 217.09.

3. An initial set of a nominal 3.45 megapascals, determined by the penetration resistance test, shall be obtained prior to the introduction of steam. The penetration resistance test shall be performed in accordance with the requirements of ASTM C403. Forms shall be covered after surface finishing of the concrete, including the delay period before introduction of steam.

4. The temperature rise in the curing enclosure shall be uniform, with a rate rise of not more than 27 °C per hour. Concrete shall be cured at a steam temperature of not more than 82 °C, with the steam temperature uniform throughout the curing enclosure, and with a variation of not more than 12 °C. Approved recording thermometers shall be placed so that temperatures can be recorded at a minimum of two uniformly spaced locations in each curing enclosure.

5. Steam curing shall be maintained until such time as the compressive strength of the concrete attains that specified on the plans for detensioning.

6. Steam curing shall be performed under a suitable enclosure to retain the live steam at 95 percent relative humidity and minimize heat losses. Enclosures shall allow free circulation of steam. Steam jets shall be positioned so that they will not discharge directly on concrete, forms, or test cylinders.

7. Concrete test cylinders shall be subject to the same curing conditions as the units.

8. Immediately after steam curing is terminated, forms shall be loosened and the stress load on the stressing strands shall be released while the concrete is still hot.

(g) **Waterproofing:** Units so designated on the plans shall be waterproofed in accordance with the requirements of Section 416.

(h) **Handling, Storing, and Erecting:** Units shall be adequately separated in storage immediately following removal from beds to facilitate repair of surface blemishes and make inspection of finished surfaces possible.

Care shall be taken in handling and storing units to avoid damage to concrete. Concrete shall have attained the minimum 28-day design compressive strength before structural units are shipped to the project site.

Piles shall not be driven until at least 7 days after the date concrete is cast and has attained the minimum design compressive strength.

Lifting and support points for units other than piles and deck panels shall be as shown on the plans or not less than 150 millimeters or more than 2/3 of the depth of the unit from the end of the unit. Piles and deck panels shall be supported and lifted at points shown on the plans. The Contractor shall be responsible for the design and safety of the lifting device used.

Requests to use lifting or support points other than those indicated must be accompanied by computations showing that stresses are within the allowable range, using 50 percent of the dead load as an impact factor.

Units that have been damaged in handling shall be satisfactorily repaired.

Shear keys required between adjacent units, recesses at ends of transverse ties, holes for anchor bars, and other recesses shown on the plans shall be filled with mortar conforming to the requirements

of Section 218. Mortar shall be applied in one continuous operation for each span.

Where waterproofing material is to be applied to tops of units in the field, longitudinal joints shall be sufficiently smoothed to prevent damage to the material.

Struts and diaphragms between spread units may be cast separately or monolithically with the deck slab. If the Contractor casts struts and diaphragms separately from the slab, the age or compressive strength of the concrete in the struts or diaphragms shall conform to the requirements for I-beams in Section 404.03(j) before deck slab concrete is placed. If the Contractor casts struts and diaphragms monolithically with the slab, each prestressed concrete beam shall be placed and restrained in such a manner that the beam will not be canted during construction of the struts, diaphragms, and slab. The Contractor's method for maintaining acceptable vertical alignment of beams shall be subject to the approval of the Engineer.

Bearing surfaces of units shall be parallel to the bottom surface of the unit or as specified on the plans. Attached bearing assemblies shall be fabricated so that their bottom bearing surfaces shall lie in truly horizontal planes in their erected position. Metal bearing plates or bottoms of precast beams that are to bear on elastomeric pads shall be coated with epoxy, Type EP-2, EP-4, or EP-5, and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit.

Ends of beams, at ends of spans, and diaphragms shall be vertical.

405.06—Tolerances.

The limits of tolerance do not necessarily represent fully acceptable construction; they are the limits at which construction may become unacceptable. In general, workmanship shall be at a level of quality that will be well within the tolerance limits.

(a) **Precast Prestressed Concrete I-Beams and T-Beams:**

Characteristics	Value
Depth (overall)	±6 mm
Width (flanges and fillets)	±6 mm
Width (web)	±6 mm
Length of beam	±3 mm/3 m or 13 mm, whichever is greater

Exposed beam ends (deviation from square or designated skew)	Horizontal ±6 mm, vertical ±10 mm/m of beam height
Side inserts (spacing between centers of inserts to ends of beams)	±13 mm
Bearing plate (spacing from centers of bearing plates to ends of beams)	±13 mm
Stirrup bars (projection above top of beam)	±19 mm
Stirrup bars (longitudinal spacing)	± 25 mm
Horizontal alignment (deviation from straight line parallel to center line of beam)	Max. 3 mm/3 m
Camber differential between adjacent beams of same type and strand pattern	3 mm/3 m or max. 13 mm (at time of erection)
Camber differential from computed camber	±50% (at time of erection)
Center of gravity of strand group	±6 mm
Center of gravity of depressed strand group at end of beam	±6 mm
Position of hold-down points for depressed strands	±150 mm
Position of handling devices	±150 mm

(b) **Precast Prestressed Concrete Box Beams and Flat Slabs:**

Characteristics	**Value**
Depth (top slab)	+13 mm to -6 mm
Depth (bottom slab)	0 to +13 mm
Depth (overall)	±6 mm
Width of web or thickness of sidewalls	±10 mm
Width (overall)	+3 mm to ±6 mm
Length	±3 mm/3 m or 13 mm, whichever is greater
Void position (longitudinal)	±13 mm adjacent to tie holes ±25 mm adjacent to end block
Square ends (deviation from square)	±6 mm

Skew ends (deviation from designated skew)	±6 mm
Skew angle equal to or less than 30°	±6 mm
Skew angle greater than 30°	±13 mm
Horizontal alignment (deviation from straight line parallel to center line of unit)	Max. 3 mm/3 m
Gap between adjacent units	Max. 13 mm
Tie rod tubes (spacing between centers of tubes and from centers of tubes to ends of units)	±6 mm
Tie rod tubes (spacing from centers of tubes to bottom of beam)	±6 mm
Camber differential between adjacent units	Max. 6 mm (at time of erection)
Camber differential between high and low units in same span	Max. 19 mm (at time of erection)
Camber differential from computed camber on plans	±50% (at time of erection)
Side inserts (spacing between centers of inserts and from centers of inserts to ends of beams)	±6 mm
Stirrup bars (projection above top of beam)	±19 mm
Stirrup bars (longitudinal spacing)	±25 mm
Center of gravity of strand group	±6 mm
Center of gravity of depressed strand group at end of beam	±6 mm
Position of hold-down points for depressed strands	±150 mm
Position of handling devices	±150 mm

(c) **Prestressed Deck Panels:**

Characteristics	Value
Width (perpendicular to strand)	0 to +13 mm
Length (in direction of strand)	±13 mm

(A distance of at least 13 mm shall be maintained between deck panel and shear connectors or shear reinforcing steel connecting deck panel to beam).	
Depth	0 to +6 mm
Distance between centerline of strands and bottom of panel	0 to –6 mm

(d) **Prestressed Concrete Piling:**

Characteristics	Value
Width or diameter	-6 mm to +10 mm
Head out of square	0.5 mm/m of width
Length of pile	± 38 mm
Horizontal alignment	Max. 5 mm/6 m of length
(deviation from straight	Max. 3 mm in 3 m chord
line parallel to centerline	1.5 mm in 300 mm
of pile)	
Void location	±6 mm
Stirrup bars or spiral position	± 25 mm
Center of gravity of strand	±6 mm
group	
Position of handling devices	±150 mm

405.07—Measurement and Payment.

Prestressed concrete piles will be paid for in accordance with the requirements of Section 403.08.

Prestressed concrete structural units that are to be incorporated in the completed structure will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

These prices shall include manufacturing and furnishing units complete-in-place in the structure; mortar seals on ends of units; structural and reinforcing steel for connecting units to struts and diaphragms; reinforcing, structural, and prestressing steel embedded in units, including dowels in place and bearing pads or bearing devices, post-tensioning fittings, strands, and rods; grouting; joint fillers and sealers; waterproofing applied to structural units at the prestressing plant; hauling; handling; and treatment.

Prestressed concrete panels will be measured in square meters of surface area, complete-in-place, and will be paid for at the contract unit price per

square meter. This price shall include manufacturing, furnishing, and installing.

Payment will be made under:

Pay Item	Pay Unit
Prestressed concrete (Shape, beam, description of cross section, and length)	Each
Prestressed concrete slab (Width, depth, and length)	Each
Prestressed concrete panel (Depth)	Square meter

SECTION 406—REINFORCING STEEL

406.01—Description.

This work shall consist of furnishing; coating, if required; and placing reinforcing steel or wire mesh used in concrete operations, except prestressed strands and wires, in accordance with these specifications and in reasonably close conformity to the lines and details shown on the plans.

406.02—Materials.

(a) **Steel used for reinforcement** shall conform to the requirements of Section 223. Except for spiral bars, bars more than 6 millimeters in diameter shall be deformed bars.

(b) **Epoxy-coated bars** shall conform to the requirements of Section 223.

(c) **Welded wire fabric** shall conform to the requirements of Section 223.

(d) **Bar mat reinforcement** shall conform to the requirements of Section 223.

406.03—Procedures.

(a) **Order Lists and Bending Diagrams:** Copies of order lists and bending diagrams shall be furnished the Engineer when required.

(b) **Protecting Material:** Reinforcing steel shall be stored on platforms, skids, or other supports that will keep the steel above ground, well drained, and protected against deformation.

Upon delivery to the project site, epoxy coated reinforcing steel shall be covered with an opaque covering. In addition, epoxy coated reinforcing steel that has been partially embedded in concrete or placed in formwork and not covered with concrete shall have the exposed surfaces covered with an opaque covering after 30 days of exposure to sunlight. The opaque coverings shall be placed in a manner to provide air circulation and prevent condensation on the reinforcing steel.

When placed in the work, steel reinforcement shall be free from dirt, paint, oil, or other foreign substances. Steel reinforcement with rust or mill scale will be permitted provided samples wire brushed by hand conform to the requirements for mass and height of deformation.

(c) **Fabrication:** Bent bar reinforcement shall be cold bent to the shape shown on the plans. Fabrication shall be in accordance with the requirements of the *Manual of Standard Practice for Detailing Reinforced Concrete Structures* (ACI 315).

Spiral bars shall be fabricated to have the proper diameter when placed in position at the pitch shown on the plans. Each end of a spiral bar shall have 1 1/2 finishing turns at each end in a plane perpendicular to the axis of the spiral.

(d) **Placing and Fastening:** Steel reinforcement shall be firmly held during the placing and setting of concrete. Bars, except those to be placed in vertical mats, shall be tied at every intersection where the spacing is more than 300 millimeters in any direction. Bars in vertical mats and in other mats where the spacing is 300 millimeters or less in each direction shall be tied at every intersection or at alternate intersections provided such alternate ties accurately maintain the position of steel reinforcement during the placing and setting of concrete.

Tie wires used with epoxy-coated steel shall be plastic coated or epoxy coated.

Following placement of epoxy-coated reinforcement and prior to concrete placement, the reinforcement will be inspected. All visible damage of the epoxy coating shall be repaired in accordance with Section 223.

The minimum clear distance from the face of concrete to any reinforcing bar shall be maintained as specified herein. In

superstructures, the cover shall be at least 65 millimeters except as follows:

1. **Bottom of slab:** 30 millimeters

2. **Stirrups and ties in T-beams:** 40 millimeters

3. **Rails, rail posts, curbs, and parapets:** 25 millimeters

In substructures, the cover shall be at least 75 millimeters except as follows:

1. **Abutment neat work and pier caps:** 65 millimeters

2. **Spirals and ties:** 50 millimeters

In corrosive or marine environments or under other severe exposure conditions, the minimum cover shall be increased 25 millimeters except where epoxy-coated reinforcement is used. Bars that must be positioned by maintaining clearances from more than one face shall be centered so that clearances indicated by the plan dimension of bars are equalized.

Bars shall be placed so that the concrete cover as indicated on the plans will be maintained within a tolerance of 0 to +13 millimeters in the finally cast concrete.

Where anchor bolts interfere with reinforcing steel, the steel position shall be adjusted without cutting to permit placing anchors in their proper locations.

Reinforcement in bridge deck slabs and slab spans shall be supported by standard CRSI metal or precast concrete bar supports. Bar supports shall be spaced as recommended by CRSI but not more than 1.2 meters apart transversely or longitudinally. Precast concrete supports shall be less than 300 millimeters in length and staggered so as not to form a continuous line. The lower mat of steel reinforcement shall be supported by a bolster block or individual bar chair supports, and the upper mat shall be supported by high chair supports. Bar supports shall be firmly stabilized so as not to displace under construction activities.

Precast concrete bar supports shall have a 28-day design compressive strength of at least 31 megapascals and shall be from the Department's list of approved products for the use specified. Supports shall be furnished with epoxy-coated or plastic ties or shaped to prevent slippage from beneath the reinforcing bar. Metal bar supports shall be fabricated from one of the following: (1) stainless steel wire

conforming to the requirements of ASTM A493, or (2) cold-drawn wire protected by plastic coating conforming to CRSI standards, epoxy coating, or other protective coating as approved by the Engineer. Reinforcing bar supports (STANDEES) may be used for the top mat of steel of simple slab spans provided they hold the reinforcing steel to the requirements specified herein and are firmly tied to the lower mat to prevent slippage. The use of standees will not be permitted for the top mat of steel on any continuous slab spans.

In reinforced concrete sections other than bridge slabs, the specified clear distance from the face of concrete to any reinforcing bar and the specified spacing between bars shall be maintained by means of approved types of stays, ties, hangers, or other supports. The use of pieces of gravel, stone, brick, concrete, metal pipe, or wooden blocks will not be permitted as supports or spacers for reinforcing steel. The use of precast concrete block supports will be permitted provided blocks are furnished in correct thicknesses and are shaped or tied to prevent slippage from beneath reinforcing bars. The clear distance between bars shall be at least 1 1/2 times the specified maximum size of coarse aggregate but not less than 40 millimeters. Before concrete is placed, reinforcing steel will be inspected and approved for proper position and the adequacy of the method for maintaining position.

(e) **Splicing and Lapping:** Reinforcement shall be furnished in full lengths as indicated on the plans. Except where shown on the plans, splicing bars will not be permitted without the written approval of the Engineer. Splices shall be as far apart as possible.

Bars shall be lapped at least 30 bar diameters to make the splice. In lapped splices, bars shall be placed in contact and wired together. Mechanical butt splicing will be permitted at longitudinal joints in deck slabs and other locations shown on the plans provided the mechanical connection develops in tension or compression, as required, at least 125 percent of the specified yield strength of the bar. Reinforcing steel shall be welded only if specified on the plans. Welding shall be in accordance with the requirements of Section 407.

Laps for sheets of welded wire fabric or bar mat reinforcement shall be at least one mesh in width.

406.04—Measurement and Payment.

Reinforcing steel will be measured in kilograms of steel placed in the structure as shown on the plans. The mass of welded wire fabric will be computed from the theoretical mass per square meter placed, including allowance for laps not to exceed 8 percent of the net area. Reinforcing steel

or welded wire fabric will be paid for at the contract unit price per kilogram. These prices shall include furnishing, fabricating, and placing reinforcement in the structure. In structures of reinforced concrete where there are no structural steel contract items, expansion joints, plates, rockers, bolts, and similar minor metal parts will be paid for at the contract unit price for reinforcement.

Epoxy-coated reinforcing steel, when a pay item, will be measured in kilograms of uncoated steel and will be paid for at the contract unit price per kilogram. The mass will be computed from the theoretical masses of the nominal sizes of steel specified and placed in the structure. Measurement will not be made for epoxy-coating material. This price shall include furnishing steel and epoxy-coating material; applying coating material; fabricating, shipping, and placing epoxy-coated reinforcement in the structure; and necessary repairing of epoxy coatings. When the Contractor elects to eliminate the epoxy coating of reinforcing steel and furnish a latex hydraulic cement concrete deck surface, payment will be made at the same contract unit price as if epoxy-coated reinforcing steel had been used.

No payment will be made for fastening devices that may be used by the Contractor for keeping reinforcing bars in their correct position. When the substitution of bars larger than those specified is allowed, payment will be made for only the amount of metal that would have been required if the specified size of bar had been used. When full-length bars are shown on the plans and the Contractor obtains approval to use short bars for his convenience, the mass paid for will be based on the full-length dimensions with no allowance made for splices.

Payment will be made under:

Pay Item	Pay Unit
Reinforcing steel	Kilogram
Welded wire fabric	Kilogram
Epoxy-coated reinforcing steel	Kilogram

SECTION 407—STEEL STRUCTURES

407.01—Description.

This work shall consist of furnishing, fabricating, and erecting steel materials in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the plans or as established by the Engineer.

407.02—Materials.

Materials shall conform to the requirements of Section 226.

407.03—Working Drawings.

The Contractor shall submit for review by the Engineer working drawings of all structural steel, bearing assemblies, and anchorage devices. Details shown on the drawings shall conform to these specifications and the requirements of the Structural Steel Design Section of AASHTO's *Standard Specifications for Highway Bridges.* In addition, primary stress units shall be detailed and identified by an individual piece mark. The review of working drawings shall not relieve the Contractor of responsibility for errors on the drawings or deviations from the plans unless such changes are approved in writing by the Engineer. Shop work shall not be performed until after the working drawings have been reviewed.

The Contractor may, in writing, authorize the fabricator to act for him in matters relating to working drawings in accordance with the requirements of Section 105.02.

Working drawings shall specifically identify each piece other than ASTM A36 steel. Pieces fabricated of different grades of steel shall not be given the same piece mark, even if they have identical dimensions and details.

407.04—Fabrication Procedures.

Workmanship, finish, and fabrication tolerances shall conform to AISC standards except where the standards are in conflict with these specifications. Where AISC standards allow alternate methods of fabrication, the method used shall be that which produces the higher quality of workmanship and finish.

Structural steel shall be fabricated in a shop certified by AISC, Category I, II, or III, as appropriate.

Fabrication and welding of structural steel bridge units shall conform to these specifications, ANSI/AASHTO/AWS Bridge Welding Code D1.5, and applicable AASHTO Guide Specifications for Fracture Critical Nonredundant Structural Steel Members.

Fabrication and welding of other structural and miscellaneous steel shall conform to these specifications and AWS Structural Welding Code D1.1.

The Contractor shall give the Engineer ample notice of the beginning of work in the shop so that an inspection can be made. Work shall not be performed in the shop before the Engineer has been notified.

Steels shall be identified during fabrication as follows: The Contractor shall furnish a complete mill analysis showing chemical and physical results from each heat of steel for all units prior to fabrication. Each piece of steel shall be properly identified.

Individual pieces shall be marked to maintain the identity of the heat number for primary stress units and pieces other than ASTM A36 steel.

Before cutting, pieces of steel other than ASTM A36 steel that are to be cut to smaller-sized pieces shall be legibly marked with the ASTM A6 specification identification color code or the material specification designation. The following identification color code or the latest system adopted under ASTM A6 shall be used to identify material required to conform to the following individual specifications:

ASTM Specification	**Color**
A572, Grade 345	Green and yellow
A588	Blue and yellow

Upon request, the Contractor shall furnish an affidavit certifying that he has maintained the identification of steel in accordance with these specifications throughout the fabrication operation.

(a) **Welds:** Only welding or tack welding noted on the plans shall be performed on structural steel, reinforcing steel, or aluminum units.

Structural units shall not be used as a work table. Welding on other work shall be completed before parts are installed on units and shall conform to the following:

1. Groove welds in flange plates, cover plates, and longitudinal stiffeners shall be ground flush. Groove welds in legs of rigid frames, webs of exterior girders, and beams shall be ground flush on the exposed side. Cope holes shall not be filled. The perimeter of cope holes shall be ground smooth. Temporary erection bolt holes shall be filled with high-strength bolts and tightened in accordance with the specifications herein.

2. Electroslag and electrogas welding processes will not be permitted.

3. Welds that do not conform to the specifications, as determined by visual inspection or nondestructive testing, shall be repaired or removed and replaced by the methods permitted in the specifications or the entire piece will be rejected. Repaired or replaced welds will be reinspected in accordance with the applicable nondestructive testing method.

4. For each welder, welding operator, or tacker, the Contractor shall submit or shall have the fabricator submit to the Department a copy of the certificate of qualification and a certificate stating that the welder, welding operator, or tacker has not exceeded any period of 3 months since the date of qualification without performing satisfactory welding in the required process. The qualification certification shall state the name of the welder, operator, or tacker; name and title of the person who conducted the examination; kind of specimens; position of welds; results of tests; and date of the examination. The qualification certification shall be made by an approved agency.

   Welds for reinforcing steel, including tack welds, shall conform to the requirements of AWS D1.4.

   Welding of aluminum shall conform to the requirements of AWS D1.2.

   Welds for tubular structures shall conform to the requirements of AWS D1.1.

(b) **Straightening and Curving Rolled Beams and Plate Girders:**

1. **Straightening material:** Rolled material shall be straight before being laid off or worked. When straightening is required, it shall be done by methods that will not damage the metal. If straightening is performed by heating, heating shall be in accordance with 2. herein.

   Sharp kinks or bends shall be cause for rejection of the material.

2. **Curving rolled beams and plate girders:** The Contractor shall submit a detailed procedure for the method of heat curving beams or girders.

   Heat shall be applied so as to bring the steel to the temperature required for heat curving as rapidly as possible but not to more

than 650 °C. When any portion of a unit is heated to a temperature in excess of 650 °C, the unit will be rejected.

a. **Sequence of operations:** Units shall be cambered before heat curving and shall be heat curved in the fabrication shop before painting.

Longitudinal stiffeners shall be heat curved or cut separately and then welded to the curved units. When cover plates are to be attached to the rolled beams, they may be attached before heat curving if the total thickness of one flange and cover plate is less than 65 millimeters and the radius of curvature is more than 300 meters. For other rolled beams with cover plates, beams shall be heat curved before cover plates are attached. Cover plates may be either heat curved or cut separately and then welded to the curved beam.

b. **Camber compensation:** To compensate for the loss of camber of heat-curved units in service having a radius of 250 meters or less, additional camber shall be provided in the units. The amount of additional camber at the midlength of the unit shall be C_h for units having a radius less than 150 meters and 1/2 C_h for units having a radius from 150 meters to 250 meters. C_h shall be computed as follows:

$$C_h = \frac{0.02L^2F}{EY_o}$$

where L is the length, in millimeters, of the unit specified to be cambered; F_y is the specified minimum yield point of the flange in megapascals; E is the modulus of elasticity in megapascals; and Y_o is the distance from the neutral axis to the extreme outer fiber in millimeters (maximum distance for nonsymmetrical sections).

The additional camber, C'_h, at any other point in the unit shall be computed as follows:

$$C'_h = \frac{C' \times C}{C}$$

where C is the camber specified at midlength in the design plans and C' is the camber specified at any other point in the design plans.

The additional camber provided shall be shown on the working drawings.

c. **Type of heating:** Where heat curving is permitted by the plans, plate girders and rolled beams may be curved by either continuous or V-type heating. Heat curving shall not be performed until camber is in conformance with the specifications.

(1) **Continuous method:** A strip along the edge of the top and bottom flange shall be heated simultaneously. The strip shall be of sufficient width and temperature to obtain the required uniform curvature.

(2) **V-type method:** The top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange. Spacing and temperature shall be as required to obtain the required uniform curvature. Heating shall progress simultaneously along the outside surface of the top and bottom flange. When the flange thickness is 32 millimeters or greater, heat shall be applied simultaneously to the inside flange surface (surface that intersects with the web) and outside flange surface.

d. **Position for heating:** The unit may be heat curved with the web in the vertical or horizontal position. When curved in the vertical position, the unit shall be braced or supported so that the tendency of the unit to deflect laterally during the heat-curving process will not cause the unit to overturn.

When curved in the horizontal position, the unit shall be properly supported to obtain a uniform curvature. The bending stress in the flanges attributable to the dead mass of the girder shall not exceed the allowable design stress. When the unit is positioned horizontally for heating, safety catch blocks shall be maintained at the midlength of the unit within 50 millimeters of the flanges at all times during the heating process.

Any method of handling, supporting, or loading that causes the unit to distort permanently (yield without the application of heat) will result in rejection of the unit.

e. **Artificial cooling:** Quenching will not be permitted. Cooling with dry compressed air will be permitted after the steel has cooled to 315 °C.

f. **Measurement of curvature:** Prior to final acceptance of horizontal curvature, welding and heating operations shall

have been completed and the unit cooled to a uniform temperature.

(c) **Camber:** Rolled beams and plate girders shall be cambered in the amount indicated on the plans. Camber shall approximate a parabolic curve. Camber for rolled beams shall be obtained by heat-cambering methods. For plate girders, the web shall be cut to the prescribed camber with a suitable allowance for shrinkage attributable to cutting, welding, and heat curving.

Tolerance for the specified camber of welded beams or girders before erection shall not exceed the greater of (A) or (B).

$$(A) + 6 \text{ mm} \times \frac{\text{Meters of test length (not to exceed 19 mm)}}{3}$$

$$(B) + 3 \text{ mm} \times \frac{\text{Meters from nearest end}}{3}$$

Tolerance for the specified camber of rolled beams as measured at mid-length shall be:

$$+3 \text{ mm} \times \frac{\text{Meters of length}}{3}$$

Camber shall be measured with the beam or girder laying on its side on a flat horizontal surface.

(d) **Bolt Holes:** Bolt holes shall be punched, drilled, or reamed as specified herein. Holes shall not be flame cut or electrode cut.

Finished holes shall be 1.5 millimeters larger than the nominal bolt size. Oversized holes will be permitted only with the permission of the Engineer or in accordance with the requirements of Section 407.06(a). Finished holes shall be within 1.5 millimeters of the plan gage and match-mating holes, with no offset greater than 1.5 millimeters. Holes varying more than 1.5 millimeters from the plan gage will be rejected.

Burrs shall be removed from holes.

1. **Punched holes:** The diameter of the die shall not exceed the diameter of the punch by more than 1.5 millimeters.

Holes shall not be punched in structural carbon steel, ASTM A36, thicker than 19 millimeters or in high-strength structural steel, ASTM A572 through A588, thicker than 16 millimeters. When these thicknesses are exceeded, holes shall be subdrilled and reamed or drilled full size.

Holes may be punched full size (1.5 millimeters larger than bolts) in secondary units, such as bracing and diaphragms and their connecting plates or angles. Holes shall be clean cut, without torn or ragged edges. Holes in primary units shall not be punched full size.

Subpunched holes that are to be reamed shall be 5 millimeters smaller in diameter than the nominal bolt size. The location offset between subpunched holes assembled for reaming shall be not more than 3 millimeters.

2. **Reamed and drilled holes:** Holes shall be subdrilled and reamed to 1.5 millimeters larger than bolts. If numerically controlled drilling equipment is used, the Contractor may be required by means of check assemblies to demonstrate that this procedure consistently produces holes that conform to the dimensions shown on the plans. Connections shall conform to the requirements of Section 407. Shop assembly for numerically controlled drilled connections shall conform to the requirements of AASHTO's *Standard Specifications for Highway Bridges.*

(e) **Cut Edges of Plates and Shapes:** Cut edges shall have their corners rounded to a radius of 1.5 millimeters.

Sheared edges of plates more than 16 millimeters in thickness shall be planed to a depth of 6 millimeters.

Structural steel may be flame cut provided a smooth surface free from cracks and notches is secured and an accurate profile is secured by the use of a mechanical guide. Free-hand cutting shall be done only where approved by the Engineer.

Flame cutting in the field is prohibited.

(f) **Facing of Bearing Surfaces:** The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall conform to the following surface roughness requirements as defined in ANSI B46.1:

	Roughness Height (millimeters)
Steel slabs	.0508
Heavy plates in contact in shoes to be welded	.0254
Milled ends of compression units, stiffeners, and fillers	.0127
Bridge rollers and rockers	.0064
Pins and pin holes	.0032
Sliding bearings	.0032

(g) **Bent Plates:** The radius of bends shall be such that the plate does not crack. The minimum bend radii, measured to the concave face of the metal, shall be as follows:

Thickness (*t*) (millimeters)

Up to 13 mm	Over 13 mm to 25 mm	Over 25 mm to 40 mm	Over 40 mm to 65 mm	Over 65 mm to 100 mm
$2t$	$2\ 1/2t$	$3t$	$3\ 1/2t$	$4t$

Low-alloy steel more than 13 millimeters in thickness may require hot bending for small radii. If a shorter radius is essential, the plates shall be bent hot at a temperature of not more than 650 °C.

Before bending, the corners of the plate shall be rounded to a radius of 1.5 millimeters throughout the portion of the plate at which the bending is to occur.

(h) **Annealing and Stress Relieving:** Structural units that are indicated on the plans or by the specifications to be annealed or normalized shall have finished machining, boring, and straightening done after heat treatment. Temperatures shall be maintained uniformly throughout the furnace during heating and cooling cycles so that the temperature of any two points on the unit will not differ at any time by more than 38 °C.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instruments, including recording pyrometers, shall be provided for determining the temperature of units in the furnace at any time. The records of the treatment operation shall be available for inspection by the Engineer.

(i) **Pins and Rollers:** Pins and rollers shall be forged or fabricated of cold-finished carbon steel shafting. In pins larger than 230 millimeters in diameter, a hole at least 50 millimeters in diameter shall be bored full length along the axis. Threads for pins shall conform to the American National Coarse Thread Series, Class 2, free fit, except that pin ends having a diameter of 35 millimeters or more shall be threaded six threads to the millimeter.

Pin holes shall be bored at right angles with the axis of the unit. Boring holes in fabricated units shall be performed after welding is completed. The diameter of the pin hole shall not exceed that of the pin by more than 0.5 millimeter for pins 125 millimeters or less in diameter or by 1 millimeter for larger pins.

(j) **Stud Shear Connectors:** The diameter shall be 22 millimeters, and the length shall be at least 100 millimeters. Heads shall project at least 50 millimeters above the plane of the bottom of the deck slab and shall be 75 millimeters below the plane of the top of the deck slab. In determining the required length, the computed dead-load deflection, vertical curve correction, and actual (measured) camber of the fabricated beam shall be taken into consideration. Studs 19 millimeters in diameter may be substituted for 22-millimeter studs, or vice versa, by making an adjustment in the pitch proportionally to the cross-sectional area of the studs with a spacing of not more than 600 millimeters. Studs shall be adjusted as necessary to provide clearance for bolts in bolted splices. When prestressed deck panels for cast-in-place concrete deck slabs are to be used, the edge distance of studs shall be adjusted to provide the necessary support areas for ends of the deck panels. Studs shall be end welded automatically or semiautomatically to the steel beams. The method and equipment used shall be as recommended by the manufacturer of the studs and shall be approved by the Department. Studs may be shop welded or field welded, either before or after slab reinforcing steel is placed.

(k) **Shop Assembly:** Assembly shall be in accordance with the following:

1. Holes for field connections and field splices in the following main units shall be drilled with units assembled or numerically controlled drilled. Holes shall not be punched full size in the following main units:

   a. girders and rolled beams

   b. trusses, arches, and towers

   c. bent and rigid frames

2. Holes for floor-beam and stringer-end connections shall be subpunched or subdrilled and reamed to a template or reamed while assembled. Templates used for connections on like parts shall be located so that the parts are duplicate and require no match marking.

3. Surfaces of metal in contact shall be cleaned before assembly. Parts shall be drawn together and securely clamped before drilling or reaming. Units shall be free from twists, bends, or other deformation.

4. Drift pins may be used only to bring parts into position. If any holes must be enlarged to admit bolts, the hole shall be reamed as permitted in these specifications.

5. Connecting parts assembled in the shop for the purpose of reaming holes shall be match marked. Miscellaneous parts that are not completely bolted in the shop shall be secured by partial bolting to prevent loss or damage in shipment and handling.

(l) **Inspection:** The Contractor shall perform quality control inspection, including, but not limited to, visual inspection and nondestructive testing. Visual inspection shall be performed in accordance with the requirements of VTM-33 by inspectors qualified in accordance with the requirements of ANSI/AASHTO/AWS Bridge Welding Code D1.5 or AWS Structural Welding Code D1.1, as applicable. Radiographic and magnetic particle testing shall be performed in accordance with the requirements of VTM-29 and VTM-31, respectively. Ultrasonic testing, when specified, shall be performed in accordance with the requirements of VTM-30. Railroad structures and fracture-critical units shall be given radiographic and ultrasonic inspections in accordance with the requirements of VTM-44.

The Department reserves the right to perform quality assurance inspection. The Contractor shall provide and furnish a Type III field office in accordance with the requirements of Section 514 for use in the Department's inspection of material and workmanship within the shop. In addition to the requirements specified therein, the Contractor shall provide telephone service, by a direct access line, a telephone, and maintenance thereof. Costs for installation of the direct access line and telephone, maintenance, and local service shall be borne by the Contractor. Long-distance costs will be borne by the Department. The Department shall be allowed free access to the necessary parts of the work. One reinspection of corrective action taken on defective material or fabrication will be performed by the Department without cost to the Contractor; however, the cost of further reinspections shall be borne by the Contractor. The cost of any retests

made necessary by the replacement of rejected welds shall be borne by the Contractor. When requested, the Contractor shall provide working space for radiographic examination of welds and shall make such space available for at least 6 hours per inspection visit.

407.05—Handling, Storing, and Shipping Materials.

Materials and units shall be placed at least 100 millimeters above the ground on platforms, skids, or other supports. They shall be supported in such a manner that they will not be overstressed or become deformed or otherwise damaged. Materials shall be kept free from dirt, grease, and other foreign materials; protected from corrosion; and properly drained.

(a) **Material Furnished by Others:** If the Contract is for erection only, the Contractor shall check the material delivered against the shipping lists and report promptly in writing any shortage or damage. The Contractor shall be responsible for the loss of any material in his care or for any damage incurred after the shipment is received.

(b) **Marking and Shipping:** Each unit shall be identified with an erection mark, and an erection diagram shall be furnished.

The Contractor shall furnish as many copies of shipping statements and erection diagrams as the Engineer may require. The mass of each unit shall be shown on the statements. Units having a mass more than 3 metric tons shall have the mass marked thereon. Structural units shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or damaged. Main structural units shall be supported at their bearings or at such other supports as may be approved or directed by the Engineer.

Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts, and packages of bolts, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

407.06—Erection Procedures.

If the Contract is for erection only, the Contractor will receive the materials entering into the finished structure, free of charges, at the place designated and loaded or unloaded as specified. The Contractor shall promptly unload material he is required to unload and shall be responsible for demurrage charges.

Before starting the work of erection, the Contractor shall fully inform the Engineer as to the method proposed to be followed and the amount and character of equipment to be used, which shall be subject to approval. No work shall be done until such approval has been obtained. The approval of the Engineer shall not relieve the Contractor of the responsibility for ensuring the safety of his methods or equipment or performing the work in accordance with the plans and these specifications.

The Contractor shall erect steel, remove temporary construction, and perform all work required to complete the structure(s) or specified in the Contract, including removing the old structure(s), if specified, in accordance with the plans and specifications.

(a) **Misfits Field Assembly:** Correction of misfits will be considered a legitimate part of erection provided corrective work is necessary on not more than 10 percent of the holes in a continuous group of 10 or more holes or 10 percent of the number of individual pieces with fewer than 10 holes.

Drift pins may be used only to bring parts into position. Misaligned holes shall be corrected, where allowed by the Engineer, by reaming. However, no hole shall be elongated in any separate part to more than 3 millimeters larger than the nominal bolt size when a reamer not more than 1.5 millimeters larger than the nominal bolt size is used. The misalignment of holes before reaming shall not be more than 3 millimeters.

Necessary work exceeding these figures will be considered caused by shop errors and will be reported to the responsible party. Damage resulting from handling or transportation shall be reported to the Engineer.

When the Contract provides for complete fabrication and erection, the Contractor shall be responsible for misfits and errors and shall make the necessary corrections or replacements. When the Contract is for erection only, the Engineer, with the cooperation of the Contractor, will keep a record of labor and material used and the Contractor shall render within 30 days an itemized bill approved by the Engineer.

(b) **Assembly of Structural Connections Using High-Strength Bolts:** Field connections shall be made with high-strength 22-millimeter diameter bolts fabricated in accordance with ASTM A325 unless otherwise specified. Consideration will be given to the substitution of adequately designed welded connections if requested in writing by the Contractor.

1. **Bolts, nuts, and washers:** Bolts, nuts, and washers shall conform to the requirements of Section 226 and shall each be from one manufacturer on any one structure unless otherwise approved by the Engineer. In addition, each bolt, nut, and washer combination, when installed, shall be from the same rotational-capacity lot. Prior to installation, the Contractor shall perform a field rotational-capacity test on two nut, bolt, and washer assemblies for each diameter and length in accordance with the requirements of Section 226.02(i)3. Bolts fabricated in accordance with ASTM A490 and galvanized bolts fabricated in accordance with ASTM A325 shall be not reused. Other bolts may be reused only if approved by the Engineer. Threads of plain (uncoated) bolts shall be oily to the touch when installed. Threads of weathered or rusted bolts shall be cleaned of loose rust and debris and relubricated.

2. **Bolted parts:** Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

   Before assembly, connecting surfaces, including areas adjacent to the washers, shall be free from scale except tight mill scale. Surfaces for bolted splices in main units fabricated from steel fabricated in accordance with ASTM A588 and joint surfaces for other connections, when required on the plans, shall be blast cleaned in accordance with the requirements of Section 411.03(b)5. The minimum area to be blast cleaned shall be 300 millimeters beyond the outermost row of bolts in the flanges and web and shall include the entire contact surfaces of the splice plates and filler plates. Contact surfaces shall be free from dirt, loose scale, burrs, oil, lacquer, and rust inhibitor.

3. **Installation:** Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

   When bolts fabricated in accordance with ASTM A490 are used with steel having yield points less than 275 megapascals, hardened washers shall be installed under the nut and bolt head.

   Bolt tensioning devices and complete bolt assemblies shall be tested with an approved tension-indicating device at the start of construction and on a periodic basis as determined by the Engineer. When turn-of-nut or direct tension indicators are used, a representative sample of at least three complete bolt assemblies of each diameter, length, and grade shall be tested. When a calibrated wrench is used for tightening, testing shall be

performed daily or as directed by the Engineer. For short grip bolts, direct tension indicators with solid plates may be used to perform the required testing. However, the direct tension indicator shall be checked with a longer grip bolt in the approved tension-indicating device prior to testing with short grip bolts.

A flat washer may be used when the surface adjacent to the bolt head or nut does not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism. The threaded ends of bolts shall be placed on the inside, where practicable, for protection from weather.

The length of bolts shall be such that the point of the bolt will be flush with or outside the face of the nut when completely installed without overtensioning the bolt.

Fasteners shall be tightened to give at least the required minimum bolt tension values specified in Table IV-3 upon completion of the connection. If required because of bolt-entering and wrench-operation clearances, tightening by either procedure may be done by turning the bolt while the nut is prevented from rotating provided both the head and nut bear against surfaces having slopes not greater than 1:20. The required minimum bolt tension is equal to 70 percent of specified minimum tensile strengths of bolts rounded off to the nearest newton as specified in ASTM A325 and ASTM A490. Tightening shall be performed with calibrated wrenches, by the turn-of-nut method, or by the use of a direct tension indicator using a load indicator washer.

TABLE IV-3
Bolt Tension

Bolt Size	Required Min. Bolt Tension (kN)	
	ASTM A325 Bolts	ASTM A490 Bolts
13 mm	53	67
16 mm	85	107
19 mm	125	156
22 mm	173	218
25 mm	227	285
28 mm	249	356
32 mm	316	454
35 mm	378	538
40 mm	458	658

a. **Calibrated wrenches:** When calibrated power or torque wrenches are used to provide the bolt tension specified in Table IV-3, their setting shall be such as to induce a tension of at least 5 percent in excess of the value specified. The initial installation shall be to a snug tight condition as defined in b. herein, after which final tightening shall be performed by progressing systematically from the most rigid part of the connection to its free edges.

Power and torque wrenches shall be calibrated by tightening, in a calibrating device furnished by the Contractor, no fewer than three typical bolts from the lot to be installed having a length representative of bolts used in the structure. This procedure shall be repeated as often as necessary but not less than once each workday. The calibrating device shall be capable of indicating actual bolt tension within a tolerance of 2 percent. The device shall have been checked for the accuracy specified herein within the previous 12 months by the manufacturer, an approved testing agency, or the Department. Power wrenches shall be adjusted to stall or cut out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the calibrating tension shall be noted and used in the installation of bolts of the tested lot. Nuts shall be in tightening motion when torque is measured. When calibrated wrenches are used to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened until all are tightened the prescribed amount.

Power wrenches shall be of adequate capacity and sufficiently supplied with air to perform the required tightening in approximately 10 seconds.

b. **Turn-of-nut tightening:** When the turn-of-nut method for tightening high-strength bolts is used, bolts shall be installed and tightened to a snug tight condition to ensure that all parts of the joint are brought into contact with each other. Snug tight is defined as the tightness attained when a power wrench begins to impact solidly or when the bolts are firmly hand tightened with a spud wrench such that the complete area of the connecting surfaces are brought into firm contact with each other. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges, and then the bolts of the connection shall be retightened in a similar systematic manner as necessary until all bolts are simultaneously snug tight and the connection is fully compacted. All bolts shall be given a suitable match-mark and tightened additionally by the applicable amount

of nut rotation specified in Table IV-4, progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench. Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance is plus or minus 30°; for bolts installed by 2/3 turn and more, the tolerance is plus or minus 45°.

TABLE IV-4
Nut Rotation From Snug Tight Condition

Bolt Length Measured From Underside of Head to Extreme End of Point	Disposition of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis and Other Face Sloped Not More Than 1:20 (Bevel Washer Not Used)	Both Faces Sloped Not More Than 1:20 From Normal to Bolt Axis (Bevel Washers Not Used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
More than 4 but not more than 8 diameters	1/2 turn	2/3 turn	5/6 turn
More than 8 but not more than 12 diameters	2/3 turn	5/6 turn	1 turn

c. **Direct tension indicators:** When direct tension indicators are used, installation shall be in accordance with the requirements of 3. herein. However, the indicator washer shall not be considered a substitute for the required hardened washer under the turned element but may be considered a substitute for the hardened washer required under the unturned element when ASTM A490 bolts are used with ASTM A36 steel. Direct tension-indicator washers shall not be painted or coated with any epoxy or similar material prior to installation. The normal installation shall consist of the load indicator being placed under the unturned bolt head or unturned nut. However, if conditions require

installation under the turned bolt portion, then a hardened flat washer or nut face washer shall be fitted against the tension-indicating protrusions. Tension-indicating washers shall not be substituted for the hardened washers required with short-slotted or oversized holes but may be used in conjunction with them.

The initial installation shall be to a snug tight condition, after which final tightening shall be performed by progressing systematically from the most rigid part of the connection to its free edges until the tension indicators on all bolts are closed to at least the required gap.

The required gap shall be 0.4 millimeter or less between the indicator and the underside of the bolt head or nut when no washer is used with the indicator. If a hardened flat washer is incorporated, the required gap shall be 0.25 millimeter or less between the indicator and the hardened flat washer. If the indication gap is closed completely, additional tightening shall not be continued.

4. **Inspection:** Installation and tightening of bolts will be observed to determine that the selected tightening procedure is properly used and that bolts are tightened.

When the calibrated wrench method of tightening is used, the Engineer shall be given full opportunity to witness the calibration tests prescribed in a. herein.

The Contractor, in the presence of the Engineer, shall use an inspected wrench that can be accurately adjusted in accordance with the requirements of a. herein.

When the inspection wrench is a torque wrench, each calibration test bolt shall be tightened in the calibration device to the minimum tension specified for its size in 3. herein. The inspecting wrench shall then be applied to the tightened bolt, and the torque necessary to turn the nut or bolt head 5 degrees (approximately 25 millimeters at 300 millimeter radius) in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job-inspecting torque.

When the inspecting wrench is a power wrench, it shall be adjusted so that it will tighten each calibration test bolt to a tension of at least 5 but not more than 10 percent greater than the minimum tension specified for its size in 3. herein. This setting of the wrench shall be taken as the job-inspecting torque.

Bolts represented by the sample prescribed in a. herein that have been tightened in the structure shall be inspected in the presence of the Engineer by applying, in the tightening direction, the inspecting wrench and its job-inspecting torque to 10 percent of the bolts, but not fewer than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job-inspecting torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job-inspecting torque, the torque shall be applied to all bolts in the connection. Bolts whose nut or head is turned by the job-inspecting torque shall be tightened and reinspected, or the bolts in the connection may be retightened and the connection resubmitted for the specified inspection.

Inspection of installations using tension-indicating washers will normally be accomplished by checking the residual gap with a metal feeler gage. Installations will be considered satisfactory if the average gap per bolt installation does not exceed 0.4 millimeter for a tension-indicating washer installed under the bolt head, or 0.25 millimeter for a tension-indicating washer installed in conjunction with a hardened, flat washer, or if the gap has been reduced to zero at any point around the indicator.

The Engineer may verify, by calibrated wrench, that the work conforms to the requirements of Table IV-4 regardless of the method of installation.

(c) **Abutting Joints:** Abutting joints in compression units, and in tension units where so shown on the plans, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall be not more than 10 millimeters.

(d) **Alignment at Bearings and Transverse Connections:** Beam ends, bearing stiffeners, and webs of girders and rolled structural shapes and other beam sections shall be vertical.

Diaphragms or cross struts composed of channel sections not attached to bearing stiffeners may be fitted with the planes of their webs perpendicular to the planes of the flanges of longitudinal beams on gradients provided the channel flanges are turned to the downgrade side where practicable.

Rolled beams and plate girders and their bearing assemblies shall be fabricated so that their bottom bearing surfaces lie in horizontal planes when in their erected positions. Steel plates for use with flexible bearing pads shall be beveled to conform to this requirement.

(e) **Falsework** shall be designed, constructed, and maintained for the loads that will rest upon it. The Contractor shall prepare and submit to the Engineer, for review, plans for falsework or for changes in an existing structure necessary for maintaining traffic. The Department's review of the Contractor's plans shall not relieve him of any responsibility.

The Contractor shall have a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia inspect the completed falsework assembly supporting a bridge superstructure prior to placing loads. The Professional Engineer shall provide a certification, based upon visual inspection of the completed falsework assembly, that the falsework assembly conforms to the approved working drawings. However, such certification shall not require an exhaustive inspection or testing or make the Professional Engineer liable for any deficiencies in workmanship or materials by the Contractor or for such conditions that cannot be ascertained from a visual inspection.

(f) **Straightening Material in the Field:** Straightening plates and angles or other shapes shall be done by methods that will not produce fracture or damage. Metal shall not be heated unless permitted by the Engineer, in which case the heating shall not exceed 650 °C as measured by temperature-indicating crayons or other approved means. After heating, the metal shall be cooled naturally.

Following straightening of the shape, the surface of the metal shall be carefully inspected for evidence of fracture. If the damage was caused by the Contractor, the cost of inspection shall be borne by the Contractor.

(g) **Assembling Steel:** Bearing surfaces that will be a permanent contact shall be cleaned before units are assembled.

Permanent bolts in splices of butt joints of compression units and permanent bolts in railings shall not be tightened until blocking and falsework have been removed. Immediately after erection, splices and field connections shall have at least 1/2 of the holes filled with bolts or cylindrical erection pins, of which 1/2 shall be bolts. Splices and connections carrying traffic during erection shall have holes filled with high-strength bolts that have been torqued prior to opening to traffic.

Erection bolts shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 0.8 millimeter larger.

(h) **Finishing:** Unpainted weathering steel units shall be cleaned after fabrication to remove oil and grease. Upon completion of erection and concrete work, the fascia of exterior beams or girders of unpainted

weathering steel shall be cleaned in accordance with the requirements of Section 411, and the fascia of exterior beams or girders of other steel-fabricated items shall be blast cleaned in the shop in accordance with the requirements of Section 411.

Whenever a depressed area is formed whereby water can be trapped or held, such as the juncture between a beam or girder web and splice plate on a bottom flange, the area shall be completely sealed with polyurethane, or other approved sealant, conforming to FS TT-S-00230C, Type II, Class A, prior to painting. When the sealant is used in conjunction with weathering steel, the sealant shall be integrally pigmented to a dark bronze color.

Weathering steel fabricated in accordance with ASTM A588 shall be painted in accordance with the requirements of Section 411.

(i) **Protective Coatings:** Nonstainless ferrous metal surfaces shall be cleaned and painted in accordance with the requirements of Section 411. Galvanizing shall conform to the requirements of Section 233.

407.07—Measurement and Payment.

Structural steel, including beams, girders, and miscellaneous steel, will be paid for at the contract lump sum price or, when specified, in kilograms of metal in the fabricated structure, including bolts shipped, as massed on a shop scale. However, any mass more than 1 1/2 percent above the computed mass for the entire structure will not be included for payment. The mass of erection bolts, field paint, boxes, crates, and other containers used for packing and materials used for supporting units during transport will not be included.

In contracts having a pay item for structural steel, structural steel components, including shear connectors, bearing plates, bearing assemblies and pads, anchorages, expansion joints, bolts, and pedestals, whether embedded in concrete or not, and other metals or materials shall be included in the price for structural steel unless paid for as a separate pay item(s).

If specified in the Contract or permitted by the Engineer, masses may be computed, in which case the computations shall be on the following basis:

1. The unit mass of metals shall be as follows:

	Kg/m³
Aluminum, cast or wrought	2771.0
Brass	8586.0
Bronze, cast	8586.0

Copper alloy	8586.0
Copper, sheet	8938.0
Iron, cast	7128.0
Iron, malleable	7529.0
Iron, wrought	7801.0
Lead, sheet	11325.0
Steel, cast, copper-bearing, carbon, silicon, nickel, and stainless	7849.0
Zinc	7208.0

2. The mass of rolled shapes and plates up to and including 1 meter in width shall be computed on the basis of their nominal masses and dimensions as shown on the approved working drawings, deducting for copes, cuts, and open holes except bolt holes.

   The allowed percentage of overrun in mass given in AASHTO M160 shall be added to the nominal masses of plates more than 1 meter in width.

3. The mass of high-strength bolt heads, nuts, and washers shall be included on the basis of the following:

Diameter (mm)	Mass Per 100 (kg)
13	8
16	14
19	24
22	35
25	50
28	69
32	93

   The mass of high-strength bolts includes the head, the nut, the projection of the bolt through the nut, and one flat washer per bolt.

4. The mass of castings shall be computed from the dimensions shown on the approved working drawings, deducting for open holes. To this mass shall be added 10 percent for fillets and overrun.

5. To the total computed mass of metal shall be added 0.4 percent as an allowance for shop paint.

6. The mass of metal railing shall be included unless it is a pay item.

7. Steel grid flooring will be measured and paid for as structural steel only if specified.

8. The mass of steel or brass shims required shall be included.

Prices for structural steel shall include furnishing, fabricating, galvanizing, transporting, erecting, and field painting.

Fabrication of structural steel, when a pay item, shall include fabricating; cleaning and shop painting structural units; bolts; nuts; washers; and transporting and storing units at the designated location.

Erection of structural steel, when a pay item, shall include equipment and incidentals required to transport units from their designated storage location to the erection site, unloading and storing, erecting, cleaning, and field painting.

The cost of testing unit(s) required by the specifications shall be included in the price for the structural unit(s).

Payment will be made under:

Pay Item	Pay Unit
Structural steel (Type)	Lump sum or kilogram
Fabrication of structural steel (Type)	Lump sum
Erection of structural steel (Type)	Lump sum

SECTION 408—BEARING DEVICES AND ANCHORS

408.01—Description.

This work shall consist of furnishing and installing bearing plates, pads, rockers, expansion devices, anchors, or other devices used in conjunction with bearings or anchorages at superstructure supports in accordance with these specifications and in conformity with the plans or as established by the Engineer.

408.02—Materials and Fabrication.

(a) **Bearing material and bearing pads** shall conform to the requirements of Section 237and those stated herein.

(b) **Metal plates, shapes, bolts, or bars** shall be of structural steel conforming to the requirements of Section 226 and those stated herein.

(c) **Metal parts** shall be fabricated in accordance with the requirements of Section 407.

(d) **Painting** shall conform to the requirements of Section 411.

(e) **Galvanizing** shall be performed in accordance with the requirements of Section 233.

408.03—Procedures.

(a) **High-Load Multi-Rotational Bearings:** High load multi-rotational bearings including sole and masonry plates shall be any type shown on the plans and shall be provided by only one manufacturer.

Other high-load multi-rotational bearing designs may be acceptable provided they are supported by engineering analysis, engineering calculations, data and evidence of acceptable service life for the proposed materials, tests and proven experience for the proposed bearing designs acceptable to the Engineer for the loads, forces, movements and service conditions specified. Engineering analysis shall be performed by a registered professional engineer.

Notations: All dimensions are in millimeters (mm).

C = Clearance between pot and surface immediately above or below it.
Dp = Diameter of elastomeric disc, inside diameter of pot bearing.
Ds = Projected diameter of loaded spherical segment.
G = Depth of pot bearing cavity.
k = Depth of chamfer on pot bearing piston.
Lh = Horizontal design load on bearing in kilonewtons.
Lv = Vertical design load on bearing in kilonewtons.
Θ = ArcTan (Lh/Lv min)
Rb = Minimum design rotation requirement of bearing in radians.
Rc = Maximum construction tolerance rotation in radians.
Rs = Minimum design rotation requirement of structure in radians.
Rmax = Maximum radius to prevent unseating of spherical surfaces.
S = Side of a square pot bearing plate.
t = Thickness of elastomeric disc.
w = Piston face width, pot bearing.
OD = Outside diameter of a round pot.

Design: High load multi-rotational bearings shall be designed to accommodate the loads, forces, and movements specified in the bearing schedule. Particular care shall be taken that all components of the bearings provide adequately for the horizontal loads and forces specified.

Maximum design stresses for all bearing components shall not exceed the allowable design stresses of the applicable issue of the AASHTO "Standard Specifications for Highway Bridges" and the applicable sections of this specifications.

Minimum rotation capacity, Rb, shall be the sum of Rc+Rs. Rc equals 0.02 radians. Rs equals the larger of 0.01 radians or the actual design rotations.

Minimum horizontal bearing design capacity for fixed and guided expansion bearing types shall be 10% of the vertical capacity or as specified in the plans. Minimum horizontal bearing design for non-guided expansion bearing types shall be equal to the frictional resistance of bearing slide surfaces or as specified in the plans.

Expansion bearings shall be designed for additional total movement capacity in each direction specified under "Design Movement" in the "Bearing Schedule". The additional total movement capacity shall be 10% of the design movement or 25 millimeters, whichever is greater. Spacing between the guides of the bearing do not require this additional movement capacity.

Bearings shall be designed so that all rotational and sliding elements can be replaced with a minimum of jacking movement not greater than 25 millimeters.

1. Pot Bearings-Rotational Elements:

a. **Pot**: Pot inside diameter, Dp, shall be the same as the elastomeric disc.

Depth of pot cavity, G, shall be equal to or greater than:
$((DP/2) \times (Rs + Rc)) + 3\ mm + k + t + w$

Where: k = 0 for flat sealing
k = 1.7 x the ring cross-section diameter for round sealing rings where rings sit 100% in the chamfer
k = 1.2 x the ring cross-section diameter for round sealing rings where rings sit half recessed in the elastomeric disc and half in the piston chamfer.
(See plans for "k" dimension details)

The section thickness of the pot beneath the elastomer shall be a minimum of 19 millimeters or Dp x 0.06 for bearings directly on concrete and 13 mm or Dp x 0.045 for bearings directly on steel masonry plates.

Minimum outer plan dimensions of pots shall be determined by analyzing horizontal loads, internal elastomer pressure and piston force due to friction, in shear, bending and tension but the wall thickness shall in no case be less than 19 millimeters.

b. **Elastomeric disc:** The thickness of the elastomeric disc, t, shall be equal to or greater than Rb x Dp / 0.3.

Area of elastomeric disc shall be designed for an average stress of 25.5 megapascals.

When using flat sealing rings, the upper edge of the disc shall be recessed to receive the rings so that they sit flush with the upper surface of the elastomeric disc.

The disc shall be lubricated with a silicone compound conforming to the requirements of MIL-S-8660 (Military Specification) or other approved equal. PTFE "shear- reducer discs" shall not be used with flat rings.

c. **Piston**: The outside diameter of piston shall be Dp – 1 mm. The piston thickness shall be adequate to resist the loads imposed on it but shall not be less than 0.06 x Dp.

The piston thickness shall be adequate to provide clearance, C, between the top of the pot and the surface immediately above it as follows:

$$C = Rb \times (0.7 \times S) + 3 \text{ mm for pots square in plan}$$
$$C = Rb \times (OD/2) + 3 \text{ mm for pots round in plan}$$

The piston face width, w, is the part of the edge of the piston that contacts the pot wall. When designing pistons for horizontal forces the piston face width, w, shall be designed assuming the contact area with the pot wall as one third of the circumference and allowable compressive stress as 0.8 Fy. In no case shall w be less than 0.03 x Dp or 6 millimeters.

Pistons for round seals shall have the lower corner chamfered at 45 degrees for a depth equal to 1.7 times the diameter of the seal less 0.5 mm where the seal is wholly within the piston thickness and 1.2 times the diameter where it extends into the elastomer for half its diameter.

d. **Elastomer sealing rings:** Flat sealing rings shall conform to the following requirements:

Width shall be a minimum of 6.5 millimeters for bearings up to 2225 kilonewtons capacity, 10 millimeters for bearings up to 8900 kilonewtons capacity, and 13 millimeters wide for bearings over 8900 kilonewtons capacity.

Minimum thickness shall be 2 millimeters for rings 6.5 and 10 millimeters wide and 3 millimeters for 13 rings millimeters wide.

Up to 8900 kilonewtons capacity, a minimum of 2 rings are required; over 8900 kilonewtons three rings shall be used. Rings shall be a snug fit to the pot wall and have their ends cut at 45 degrees with a maximum gap of 1 millimeter when installed. Ring gaps shall be staggered equally around the circumference of pots. Rings shall be free of nicks, burrs, or sharp edges.

Round sealing rings shall conform to the following requirements:

Rings shall be rolled into a circle from a rod and brazed or welded. They shall fit the pot snugly so that they are in full contact with the pot wall when installed.

Ring diameters shall be equal to or greater than the larger of 0.0175 x Dp or 4 millimeters.

2. Spherical bearings with PTFE/stainless steel surfaces:

a. **Spherical concave surfaces - PTFE:** The spherical radius shall be determined such that the resulting geometry of the bearing is capable of withstanding the greatest ratio of horizontal load to vertical load under all loading conditions to prevent unseating the concave element. If required during construction, mechanical safety restraints shall be incorporated to prevent overturning of the bearing. Unseating of the curved surfaces relative to each other shall be prevented by transferring horizontal forces through specifically designed restraints or by control of the radius. Acceptable radius control is given when $R_{max} = D_s/(2 \times \sin(\Theta + R_c + R_s))$. Calculations showing the determination of the radius shall be submitted for approval.

The projected area of woven fiber PTFE shall be designed for a maximum average working stress of 24 megapascals.

The concave shall face down whenever possible.

The thickness of PTFE fabric in the free state shall be a minimum of 1.6 millimeters when measured in accordance with ASTM D1777.

The minimum center thickness of the spherical surfaces shall be 19 millimeters.

The vertical clearance between rotating and non-rotating bearing parts shall be no less than 3 millimeters at maximum rotation.

b. **Spherical concave surfaces - Bronze:** The spherical radius shall be determined such that the resulting geometry of the bearing is capable of withstanding the greatest ratio of horizontal force to vertical load under all loading conditions to prevent unseating the concave element. If required, mechanical safety restraints shall be incorporated to prevent overturning of the bearing. A bearing rotation of Rs + Rc radians shall be considered in the bearing design to prevent overturning or uplifting of the bearing. Calculations showing the determination of the radius shall be submitted for approval.

The spherical element shall be made from the following or other approved bronze alloys:

Type 1	ASTM B22	Alloy C90500
Type 2	ASTM B22	Alloy C91100
Type 3	ASTM B22	Alloy C86300

The maximum design compressive stress for the projected area shall be:

Type 1	13.8 megapascals
Type 2	17.2 megapascals
Type 3	55.2 megapascals

The bearing surfaces shall have lubricant recesses consisting of either concentric rings, with or without central circular recesses with a depth at least equal to the width of the rings, or recesses. The recesses or rings shall be arranged in a geometric pattern so that adjacent rows overlap in the direction of motion.

The entire area of all bearing surfaces that provide for relative motion shall be lubricated by means of the lubricant-filled recesses. The lubricant-filled areas shall comprise not less

than 25 percent of the total bearing surface. The lubricating compound shall be integrally molded at high pressure and compressed into the rings or recesses and project not less than 0.25 millimeter above the surrounding bronze plate.

The minimum center thickness of the spherical surface shall be 19 millimeters.

c. **Spherical convex surfaces:** The convex element shall be designed for rotation, Rb = Rc + Rs.

The edge thickness shall be a minimum of 19 millimeters for bearings directly on concrete or 13 millimeters for bearings directly on steel masonry plates.

For PTFE/stainless and bronze/stainless rotational surfaces, the stainless surface shall conform to one of the following:

ASTM A167 or A240, Type 304, 1.5 millimeters to 2.3 millimeters thick with a finish equal to or less than 0.50 micrometer.

Solid stainless steel conforming to ASTM A240, Type 304 or 304L with a finish equal to or less than a 0.50 micrometer.

Stainless steel weld overlay a minimum of 2.4 millimeters thick with a finish equal to or less than 0.50 micrometer rms.

If sheet PTFE is used for guided surfaces, it shall be pigmented.

For bronze/carbon steel sliding surfaces, the surface finish shall be not more than 2.5 micrometers rms.

3. Non-Rotational Bearing Elements:

a. **PTFE sliding surfaces**: Sheet PTFE primary sliding surfaces, filled or unfilled, not including PTFE on guide bars or keys, shall be designed for 24.1 megapascals average maximum working stress. The maximum edge stress shall be 34.5 megapascals. Sheet PTFE shall be a minimum of 3 millimeters thick, epoxy-bonded into a square-edge recess 1.6 millimeters deep.

Fabric PTFE sliding surfaces shall be designed for 24.1megapascals average maximum working stress. Fabric PTFE in the free state shall be a minimum of 1.6 millimeters thick when measured in accordance with ASTM D1777 and

shall be epoxy-bonded to the substrate using a system that prevents migration of epoxy through the fabric. Any edges, other than the selvage, shall be oversown or recessed so that no cut fabric edges are exposed.

b. **Stainless steel sliding surfaces:** The stainless surface shall cover the mating surface in all operating positions plus 25 millimeters in each direction of movement. This is to conform with the requirements of Section 408.03(a)1. Sheet stainless steel shall be 1.5 to 2.3 millimeters thick and connected to the substrate by a continuous weld around the entire perimeter. The sheet shall be in full contact with the substrate. Stainless steel welded overlay shall be a minimum thickness of 2.4 millimeters after welding, grinding, and polishing and be produced using Type 309L electrodes. Stainless steel sliding surfaces shall, preferably, face down.

c. **Guide bars and central guide keys**: Central guide keys may be made integral by machining from the solid. Where a separate key or guide bar is used, they shall be fitted in a keyway slot machined to give a press fit and bolted, or welded to resist overturning.

Guide bars may be made integral by machining from the solid or fabricated from bars welded, bolted, and/or recessed at the manufacturer's option.

Guide bars and central guide keys shall be designed for specified horizontal forces, but not for less than 10 percent of the vertical capacity of the bearing. Frictional resistance of bearing slide surfaces shall be neglected when calculating horizontal load capacity.

The total clearance between the key/guide bars and guided members (both sides) shall be 1.6 millimeters maximum. Guided members shall have their contact area within the guide bars in all operating positions. Guiding off the fixed base or any extensions of the base where transverse rotation is anticipated shall be avoided.

d. **Sole and masonry plates:** For masonry plates, the concrete bearing stress on the loaded area shall not exceed 0.3 f'c. When the supporting surface is wider on all sides than the loaded area, the allowable bearing stress on the loaded area may be increased by the square root of (A2/A1), but not by more than 2. When the supporting surface is sloped or stepped, A2 may be taken as the area of the lower base of the largest frustrum of the right pyramid or cone contained wholly within

the support and having for its upper base the loaded area A1 and having side slopes of 1 vertical to 2 horizontal.

The allowable bending stress in sole and masonry plates is 0.75 Fy.

The minimum thickness of sole and masonry plates shall be 19 millimeters.

When designing recesses in masonry plates for horizontal forces, the depth of the recess shall be designed assuming the contact area as one third of the circumference and allowable compressive stress as 0.8 Fy. The minimum recess depth shall be 5 millimeters.

e. **PTFE on guiding surfaces:** PTFE on guiding surfaces, when they are used, shall be designed for an average stress not to exceed 24.1 megapascals.

PTFE, when used on guiding surfaces, shall be bonded to and recessed in their substrates. In addition, the PTFE shall be mechanically fastened by two screws to the substrate. The centerline of the screws shall be located a distance equal to twice the nominal screw diameter from the end of the PTFE strip. The top of the screws shall be recessed a minimum of 50 percent of the amount of protrusion of the PTFE above the guiding surface.

Unfilled sheet PTFE used on guide bars shall contain an ultraviolet inhibitor/screen.

4. Materials:

All steel, except steel for guide bars and shear-restriction pins and sleeves, shall conform to ASTM A709, Grades 290, 345, or 345W. All exposed steel surfaces shall be painted. Guide bars and shear-restriction devices shall be as specified by the manufacturer.

The elastomeric disc for pot bearings shall be a Shore A 50 durometer, and the base polymer shall be either 100 percent virgin natural polyisoprene (natural rubber) or 100 percent virgin chloroprene (neoprene) having the following physical properties as determined by the applicable ASTM tests:

Property	Test Procedures	Natural Rubber	Neoprene
Tensile strength, MPa, min.	ASTM D412	15.51	15.51
Elongation at break, %, min.	ASTM D412	450	400
Hardness, durometer A	ASTM D2240	50 ± 5	50 ± 5
Oven aging, 70 hrs/70 °C for natural rubber, 70 hrs/100 °C for neoprene			
Tensile strength, change, max. %	ASTM D573	-25	-15
Elongation, change, max. %		-25	-40
Hardness, points change, max.		+10	+15
Compression set, 22 hrs/ 70 °C for natural rubber, 22 hr/100 °C for neoprene, max. %	ASTM D395 Method B	25	35
Ozone resistance, 20% Strain 38 °C ± 1 °C, Mounting procedure D518, Method B 48 hr @25 pphm ozone by vol.	ASTM D1149	No cracks	—
100 hr@100 pphm ozone by vol.	ASTM D1149	—	No cracks
Low temperature test Brittleness @ -40 °C	ASTM D476 Procedure B	No failure	No failure

PTFE sliding surfaces shall be virgin PTFE resin filled or unfilled PTFE sheets or PTFE fabric.

PTFE resin shall be virgin material (not reprocessed) conforming to the requirements of ASTM D1457. Specific Gravity shall be 2.13 to 2.19. The melting point shall be 327 °C ± 10 °C. Filler material, when used, shall be milled glass fibers, carbon, or other inert filler materials.

Adhesive material shall be an epoxy resin conforming to the requirements of Federal Specification MMM-A-134, PEP film or equal, as approved by the Engineer.

Unfilled PTFE sheet shall be made of virgin PTFE resin and shall be in accordance with ASTM D3293, Type 2, Grade 1, Class C.

Filled PTFE sheet shall be made from virgin PTFE resin uniformly blended with inert filler material and shall conform to the following:

Property	Test Procedures	15% Glass Fibers	25% Carbon
Tensile strength, MPa, min.	ASTM D1457	13.8	9.0
Elongation, min. %	ASTM D1457	150	75
Specific gravity, min.	ASTM D792	2.2	2.1
Melting point	ASTM D1457	327 °C	± 10 °C

Fabric PTFE shall be made from virgin PTFE oriented multifilament and other fibers. The minimum thickness under the application of vertical load shall be:

1.6 millimeters up to 24.1 megapascals load
4.8 millimeters from 24.1 to 41.4 megapascals load

Where the PTFE surface is to be epoxy bonded, the PTFE shall be etched by an approved manufacturer by the sodium naphthalene or sodium ammonia etching process.

Stainless steel sliding surfaces shall conform to ASTM A167 or A240, Type 304, with a surface finish of 0.5 micrometer rms or less. Welded stainless steel overlay shall be produced using Type 309L electrodes.

Sealing rings shall be made of metal and shall conform to the following:

Flat brass rings, ASTM B36, half hard.

Round cross section rings, Federal Specification QQB626, composition 22, half hard.

Bronze elements shall conform to the following:

Type 1	ASTM B22	Alloy C90500
Type 2	ASTM B22	Alloy C91100
Type 3	ASTM B22	Alloy C86300

Solid lubricant shall consist of a combination of solids having nondeteriorating characteristics, as well as lubricating qualities, and shall be capable of withstanding long-term atmospheric exposure, de-icing materials, and water. The use of molybdenum disulfide and other ingredients that may promote electrolytic or chemical action between the bearing elements shall not be used.

Shellac, tars and asphalts, and petroleum solvents shall not be used as binders.

Socket head cap screws shall conform to ASTM A-574, high strength, 1960 Series.

5. **Construction:**

a. **Flatness of bearings** after welding and fabrication shall be determined by the following method:

A precision straightedge, longer than the nomimal dimension to be measured shall be placed in contact with the surface to be measured or as parallel to it as possible.

Select a feeler gage having a tolerance of plus or minus 0.0254 millimeter and attempt to insert it under the straightedge. Since layering of feeler gages tends to degrade accuracy, the least number of blades shall be used.

Flatness is acceptable if the feeler does not pass under the straightedge.

Flatness tolerances are arranged in the following classes:

Class A – 0.0127 millimeter x nominal dimension
Class B – 0.0254 millimeter x nominal dimension
Class C – 0.0508 millimeter x nominal dimension

Nominal dimension shall be interpreted as the actual dimension of the plate, in millimeters, under the straightedge.

In determining flatness, the straightedge may be located in any position on the surface to be evaluated and not necessarily at 90 degrees to the edges.

b. **Rotational elements: pot bearings**:

Pot bearings may, preferably, be made from a solid plate by machining or fabricated by welding a flame cut shape to a plate. Fabricated pots shall be manufactured in conformance with AASHTO/AWS D1.5 Bridge Welding Code. The inside diameter of pots shall be machined to a tolerance of ± 0.13 millimter for pots up to 508 millimeters and ± 0.18 millimeters for pots over 508 millimeters. The underside of pots shall be machined parallel to the inside to a Class A tolerance. Machined surfaces in contact with elastomer shall have a finish

of 63 rms or better. Other machined surfaces shall have a finish of 125 rms or better.

Elastomeric disc tolerance shall be:

Diameters greater than 508 millimeters, ± 2.38 millimeters.
Diameters less than 508 millimeters, ± 1.6 millimeters.
Discs may be made from up to 3 pieces, but the thinnest piece shall not be less than 12.7 millimeters.
The total thickness of all pieces shall be -0 millimeter + 3.18 millimeters.

Piston tolerances shall be:
Diameter greater than 508 millimeters, ± 0.18 millimeter.
Diameter less than 508 millimeters ± 0.13 millimeter.
Sliding side, Class A tolerance
Elastomer side, Class B tolerance

c. **Rotational Elements: Spherical Bearings**:

Spherical bearing machined diameters shall be ±0.38 millimeter. Convex radius dimensions shall be +0.0 - 0.25 millimeter. Concave radius dimensions shall be +0.25 -0.0 millimeter. Mating surfaces shall be as in Design section, external edges may be as cast or flame-cut. The lower surface of the convex element shall be Class C tolerance.

d. **Non-rotational elements: All bearings**:

Masonry and distribution plate tolerances shall be:

Plan dimensions under 762 millimeters, -0 +4.76 millimeters
Plan dimensions over 762 millimeters, -0 + 6.35 millimeters
The thickness tolerance shall be -0.76 millimeter +1.52 millimeters

Masonry plates used with pot or spherical bearings shall be Class "C" for the underside and Class "A" for the upperside tolerance.

PTFE sheet sliding surfaces shall be bonded by the bearing manufacturer under controlled conditions and in accordance with the requirements of the manufacturer of the approved adhesive system. After completion of bonding, the PTFE surface shall be smooth and free from bubbles. Filled PTFE surfaces shall be polished after bonding until smooth.

PTFE fabric sliding surfaces shall be mechanically attached to a rigid substrate. The fabric shall be capable of carrying loads of 68.9 megapascals without cold-flow.

Tolerances of PTFE surfaces shall be:

Plan dimensions total design area +5% -0%
Substrate flatness, Class A

Stainless steel sheet shall be seal welded around the entire perimeter using techniques that ensure it remains in contact with the backing plate. The finish shall be at least 0.5 micrometer rms. Flatness shall be to Class A tolerance.

Sole plates shall conform to the following:

Plan dimensions under 762 millimeters, -0 + 4.76 millimeters
Plan dimensions over 762 millimeters, -0 + 6.35 millimeters
Centerline thickness, -0.8 millimeter + 3.18 millimeters
Flatness of surface in contract with steel beams, Class B; in contact with poured in place concrete, none; in contact with stainless steel sliding surface, Class A; in contact with another steel plate, Class B.
No part shall be thinner than 19 millimeters.
Bevels shall be machined to an angular tolerance of ± 0.002 radians.
Flatness of bevelled surfaces shall be Class A.

Guide bars shall conform to the following:

Length, unless integral with plate, ± 3.18 millimeters.
Section dimensions, ± 1.6 millimeters.
Flatness where it bears on another plate, Class A.
Bar-to-bar, nominal dimensions ± 0.8 millimeter.
Not more than 0.8 millimeter out of parallel.

The overall bearing height shall not be more than 4.76 millimeters or less than 1.6 millimeters under nominal dimensions. All edges shall be broken and not sharp.

6. **Testing**:

a. **General**: Testing shall be performed on test bearings as specified herein to ensure the requirements of the specification has been met. As soon as all bearings have been manufactured for the project, the Contractor shall notify the Engineer, who

will select test bearing(s) at random from the lot. Manufacturer's certification of conformance with applicable requirements for the steel, elastomeric pads, preformed fabric pads, PTFE, and other materials used in the construction of the bearings shall be furnished along with notification of fabrication completion. Testing shall be performed at the manufacturer's plant. Bearing capacities that exceed the manufacturer's testing capacity shall be tested at an approved testing laboratory. If suitable test equipment is not available in the United States, alternative testing/inspection shall be agreed upon between the Engineer and the manufacturer. The Engineer may witness the testing.

b. **Sampling**: Tests shall be performed on randomly selected samples from the production bearings. One bearing per lot shall be tested. A lot shall be defined as the smallest number of bearings as determined by the following criteria: (1) one lot shall not exceed a single contract or project quantity, and (2) one lot shall not exceed 25 bearings.

A lot shall consist of those bearings of the same type within a load category. Bearing types shall be fixed type bearings or expansion type. Guided and non-guided expansion bearings will be considered a single type.

One load category shall consist of bearings of differing vertical load capacity within a load range as follows:

Bearings less than or equal to 4448 kilonewtons capacity, the load category shall be based on a range of 2224 kilonewtons.

Bearings greater than 4448 kilonewtons capacity but less than or equal to 13,345 kilonewtons capacity, the load category shall be based on a range of 4448 kilonewtons.

Bearings in excess of 13,345 kilonewtons capacity, the load category shall be based on a range of 8896 kilonewtons.

c. **Friction test**: A sample from each lot of expansion bearings shall be tested. Specially made bearings shall not be used; only actual bearings to be used in the project shall be tested. The test method and equipment shall be approved by the Engineer and conform to the following requirements:

The test shall be arranged so that the coefficient of friction on the first movement of the manufactured bearing can be determined.

The bearing surface shall be cleaned prior to testing.

The test shall be conducted at the maximum working stress for the PTFE surface with the test load applied for 12 hours prior to measuring the friction.

The first movement static and dynamic coefficients of friction shall be determined at a sliding speed of 25 millimeters per minute or less and shall not exceed the following:

Materials	**Bearing**	**Pressures**	**(MPa)**
Unfilled PTFE, fabric containing PTFE	3.45	13.79	24.13
Fibers, PTFE-perforated metal composite	.08	.06	.04
Filled PTFE	.12	.10	.08
Interlocked bronze and filled PTFE structures	.10	.07	.05

The bearing specimen shall be subjected to a minimum of 100 movements of at least 25 millimeters of relative movement and if the facility permits, the full design movement, at a speed of less than 305 millimeters per minute. After cycling, the static and dynamic coefficients of friction shall be determined again at a speed of less than 25 millimeters per minute and shall not exceed the specified coefficient of friction. The bearing shall show no appreciable sign of bond failure or other defects.

d. **Proof load test**: One bearing shall be tested from each production lot of fixed and expansion bearings. A load shall be applied to the test bearings equal to 150 percent of the rated design capacity of the bearing and simultaneously rotated 0.02 radian or the design rotation, whichever is greater, for 1 hour. During the test or subsequently upon disassembly, the bearing shall show no sign of deformation or extrusion of elastomer or PTFE.

e. **PTFE bond test**: For bearings with sheet PTFE primary surfaces, at the option of the Engineer, one bearing from each production lot shall have a 180-degree peel test performed on

the primary PTFE sliding surface using the ASTM D903 Test Method. The minimum peel strength shall be 3.5 newtons per millimeter.

For bearings with fabric PTFE primary sliding surfaces, one bearing from each production lot shall have the primary PTFE tested in shear as follows: The component carrying the fabric PTFE (or complete bearing at the option of the manufacturer) shall be subjected to the maximum vertical design load of the bearing and simultaneously, but transversely, a load equal to 13 percent of the vertical design load for a period of 1 minute. Slip or creep shall not exceed 3.18 millimeters during the test.

Bearings represented by test specimens passing all the above requirements will be approved for use in the structure.

7. **Shipping and packing**: Bearing assemblies including sole and masonry plates shall be securely fixed together as units so that they may be shipped to the jobsite and stored without relative movement of the bearing parts or disassembly at any time. Bearings shall be wrapped in moisture-resistant and dust-resistant material to protect against shipping and job site conditions. Care shall be taken to ensure that bearings at the job site are stored in a dry sheltered area free from dirt or dust until installation. Each completed bearing shall have its components clearly identified and marked on its top as to location in each structure in the project in conformity with the plans.

   When bearings are to be inspected on site, they shall be inspected within 1 week of arrival and may not be disassembled except under the supervision of the manufacturer. Following inspection, the wrapping shall be reapplied and the bearings kept clean until installation.

   Removal of sole and top plates of bearings for separate attachment to the structure is not permitted except under direct supervision of the manufacturer and with permission of the Engineer.

8. **Installation**: Bearings shall be evenly supported over their upper and lower surfaces under all erection and service conditions. Bearings shall only be lifted by their undersides or specially designed lifting lugs. When installing bearings, care shall be taken to avoid damage to and contamination of bearing surfaces.

   The centerlines of the bearing assembly shall be aligned with those of the substructure and superstructure. On guided bearings, special

care shall be taken to properly align the guiding mechanism with the designated expansion direction of the structure.

Bearing straps or retaining clamps shall be left in place as long as possible to ensure parts of bearings are not inadvertently displaced relative to each other. Care shall be taken to remove straps or clamps before normal structural movement takes place, such as post-tensioning.

The upper part of expansion and guided expansion bearings shall be located relative to the base of the bearing to compensate for deviations from normal atmospheric temperature.

When bearings will sit directly on concrete with only an elastomeric, preformed fabric or lead sheet beneath the bearing, concrete bearing seats shall be prepared at the correct elevation and bush-hammered or dressed to the following flatness tolerance:

Bearing seats up to 762 millimeters long, 1.59 millimeters.
Bearing seats over 762 millimeters but less than 1143 millimeters long, 2.34 millimeters.
Bearing seats over 1143 millimeters long, 3.18 millimeters.
There shall be no projecting irregularities exceeding 0.8 millimeters.
Bearing seats shall be level within 1:200 slope.

Where grouted bearing seats are used, the grout shall be the non-shrink type and of the strength specified on the contract drawings but not less than the concrete strength in the main support. Grout shall be placed at even density beneath the entire bearing surface without any voids or hard spots. Grout shall be allowed to reach optimum strength before placing any load on the bearing.

The mating surface of the superstructure shall be level within a slope of 1:200. There shall be no local projecting irregularities exceeding 0.18 millimeter.

The Contractor shall repair any damage to bearing finishes following installation.

Welding procedures shall be established by the Contractor to restrict the maximum temperature reached by the bonded PTFE surfaces to a maximum of 149 degrees Celsius and to restrict the maximum temperature reached by the elastomer (neoprene or natural rubber) to 121 degrees Celsius. Temperatures shall be determined by temperature-indicating wax pencils or other suitable means. No

load shall be transmitted to the bearings until erection of structural steel for spans contiguous to the bearing is substantially complete. Field welding of bearing plates shall be accomplished under the no load condition.

Particular care shall be exercised to mask and protect the PTFE and polished stainless steel surfaces to protect them from blast abrasives and paint application during construction.

9. **Shop drawings**: Shop drawings shall be submitted to the Engineer for review in accordance with Section 105.02. These drawings shall include but not be limited to the following:

   a. Plan and elevation view and section elevation of the bearing.

   b. Complete details of all components and sections showing all materials incorporated into the bearing.

   c. All ASTM or other material designations.

   d. Vertical and horizontal load capacity.

   e. Rotation and movement capacity.

   f. Compression stress on all sliding surfaces, as well as on the elastomeric surfaces, at maximum and minimum design loads.

   g. Complete design calculations.

   h. Shop paint or coating requirements.

(b) **Steel Plates, Shapes, and Bars**: Unless galvanizing is specified, items shall be painted in accordance with the plans.

(c) **Bronze Plates**: Sliding surfaces of bronze plates shall be polished.

(d) **Copper-Alloy Plates**: Finishing of rolled copper-alloy plates will not be required provided their surfaces are plane, true, and smooth.

(e) **Self-Lubricating Plates**: Plates shall be fabricated from cast bronze or rolled copper alloy.

Sliding surfaces of plates shall be provided with annular grooves or cylindrical recesses or a combination thereof, which shall be filled with a lubricating compound. The lubricating compound shall be compressed into recesses under sufficient pressure to form a nonplastic lubricating inset. The inset shall comprise at least 25 percent of the total area of the plate. The frictional coefficient shall be not more than 0.10. The

compound shall be free from material that will cause abrasive or corrosive action on metal surfaces and able to withstand extremely high pressures and atmospheric elements over long periods of time.

Items shall be the standard products of the manufacturer of such materials for the application.

Prior to assembly, the steel surface that will bear on the self-lubricating bearing plate shall be thoroughly lubricated with additional antioxidant lubricant furnished by the manufacturer. Coatings shall be removed before application of antioxidant lubricant.

(f) **Elastomeric Pads**: Care shall be taken in fabricating pads and related metal parts so that effects detrimental to their proper performance, such as uneven bearing and excessive bulging, will not occur.

(g) **Placement**: Bearing plates or pads shall have uniform bearing over the entire area. Provision shall be made to keep plates or pads in the correct position during erection of beams or placement of concrete.

Elastomeric pads and other flexible bearing materials shall be placed directly on masonry surfaces that have been finished to a roughness equivalent of a No. 36 to No. 46 grit. Pads, bearing areas, or bridge seats and metal bearing plates shall be thoroughly cleaned and free from oil, grease, and other foreign materials. Metal bearing plates or bottoms of prefabricated beams that are to bear on elastomeric pads shall be coated with epoxy Type EP-2, EP-4, or EP-5, conforming Section 243 and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit. Bearing areas shall be finished to an equivalent roughness.

Metal bearing plates shall be bedded on bridge seats as follows: The bridge seat bearing area shall be thoroughly swabbed with No. 1 paint, and three layers of duck, 410 to 510 grams per square millimeter, shall be placed on it, each layer being thoroughly swabbed with paint on its top surface.

Superstructure shoes or pedestals shall be placed in position while paint is plastic. As an alternate to duck and paint, sheet lead at least 2.5 millimeters in thickness or preformed fabric bedding material at least 3 millimeters in thickness may be used when called for on the plans or approved in writing by the Engineer.

Rockers or other expansion devices shall be centered and aligned so that the vertical axis will be vertical at 16 °C.

(h) **Anchors**: Anchor bolts, nuts, and washers shall be painted or galvanized on superstructures having steel beams or girders. When superstructure

units are concrete, anchor bolts, nuts, washers, bearing assemblies, and insert plates shall be galvanized. Shop paint shall cover the threaded end of the anchor to 25 millimeters below the surface of the masonry. Anchors shall be positioned to provide the required fit with bearing plates. Anchors shall be cast into the masonry and positioned by means of templates or other methods that will hold them securely in the correct position until concrete has set. The method of setting shall allow for proper finishing of the concrete bearing areas.

Anchors that are not designed to project through bearing plates shall be checked for proper projection above the masonry bearing area immediately prior to placement of bearing plates and beams. Nuts on anchor bolts at expansion ends shall be adjusted to permit free movement of the span.

Angles for anchor assemblies to be attached to sides of concrete beams shall not be installed until beams have received their full dead load and supporting falsework has been removed.

408.04—Measurement and Payment.

Metal bearing and expansion plates and anchors will be measured by shop scales in kilograms of actual material placed according to the plans. When not a separate pay item, the Department will include the masses of plates and anchors in the mass of structural steel or reinforcing steel for payment. When a pay item, bearing plates will be paid for at the contract unit price per kilogram and shall include elastomeric and other flexible bearing pads. Bearings and anchors for prestressed concrete deck units will be paid for as provided in Section 405. The cost of bedding and preparation for metal bearing plates shall be included in the prices for superstructure items. This price shall include furnishing material, galvanizing, painting, and lubricating.

Payment will be made under:

Pay Item	Pay Unit
Bearing plates	Kilogram

SECTION 409—STEEL GRID FLOORS

409.01—Description.

This work shall consist of constructing a steel grid floor.

409.02—Materials.

Materials shall conform to the requirements of Section 227.

409.03—Procedures.

The floor shall conform to the requirements for the design of steel grid floors of AASHTO's *Standard Specifications for Highway Bridges.*

(a) **Arrangement of Sections:** Where main elements are normal to the center line of the roadway, units shall generally be of such length as to extend over the full width of any roadway up to 12 meters. In every case, units shall extend over at least three panels. Where joints are required, ends of main floor units shall be welded at joints over their full cross-sectional area or otherwise connected to provide full continuity in conformance with the manufacturer's recommendations.

Where main elements are parallel to the center line of the roadway, sections shall extend over at least three panels, and ends of abutting units shall be welded over their full cross-sectional area or otherwise connected to provide full continuity in accordance with the approved design.

(b) **Provision for Camber:** Steel units so rigid that they will not readily follow the camber required shall be cambered in the shop. To provide a bearing surface normal to the crown of the roadway, the stringers shall be canted or provided with shop-welded beveled bearing bars. If beveled bars are used, they shall be placed along the center line of the stringer flange, in which case the design span length shall be governed by the width of the bearing bar instead of the width of the stringer flange.

Longitudinal stringers shall be cambered at the mill or provided with bearing strips so that the completed floor after dead-load deflection shall conform to the longitudinal camber shown on the plans.

(c) **Field Assembly:** Areas of considerable size shall be assembled before the floor is welded to its supports. Main elements shall be made continuous, and sections shall be connected together along their edges by welding of bars. Connections shall be approved by the Engineer.

(d) **Connection to Supports:** The floor shall be connected to its steel supports by welding. Before any welding is done, the floor shall be loaded to make a tight joint with full bearing or clamped down. The location, length, and size of the welds shall be as approved but in no case less than the manufacturer's standards.

Ends of main steel units of the slab shall be securely fastened together at sides of the roadway for the full length of the span by means of steel plates or angles welded to ends of main units or by encasing ends with concrete.

(e) **Welding:** Welding shall conform to the requirements of Section 407.

(f) **Damaged Galvanized Coatings:** Damaged coatings shall be repaired in accordance with the requirements of Section 233.

(g) **Concrete Filler:** Floors with open bottom flanges shall be provided with bottom forms of metal or wood to retain the concrete filler.

If metal form strips are used, they shall fit tightly to bottom flanges of floor units and be placed in short lengths extending approximately 25 millimeters beyond the edge of each support. The form shall be such as will result in the adequate bearing of the slab on the support.

Concrete shall be placed and cured in accordance with the requirements of Section 404 and thoroughly consolidated by vibrating the steel grid floor. The vibrating device and manner in which it is operated shall be subject to the approval of the Engineer.

(h) **Painting:** Steel grid flooring furnished without galvanizing but with a shop coat of paint shall be painted in accordance with the requirements of Section 411.

If a structural steel plate is used on the bottom of a filled floor, the bottom surface of the plate shall be painted in accordance with the requirements of Section 411.

409.04—Measurement and Payment.

Steel grid floors will be measured in square meters of surface area, complete-in-place, and will be paid for at the contract unit price per square meter.

Payment will be made under:

Pay Item	Pay Unit
Steel grid floor	Square meter

SECTION 410—RAILINGS AND PARAPETS

410.01—Description.

This work shall consist of furnishing and installing railings, bridge median barriers, and concrete parapets reasonably true to the line, grade, and dimensions shown on the plans or as established by the Engineer.

410.02—Materials.

(a) **Concrete** shall conform to the requirements of Section 217. In the event the Contractor places concrete by the extrusion method, the slump may be less than 50 millimeters, the air content shall be no less than 4 percent, and coarse aggregate shall be no less than No. 7.

(b) **Steel reinforcement** shall conform to the requirements of Section 223.

(c) **Steel for metal parapets** shall conform to the requirements of Section 226.

(d) **Hydraulic cement mortar and grout** shall be nonshrinking and shall conform to the requirements of Section 218.

(e) **Aluminum railings and materials** shall conform to the requirements of Section 229.

(f) **Anchor bolts** shall conform to the requirements of Section 226.

410.03—Procedures.

(a) **Post Alignment:** Posts shall be normal with respect to the profile grade and plumb in the transverse direction regardless of the cross slope.

(b) **Metal Railings:** Fabrication and erection shall be performed in accordance with the requirements of Section 407. Working drawings shall be furnished in accordance with the requirements of Section 407. In welded railing, exposed joints shall be finished by grinding or filing to give a neat appearance.

When alternate metal railings are permitted, bridges under any one contract shall have the same type of railing.

Metal railings shall be carefully adjusted prior to being fixed in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled wherever possible with railing in place at the proper grade and alignment.

Abutment ends of metal rails and metal parapets shall be grounded. Grounding shall be accomplished by using a No. 6 AWG, bare or insulated, stranded copper conductor securely affixed to end units and ground rods. Ground rods and other grounding material shall

conform to the requirements of Section 238 and shall be installed in accordance with the requirements of Section 705. Movable joints of metal railings and metal parapets shall be bonded internally wherever possible. Ground wire shall pass through bridge parapets and backwalls in 25-millimeter PVC conduit to a point 100 millimeters to 200 millimeters below the finished grade and attached to-a ground rod at least 3 meters in length. Each run of wire shall be provided with a 100-millimeter exposed loop.

1. **Painting:** Steel or iron railing that is not galvanized shall be given one shop coat and three field coats of paint after erection. Painting shall be in accordance with the requirements of Section 411.

2. **Anchorages:** Metal railing anchorages in concrete shall be placed in accordance with the requirements of Sections 404 and 408.

3. **Aluminum railings:** Components of railing shall be designed for adequate structural strength. Castings shall have a thickness of at least 6 millimeters, and other units shall have a thickness of at least 5 millimeters.

   Aluminum in contact with concrete shall be coated with an approved aluminum-impregnated caulking compound. Aluminum surfaces in contact with metals other than stainless or galvanized steel shall be insulated with approved materials.

(c) **Concrete Railings, Bridge Median Barriers, and Parapets:** Concrete railings or parapets shall not be placed until centering or falsework for the span has been released, rendering the span self-supporting.

Railings, bridge median barriers, and parapets shall be constructed in accordance with the requirements of Section 404, for the class of concrete specified on the plans, and shall be given a Class I finish. Care shall be taken to secure smooth and tight-fitting forms that can be rigidly held to line and grade and removed without damage to concrete. Concrete parapets and median barriers shall be constructed within an allowable tolerance of ±13 millimeters for overall depth and overall width, ±6 millimeters for the width of the upper portion of the barrier, and ±6 millimeters per 3 meters for horizontal alignment.

Forms for concrete railing shall be fabricated of single-width boards lined with approved material. Form joints in plane surfaces will not be permitted.

Moldings, panel work, and bevel strips shall be constructed with neatly mitered joints. Corners in finished work shall be true, sharp, clean cut, and free from cracks, spalls, or other defects.

Reinforcing steel shall be placed in accordance with the requirements of Section 406.

Expansion joints shall be constructed so as to permit freedom of movement. After all other work is completed, loose or thin shells of mortar likely to spall under movement shall be removed from expansion joints by means of a sharp chisel.

In the event the Contractor elects to construct railing, parapet, or median barrier by the extrusion method, construction shall conform to the following:

1. In the event the bridge deck needs to be widened or additional reinforcing steel placed in the railing, parapet, or median barrier to accommodate the extrusion machine, the Contractor shall submit all necessary details for approval. Cost for widening the bridge deck or placement of additional reinforcing steel shall be at the Contractor's expense.

2. The extrusion machine shall be equipped with internal vibrators to consolidate concrete along the face and adjacent joints in one complete pass of the machine. This shall be accomplished in such a manner that a minimum of hand finishing will be required to produce a dense homogenous finish, free from voids and honeycomb.

3. When the plans require horizontal drains in the railing, parapet, or median barrier, the Contractor shall submit his proposed method of forming drains to the Engineer for approval.

4. Deflection and expansion joints shall be grooved in accordance with the plans immediately after the extrusion process, and all required saw cutting shall be completed the same day the concrete is placed.

410.04—Measurement and Payment.

Railing will be measured in meters along the center line of the top rail between the extremities of each railing, without deductions for breaks or interruptions. When railing is not a pay item, the cost thereof shall be included in the price for other appropriate items. When a pay item, railing will be paid for at the contract unit price per meter. This price shall include furnishing rails, rail

posts, post bearing pads, anchor assemblies, and sleeves; furnishing and installing grounding materials; painting; and galvanizing.

Parapets will be measured in meters along the face of the parapet, and **bridge median barriers** will be measured in meters along the barrier center line. Parapets and bridge median barriers will be paid for at the contract unit price per meter. This price shall include furnishing and installing materials designated above the bridge deck surface, including anchorage material and reinforcing steel.

Payment will be made under:

Pay Item	Pay Unit
Railing (Type)	Meter
Parapet (Type)	Meter
Bridge median barrier (Type)	Meter

SECTION 411—PROTECTIVE COATING OF METAL IN STRUCTURES

411.01—Description.

This work shall consist of preparing and coating ferrous metal surfaces on new and existing structures, including, but not limited to, main units, diaphragms, bearing assemblies, shop and field contact surfaces, surfaces in contact with concrete, parts designed to be embedded in concrete, rails, expansion joints, drainage systems, utility lines, and attachments, in accordance with these specifications.

411.02—Materials.

(a) **Paint** shall conform to the requirements of Section 231.

(b) **Water used in cleaning operations** shall be potable.

(c) **Abrasives used in cleaning operations** shall be from the Department's approved products list.

411.03—Procedures.

Galvanized surfaces and surfaces protected with other coatings shall not be painted. Cast, ductile, and nodular iron castings need not be painted.

(a) **Mixing Paint:** Paint shall be mixed in accordance with the requirements of the manufacturer's instructions. Paint shall be continuously mixed during application. Zinc-rich paints shall be applied from containers equipped with a mechanical agitator, which shall be in motion throughout the application period. Paint shall not be thinned without the prior approval of the Engineer. All multi-component paints shall be mixed prior to use with a power mixer. Each individual component shall be mixed prior to its being mixed together with other components.

(b) **Preparing Surfaces To Be Coated:** The Contractor shall prevent dust and dirt from coming in contact with surfaces during surface preparation and painting operations.

Prior to painting, surfaces shall be free from rust, loose or brittle paint, chalking, oil, grease, salt contaminants, dirt, and other substances that would prevent film from adhering tightly. Loose or brittle paint is defined as that which is obviously deteriorated and that which has an adherence rating less than a 3B rating when tested by the cross-cut test, Method B of ASTM D3359, except a 5-millimeter guide may be used for coatings thicker than 0.13 millimeter.

Connections, small cracks, and cavities that are not sealed in a watertight manner and depressed areas on flanges shall be filled as specified in Section 407.

Prior to application of coating, the surface shall be prepared according to one of the following methods:

Method 1: Solvent, steam, and alkaline washing shall remove oil, dust, dirt, grease, concrete, chalking, and salt contaminants in accordance with the requirements of SSPC-SP-1. Solvent and alkaline washing shall not be used in field operations unless approved by the Engineer.

The Contractor shall collect all waste water, test it for hazardous waste, and dispose of it properly.

Method 2: Hand-tool cleaning shall remove loose paint, loose rust, and loose mill scale in accordance with the requirements of SSPC-SP-2.

Method 3: Power-tool cleaning shall remove loose paint, loose rust, and loose mill scale in accordance with the requirements of SSPC-SP-3.

Method 4: Power-tool cleaning shall remove paint, rust, and mill scale to bare metal in accordance with the requirements of SSPC-SP-11. The cleaning shall produce a profile of at least 0.025

millimeter, and stains may remain on not more than 0.0625 centimeter of surface.

Method 5: Abrasive blast cleaning shall remove paint, rust, and mill scale except that stains from each may remain on not more than 0.0625 centimeter of surface.

Abrasive blast cleaning shall conform to the requirements of SSPC-SP-10, Near White Blast Cleaning. Abrasives shall be recycled. Cleanliness of the abrasive shall be verified prior to start up and at least one time per 8-hour shift in accordance with the requirements of VTM-82.

After abrasive blast cleaning, the surface profile shall be from 0.025 to 0.075 millimeter in a dense uniform pattern of depressions and ridges as determined by the Keane-Tator surface profile comparator or Testex tape or its equivalent. Shop-blasted surfaces shall be painted within 24 hours, and field-blasted surfaces shall be painted the same day. If rust bloom develops, blast cleaning shall be repeated.

Method 6: Brush-off blasting shall remove loose or brittle paint, loose rust, and loose mill scale in accordance with the requirements of SSPC-SP-7.

Abrasives for Type A and B structures shall be from the Department's approved products list.

(c) **Application:** Paint shall not be applied under the following conditions, unless recommended by the manufacturer and approved by the Engineer. A manufacturer's more stringent application guidelines shall be adhered to with the approval of the Engineer.

1. when the temperature of the air, paint, or metal is below 4 °C

2. when the temperature of the air, paint, or metal is expected to fall below 4 °C before the paint has cured

3. when snow, sleet, or rain is falling

4. when moisture is visible on metal

5. when humidity is above 85 percent

6. when the temperature of the metal in the structure would cause blistering per the manufacturer's product data sheet

7. when the surface temperature is less than 3 °C above the dew point or is expected to fall to that point before the paint has dried or cured

The surface shall be dry prior to application of paint. Painting shall be performed in a neat and orderly manner by brushing, rolling, or spraying as recommended by the manufacturer. However, rollers, daubers, or sheepskins shall not be used to apply zinc-rich paints. Zinc-rich paints may be applied by a brush to isolated areas of 0.09 square meter or less.

Application of paint shall provide a tight film of specified uniform thickness well bonded to metal or underlying coatings, including crevices and corners, and shall be free from laps, streaks, sags, runs, overspray, dry spray, shadow through, skips, excessive film build-up, mud cracking, misses, and other defects. Edges shall be striped with a longitudinal motion and bolt heads and nuts with a rotary motion followed immediately by application of the full coat. A stripe coat will not be required for zinc-rich primer.

Deficient, impaired, or damaged areas of each coat shall be repaired using material from the Department's approved systems list. Two-component, solvent-based, inorganic zinc shall be considered cured when only trace amounts are removed in accordance with the requirements of VTM 67.

Paint coatings shall have an adherence rating of at least 3B when tested by the cross-cut test, Method B of ASTM D3359, except that a 5-mm guide may be used for paint coatings thicker than 0.125 mm (0.13 mils).

Paint shall not be applied until each preceding coat has dried or cured in accordance with the requirements of the manufacturer's recommendations and has been approved by the Engineer. Paint shall be applied in accordance with the requirements of Table IV-6.

TABLE IV-6
Paint Systems

System	Coat	Paint	Min. Dry Film Thickness (DFT) (mm)
A	Primer	No.1	0.050
	Intermediate	No. 8, Federal No. 595-20219	0.063
	Finish	No. 8, color as specified	0.063
AA	Primer	No. 1	0.050
	Intermediate	No. 13 (nonleafing)	0.025
	Finish	No. 13 (leafing)	0.025
B	Primer	Zinc-rich (from approved systems list)	
	Intermediate		
	Finish		
F	Primer	No. 14	0.125
	Finish	No. 14	0.125
W	1st Primer	No. 101 Federal No. 595-30045	0.050-0.10
	2nd Primer	No. 102,White	0.050-0.10
	Intermediate	No. 103 Federal No. 595-20219	0.050-0.10
	Finish	No. 103[1]	0.050-0.10[2]

[1]Color as specified. If not specified, color shall be Federal No. 595-26307.

[2]DFT shall be no less than the specified thickness; however, it shall completely cover the intermediate coat.

(d) **Measuring Film Thickness:** The dry-film thickness of paint will be determined by the Engineer with a Tooke gage when the thickness of previous paint coats is not known and with a magnetic dry-film thickness gage when the previous thickness is known. The magnetic gage will be used and calibrated in accordance with the requirements of SSPC-PA-2 except that the 20 percent tolerance will not be allowed. The Contractor shall repair test areas at his own expense.

411.04—New Structures.

Nonstainless ferrous metal shall be painted using System B as specified in Table IV-6.

(a) **Shop Painting:** Metal surfaces to be painted shall be abrasive blast cleaned in accordance with the requirements of Method 5 prior to application of primer.

Corrections shall be performed prior to shipment.

Material shall not be shipped until the primer has cured.

Machine-finished surfaces or portions thereof that are to bear on other surfaces in a sliding movement shall not be painted but shall be coated with a multipurpose grease or other specified coating prior to shipment.

Erection and weight marks shall be stenciled or painted on structural steel subsequent to application of shop primer. No other lettering will be allowed.

The following areas of weathering steel fabricated in accordance with the requirements of ASTM A709, Grade 50W (ASTM A588), shall be painted when these areas are within 1.5 meters of a deck joint: cross frames, diaphragms, stiffeners, connector plates, girders, and beams, including the entire outside surface of fascia girders and beams. These areas shall be thoroughly cleaned to no less than 150 millimeters outside the area to be painted and shall be painted with System B.

(b) **Field Painting:** Field painting shall not be performed until concrete work is completed and forms are removed. Concrete deposited on painted steel surfaces shall be removed. Prior to painting, surfaces shall be steam washed in accordance with the requirements of Method 1. All unpainted surfaces and deficient or damaged areas shall be cleaned in accordance with Method 4 or 5 and primed with a touch up primer from System B.

After installation and approval by the Engineer, erection bolts shall be degreased, blasted, and coated as required by the System B approved systems list. Galvanized or other bolts protected with approved coatings shall not be blasted but shall be degreased and coated with intermediate and topcoats from the approved list.

Surfaces that will be inaccessible after assembly and erection shall be painted prior to assembly.

When the superstructure is concrete, the color of bearing assemblies shall be gray, Federal No. 595-26307.

The finish paint for weathering steel fabricated in accordance with the requirements of ASTM A709, Grade 50W (ASTM A588), shall be brown, Federal No. 595-20059. Other structures shall have gray finish paint, Federal No. 595-26173, unless otherwise specified on the plans. When only portions of a structure are designated for painting, the edges of painted areas shall be masked to a straight line.

411.05—Existing Structures.

Painted steel structures built before 1978 and structures of weathering steel fabricated in accordance with the requirements of ASTM A709, Grade 345W (ASTM A588), may contain mill scale.

Painting will be specified as follows:

1. **Prepare and spot paint existing structure:** Prepared areas shall be spot painted with primer(s) from the system specified. Intermediate and finish coats shall be applied to spot-painted areas only. The paint system shall be as specified on the plans. If no system is specified, System W shall be used.

2. **Prepare and paint existing structure:** Prepared areas shall be spot painted with primer(s) from the system specified. Intermediate and finish coats shall be applied to the entire structure. The paint system shall be as specified on the plans. If no system is specified, System W shall be used.

3. **Repaint existing structure:** The entire structure shall be cleaned to bare metal in accordance with the requirements of Method 4 or abrasive blast cleaned in accordance with the requirements of Method 5. The structure shall be repainted using System B.

Prior to surface preparation, surfaces shall be steam washed in accordance with the requirements of Method 1.

Rust shall be removed in accordance with the requirements of Method 4 or 5 on areas to be painted. Deteriorated paint or paint with an adhesion rating of less than 3B, when determined in accordance with ASTM D3359, Method B, except a 5-millimeter guide may be used for existing coatings greater than 0.125 millimeter, shall be removed until an intact and adherent paint film or bare

metal is attained as determined by the Engineer. When the existing finish is an aged coating to which new paint will not adhere without roughening as determined by the Engineer, the entire structure shall receive a brush-off blast as specified in Method 6.

Existing steel on structures to be widened shall not be prepared and painted. When shown on the plans for painting, coating on the existing structure shall be removed in accordance with the requirements of Method 4 or 5 and the existing structure shall be painted with the same system as required on the new steel.

Unpainted weathering steel fabricated in accordance with the requirements of ASTM A709, Grade 50W (ASTM A588), shall be cleaned in accordance with the requirements of Method 4 or 5 and shall be painted with System B. Steel within 1.5 meters of a deck joint shall be painted; these members shall include but not be limited to cross frames, diaphragms, stiffeners, connector plates, girders, and beams including the entire outside surface of fascia girders and beams. Application of paint shall conform to the requirements of Section 411.03 (c).

If a winter season elapses between application of coats, the structure shall be steam washed in accordance with the requirements of Method 1 prior to painting.

411.06—Painting Galvanized Surfaces.

Prior to painting, galvanized surfaces shall be steam washed in accordance with the requirements of Method 1. The surface shall be painted with System W.

411.07—Environmental Protection.

In accordance with the requirements of Section 107, the Contractor shall protect the health and safety of the workers, the public, and the environment from leaded paint or hazardous material resulting from removal operations, blast abrasive, rust, and overspray. Before commencing operations, the Contractor shall submit to the Engineer a detailed site-specific worker health and protection plan and detailed environmental plan. The environmental plan shall be reviewed by a Professional Engineer, registered in Virginia, and certified as to the design acceptability for the structural load of the containment system. These plans shall not be submitted to the Engineer for approval but shall be submitted for the Engineer's records.

Visual inspection shall be performed continuously. Emissions will not be permitted from the containment system into the outside air. In the event

emissions do occur, the Contractor shall cease operations until corrective actions are completed.

The environmental plan shall include controls for capture, containment, collection, storage, and transportation of disposable material generated by the work in compliance with Section 107.14 and the regulations of the following agencies: EPA, U.S. Department of Transportation, Department of Environmental Quality, Virginia Department of Labor and Industry, and the U.S. Coast Guard. The Contractor shall use the most effective method possible for collection, containment, and transportation operations. Plans shall include measures for accidental spill cleanup.

The worker health and protection plan shall be in accordance with the Virginia Occupational Safety and Health Administration requirements, 29CFR 1926.62 requirements, and the applicable requirements of 29CFR 1910.1025 whichever are strictest.

The environmental and worker health plans shall be approved by a Certified Industrial Hygienist (CIH), certified by the American Board of Industrial Hygiene. The CIH or a designated representive shall be present during start-up, surface preparation, and removal operations to ensure human safety and environmental protection. The CIH shall submit written certification at the completion of project that the plans fully complied with all regulations and that the plans were fully implemented. A CIH will not be required on structures where weathering steel is being painted.

(a) **Classification of Structures:** Structures to be prepared and painted will be classified by the Department as follows:

1. **Type A:** structures that have no coatings.

2. **Type B:** structures that have coatings that may generate hazardous wastes or pose hazards for employees, including but not limited to lead, chromium, and cadmium.

(b) **Requirements:** Depositing or dropping spent materials into water, onto the ground, onto roadways, or outside the containment system will not be permitted. Waterways shall be protected against paint drift and overspray. All containment devices shall be decontaminated prior to relocating or moving.

Material removed from Type A structures shall be disposed of as a nonhazardous waste in accordance with the requirements of (c)1. herein.

Material removed from Type B structures shall be contained, collected, and stored. The Department will sample and test the spent material,

and if the sample tested is hazardous, the material shall be disposed of in accordance with the requirements of (c)2. herein.

Each structure shall have a separate storage area for spent material. The Contractor shall collect the material at the end of each workday and shall transport the spent material to the storage area in a closed container that will not permit leakage.

The storage site may contain spent material from various structures provided material from each structure is labeled and stored separately.

The site for the temporary storage of the spent material shall be approved by the Engineer and shall not be located within a flood plain or drainage area or where water will pond. The site shall have a berm around the perimeter to ensure spill control. Containers of disposable material shall be covered with waterproof coverings, and the site shall be secured.

(c) **Disposal:**

1. Disposable material from Type A and from Type B structures that is determined by the Department not to be a hazardous waste shall be disposed of in a sanitary landfill that has a permit from the Virginia Department of Environmental Quality. The Contractor shall identify the landfill used by name, address, and permit number and shall certify that the spent material was properly disposed.

2. If spent material from Type B structures is classified as a hazardous waste, the Contractor shall obtain a provisional generator number in accordance with the applicable federal and state regulations and shall legally store, pack, label, and ship such material by a transporter with a Virginia Hazardous Waste Transporter permit to a RCRA, Subtitle C, Treatment, Storage and Disposal Facility (TSDF) for treatment and disposal. The Contractor shall provide a copy of the shipping manifest signed and dated by the licensed TSDF designated in the shipping manifest.

411.08—Measurement and Payment.

Painting of metal in structures will not be measured for separate payment but shall be included in the price for structural steel or metal items. When a pay item, painting of metal in structures will be paid for at the contract lump sum price per structure.

Prepare and spot paint existing structure, when a pay item, will be measured in square meters of surface area and will be paid for at the contract unit price per square meter.

Prepare and paint existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

Repaint existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

These prices shall include washing, surface preparation, and applying paint.

Environmental protection will be paid for at the contract lump sum price per structure. This price shall include containment operation, monitoring regulations, providing CIH services, worker protection, and other related costs.

Disposal of material will be paid for at the contract lump sum price per structure. This price shall include transporting, storing, and disposal.

Payment will be made under:

Pay Item	Pay Unit
Painting of metal in structures (B or Str. No.)	Lump sum
Prepare and spot paint existing structure (B or Str. No. and type)	Square meter
Prepare and paint existing structure (B or Str. No. and type)	Lump sum
Repaint existing structure (B or Str. No. and type)	Lump sum
Environmental protection (B or Str. No.)	Lump sum
Disposal of material (B or Str. No. and type)	Lump sum

SECTION 412—WIDENING, REPAIRING, AND RECONSTRUCTING EXISTING STRUCTURES

412.01—Description.

This work shall consist of widening, repairing, or reconstructing existing structures in accordance with plan details and these specifications or as directed by the Engineer.

412.02—Materials.

(a) **Epoxy and mineral fillers** shall conform to the requirements of Section 243. Epoxy for epoxy mortar shall be Type EP-5. Epoxy used for crack repair shall be Type EP-4 or EP-5, low viscosity.

(b) **Hydraulic cement concrete and latex hydraulic cement concrete** shall conform to the requirements of Section 217 except that coarse aggregate shall be No. 7 or No. 8 for depths and steel clearances less than 50 millimeters and may be No. 57, No. 7, or No. 8 for depths more than 50 millimeters. An approved accelerator may be permitted when justified by traffic conditions.

(c) **Reinforcing steel** shall conform to the requirements of Section 406.

(d) **Accelerators** shall be noncorrosive and shall be approved by the Engineer.

(e) **Materials for shotcrete** shall be as follows:

1. Portland and blended cements shall conform to the requirements of Section 214.

2. Fly ash, slag, and silica fume shall conform to the requirements of Section 215.

3. Water shall conform to the requirements of Section 216.

4. Air-entraining admixtures shall conform to the requirements of Section 215.

5. High-range and regular water reducers shall conform to the requirements of Section 215.

6. Accelerators shall conform to the requirements of Section 215 but may be used only if approved by the Engineer. If used, they shall be added at the nozzle.

7. Fine aggregates shall conform to the requirements of Section 202 for Grading A. Coarse aggregates shall conform to the requirements of Section 203 for size No. 8.

8. Steel fibers shall have a minimum length of 19 millimeters and a diameter between 4 and 6 millimeters. They shall have bent or deformed ends or be continuously deformed throughout.

9. Synthetic fibers shall have a minimum length of 19 millimeters and shall have demonstrated long-term resistance to deterioration in concrete.

(f) **Welded wire fabric** shall conform to the requirements of Section 223 and shall be galvanized or epoxy coated.

(g) **Expansion bolts** shall conform to the requirements of Section 226.02(d).

412.03—Procedures.

Repairing concrete structures shall consist of removing and replacing deteriorated material, thoroughly cleaning exposed concrete surfaces and reinforcing steel, and replacing reinforcing steel. Cleaning shall be performed by sandblasting, waterblasting, or other approved methods to remove concrete, rust, oil, and other foreign materials detrimental to achieving a bond. The area and depth of repairs shall be as directed by the Engineer.

Dimensions of existing structures shown on the plans are approximate, and those that are pertinent to the construction of the new portion shall be check measured in the field by the Contractor. Where details of new portions of the structure shown on the plans are not adaptable to the shape of the existing structure, practical modifications may be made during construction with the approval of the Engineer provided neither the existing nor the new portions are impaired in structural strength.

Areas to be repaired shall be outlined with saw cuts to a depth of at least 25 millimeters or to a depth that will clear the top of the reinforcing steel.

Loose and unsound materials shall be removed by the use of hand tools or pneumatic hammers having a mass of 14 kilograms or less. Pneumatic hammers shall be worked at an angle of 45 to 60 degrees to the plane of the concrete surface being removed. The surface shall be sounded with a masonry hammer to determine the relative concrete strength.

When reinforcing bars are exposed, the exposed length shall be cleaned. Epoxy-coated steel shall not be cleaned by sandblasting. Damaged epoxy coating shall be repaired in accordance with the requirements of Section 243. Care shall be taken to prevent striking reinforcing bars with hammer points. Reinforcing steel that has lost 1/4 or more of its original cross-sectional area shall be lapped with new bars of the same size and shape. New bars shall lap existing bars a length of 30 diameters on each side of the damaged portion if a sufficient length of the existing bar is exposed. Otherwise, new bars shall be welded with a 150-millimeter arc-welded lap on each side of the damaged portion with a double-flare V-groove weld in accordance with

the requirements of Section 407 or mechanically connected in accordance with the requirements of Section 406.

Dust and debris shall be removed by blowing with compressed air or hosing with water. A fine spray of moisture shall be applied to the surface to outline, as it evaporates, loose fragments that are locked in place. Just prior to placement of repair material, the surface shall be cleaned.

Unsupported areas shall be supported with forms.

Excess material and debris resulting from repairs shall be removed and disposed of in an approved disposal area in accordance with the requirements of Section 106.04.

Wherever concrete is placed against existing concrete, dowels at least 19 millimeters in diameter shall be placed at no more than 750 millimeters center to center over the entire jointing surface and 150 to 300 millimeters from the edge. Dowels shall be placed perpendicular to the surface of existing concrete by drilling and grouting and shall project into both new concrete and existing concrete to a depth as great as the thickness of the concrete will allow but need not project more than 230 millimeters.

For footings and neat work of substructures where joining planes are vertical, 19-millimeter headed expansion bolts shall be used instead of dowels. Bolts shall project at least 230 millimeters into new concrete and shall extend sufficiently far into existing concrete to develop their rated pullout strength, but not less than 150 millimeters. When drilling holes for expansion bolts, care shall be taken so that existing reinforcing steel is not damaged.

Where necessary to prevent featheredges, existing concrete shall be removed to ensure a thickness for new concrete of at least 150 millimeters.

Concrete shall be constructed in accordance with the requirements of Section 404 except that surfaces shall be finished to match the existing adjacent surfaces. Superstructure concrete shall be Class 30, and substructure concrete shall be Class 20.

(a) **Bridge Superstructure Repairs:**

1. **Type A milling** shall consist of milling the surface of the bridge deck and concrete approaches to a depth of at least 13 millimeters.

   Equipment shall be capable of removing material to the required depth while maintaining a reasonably uniform surface without damaging adjacent areas or the remaining material. Milling equipment shall be capable of removing at least 13 millimeters

per pass. Power driven hand tools for removing unsound concrete around reinforcing steel and in confined areas will be required.

2. **Type A patching** shall consist of repairing the deck from the existing deck surface or milled surface to a depth that will not expose reinforcing steel.

3. **Type B patching** shall consist of repairing the deck from the existing deck surface or milled surface to a depth at least 25 millimeters below the top mat of reinforcing steel.

4. **Type C patching** shall consist of repairing the deck from the existing deck surface or milled surface to its full depth. Forms may be suspended from reinforcing steel by wire ties for areas of less than 0.3 square meter. In the case of larger area openings, forms shall be supported by blocking. Sound concrete shall be removed to obtain a somewhat vertically shaped surface at the edges of the patch.

5. **Epoxy-mortar patching** shall be performed in accordance with Type A patching and to a depth up to and including 19 millimeters. Proportions of sand and epoxy shall be approved by the Engineer. Surface areas to be patched shall be dry and primed with neat epoxy just prior to mortar placement. Mortar may be troweled in place to feather edges. The patched surface shall be sprinkled with sand before the epoxy sets or sandblasted just prior to placement of the seal to ensure bonding. When epoxy mortar is to be the finished riding surface, patches exceeding 2.4 meters in a longitudinal direction shall be tested in that direction in accordance with the requirements of Section 404.04.

6. **Crack repairs** shall be performed as follows: Structural cracks and dormant cracks shall be V-grooved to a depth of approximately 13 millimeters and blown clean. The groove shall be filled with neat epoxy. At the Contractor's option, latex concrete may be brushed into the groove in lieu of epoxy when latex concrete is monolithically placed for Type A, B, or C patching or joint repairs.

7. **Concrete superstructure surface repair** shall include repairing raised medians, median barriers, beams, diaphragms, parapets, posts, rails, curbs, and sidewalks. Superstructure surface repair shall be performed in accordance with Type B patching.

   When the thickness of the surface repair is 50 millimeters or more, 50 millimeter by 50 millimeter MW 9.1 by MW 9.1 welded wire fabric shall be used. The fabric shall be tied to reinforcing

steel where possible. If reinforcing steel is not exposed or if the steel has a spacing greater than 450 millimeters, expansion bolts 10 millimeters in diameter shall be placed and the fabric tied to the bolts. The expansion bolts shall be spaced not more than 450 millimeters apart and shall be embedded at least 50 millimeters into the concrete. The minimum thickness of Class A and Class B shotcrete over reinforcing steel, including expansion bolts and welded wire fabrics, shall be 50 millimeters, except in transition areas where shotcrete is feathered to existing concrete with less than 50 millimeters of cover or where patches are made on existing concrete with less than 50 milllimeters of cover. Where shotcrete containing silica fume is used, the minimum cover over reinforcing steel shall be 40 millimeters.

8. **Joint opening repairs** shall be performed as follows: Expansion joint removal shall consist of removing and disposing of concrete, repairing and replacing reinforcing steel, and cleaning exposed surfaces.

   Expansion joint reconstruction shall consist of removing and disposing of concrete, repairing and replacing reinforcing steel, cleaning exposed surfaces, and recasting the joint to the limits detailed with hydraulic cement concrete.

   When not included in other joint repairs, saw cutting of the joint shall consist of saw cutting concrete to the limits detailed.

(b) **Bridge Deck Overlay Repairs:** Overlays shall not be placed until deck repair concrete has attained 93 percent of the minimum design compressive strength. Vehicular traffic will not be permitted on the bridge until the overlay has attained a compressive strength of 24 megapascals.

Unless otherwise specified, the Contractor may use latex hydraulic cement concrete or silica fume hydraulic cement concrete in the overlay.

Expansion joints and dams shall be maintained through the overlay. A bulkhead equal in thickness to the width of the joint shall be installed to the required grade and profile prior to concrete placement.

A construction dam or bulkhead shall be installed in the case of a major delay in placement operations. During minor delays of 1 hour or less, the end of the placement shall be protected from drying.

1. **Latex or silica fume:** Within 24 hours immediately preceding the beginning of the overlay operations, the entire surface to be overlaid and the edge of previously placed overlay shall be

thoroughly cleaned. This shall include the widened portion of bridge decks that are specified to be overlaid with latex or silica fume concrete.

For at least 1 hour prior to placement of overlay concrete, the surface shall be continuously and thoroughly water soaked. Puddles of standing water shall be removed before overlay is placed.

Overlay shall be placed only when the ambient air temperature is 10 °C and rising. At temperatures above 30 °C, the Engineer may require placement to be made at night or during early morning hours if a satisfactory surface finish is not being achieved.

Mixers for latex hydraulic cement concrete shall be batch mixers or automatic mobile continuous mixers conforming to the requirements of Section 217. The mixing capacity shall be such that placing and finishing operations can proceed at a uniform rate, with final finishing completed before formation of the plastic surface film. A yield test shall be performed by the Contractor prior to deck placement for each mixing unit, when each unit is moved from the job site for recharging, when the source of stockpiled materials is changed, and when there is reason to believe that the calibration may be erroneous. Mixers for silica fume concrete shall be truck mixers conforming to the requirements of Section 217. The amount mixed shall be such that the placing and finishing operations can proceed at a uniform rate. The latex concrete shall be uniform in composition and consistency when discharged from the mixer.

The overlay shall have a thickness of at least 32 millimeters of latex or silica fume hydraulic cement concrete. At the Contractor's option, latex or silica fume concrete may be used in lieu of hydraulic cement concrete as required for Type A, B, or C patching, or joint and crack repairs, and such material shall be placed monolithically with the overlay.

Prior to placement of the overlay, a portion of the latex or silica fume concrete shall be brushed onto the prepared surface. Care shall be taken to ensure that both vertical and horizontal surfaces receive a thorough even coating and that the rate of progress is limited so that the brushed material does not become dry before it is covered with additional material and brought to final grade. Excess coarse aggregate remaining after brushing shall be removed.

If the rate of evaporation of surface moisture from the latex modified or the silica fume concrete exceeds 0.25 kilogram per square meter per hour during placement, measures shall be taken to reduce the rate of evaporation. One effective method is to increase the relative humidity near the surface by fogging.

The surface shall be protected from drying or cracking by prompt application of wet burlap. Care shall be taken to ensure that the burlap is well drained and that it is placed as soon as the surface will support it without deformation. The burlap and surface of the concrete shall be maintained in a continuously moist condition during the initial curing period. For the latex concrete, the initial moist curing period shall be 48 hours, unless otherwise specified, followed by an additional 48 hours of air curing before opening to traffic. For the silica fume concrete, the initial moist curing period shall be 72 hours, unless otherwise specified, followed by the immediate application of a liquid membrane-forming curing compound conforming to Section 220. The curing compound shall be completely dry before opening the overlay to traffic.

2. **Polymer:** Polymer overlays shall be placed in accordance with the applicable special provisions.

(c) **Removing Asphalt Concrete Overlay:** Removal of the asphalt wearing surface from bridge decks and approach slabs shall be performed in a manner such that underlying sound concrete can be prepared to receive necessary treatment. The asphalt material shall be disposed of in an approved manner. Sound concrete damaged as a result of the Contractor's operations shall be repaired in accordance with (a) herein at the Contractor's expense. Fuel oils or other materials that will prevent subsequent treatments from bonding to remaining concrete shall not be used.

(d) **Bridge Substructure Repairs:** Concrete substructure surface repair shall include repairing piers, wing blocks, and abutments. Substructure surface repair shall be performed in accordance with Type B patching. Removal of concrete shall be to a depth as specified on the plans or as directed by the Engineer. Welded wire fabric shall be installed in accordance with the requirements of (a)7. herein.

(e) **Blocking and Jacking Beams:** The Contractor shall submit to the Engineer for approval his method of jacking and blocking beams to repair beam seats. Unless approved by the Engineer in writing, structures supported on jacks will not be subjected to traffic loadings.

(f) **Shotcrete:** When specified for repairs or approved in lieu of hydraulic cement concrete, shotcrete repairs shall be performed in accordance with the requirements of Section 412.03(a)7 and 412.03(d).

1. **Classes of shotcrete and mixture proportions:** Two classes of shotcrete are established. The minimum amount of cementitious material shall be 390 kilograms per cubic meter for Class A and 375 kilograms per cubic meter for Class B. The classes are as follows:

   a. **Class A:** Class A shotcrete shall be reinforced by either steel or synthetic fibers as specified on the plans and shall have a minimum compressive strength at 28 days of 35 megapascals. When steel fibers are used, the minimum fiber content shall be 36 kilograms per cubic meter. When synthetic fibers are used, the minimum fiber content shall be 4 kilograms per cubic meter. Shotcrete shall also contain silica fume at a minimum of 7 percent by mass of the cementitious material. Use of fly ash (maximum 20 percent by mass of the cementitious material) or slag (maximum 50 percent by mass of the cementitious material) will be permitted. The minimum thickness of Class A shotcrete cover over reinforcing steel shall be 50 millimeters except in transition areas where shotcrete is feathered to existing concrete with less than 50 millimeters of cover or where patches are made on existing concrete with less than 50 millimeters of cover over reinforcing steel.

   b. **Class B:** Class B shotcrete shall have a minimum 28-day compressive strength of 30 megapascals. The cementitious material shall be either all portland cement; portland cement and fly ash (maximum 20 percent by mass of the cementitious material); portland cement and slag (maximum 50 percent by mass of the cementitious material); or portland cement and silica fume (minimum 7 percent by mass of the cementitious material). The minimum thickness of Class B shotcrete cover over reinforcing steel shall be 50 millimeters except in transition areas where shotcrete is feathered to existing concrete with less than 50 millimeters of cover or where patches are made on existing concrete with less than 50 millimeters of cover over reinforcing steel. Where shotcrete containing silica fume is used, the minimum cover over reinforcing steel shall be 40 millimeters.

   The Contractor shall submit for the Engineer's approval shotcrete mixture proportions and performance test data for each class of shotcrete based on the materials to be used in the project. If appropriate recent test data do not exist, the

Contractor shall prepare trial mixtures and submit the test results as obtained from tests specified in Section 7. Quality Assurance and Testing.

Wet process: Shotcrete subject to freezing and thawing shall contain an air content of 7.0% ± 1.5% as delivered to the job site. The materials for wet process shotcrete shall be mixed in accordance with the requirements of Section 217 and applied within 90 minutes after batching.

Dry process: Solid ingredients for dry-mix shotcrete shall be predampened as needed and mixed in a batch type or continuous mixer. Most of the mixing water shall be added at the nozzle. Dry-mix shotcrete material shall be applied within 45 minutes after batching or predampening.

2. **Equipment and personnel:**

   a. **Equipment:** Shotcrete delivery equipment shall be approved by the Engineer before the commencement of the work. It shall be capable of discharging the shotcrete mixture in a continuously smooth stream of uniformly mixed ingredients. Air added at the nozzle shall be free from oil or other contaminants, and the air pressure shall be capable of maintaining sufficient nozzle velocity to all parts of the work.

   b. **Personnel:** Nozzle operators with at least 100 hours of recent similar shotcrete application experience and supervisors with at least 3 years of recent similar shotcreting experience who can provide references showing satisfactory performance on at least three similar jobs may be approved as being qualified without gunning prequalifying panels.

      When proposed nozzle operators do not have the required experience or when the Engineer deems the work to be done is of a sufficiently critical nature to require prequalifying tests, approval will be based on test panels as described herein prior to the commencement of the work. The Engineer will observe the gunning of such test panels and judge the qualifications of the nozzle operator on the basis of the texture, uniformity of work, and adequacy of the encasement of shotcrete around the reinforcement.

3. **Surface preparation:**

   a. Edges of existing concrete in repair areas shall be cut to a 45° (approximate) slope to eliminate the need for

featheredging and to avoid the accumulation of rebound material in the squared shoulders.

b. Earth surfaces shall be trimmed to line and grade and shall have adequate support to prevent displacement during shotcrete placement. Shotcrete shall not be placed on an earth surface that is frozen, spongy, or subject to free running water at the time of the application of shotcrete. Active seeps, drips, and flowing water shall be controlled by installation of suitable drain systems such that water pressure does not build behind shotcrete linings. The Contractor shall prevent excessive loss of mixing water from the shotcrete. This shall be accomplished by one of the following procedures:

1. Wet the soil prior to the time of gunning to the extent that it is damp but with no visible free water on the surface. Puddling, ponding, or free standing water shall be eliminated from areas to be shotcreted.

2. As an alternative or when specified, install a moisture barrier system to inhibit the movement of moisture from the newly placed shotcrete into the earth. Wrinkling and folding of moisture barrier will not be permitted.

c. Rock surfaces shall be free of loose material, debris, chips, mud, dirt, and other foreign matter. Surfaces shall be damp at the time of gunning, but puddling, ponding, or free standing water shall not be permitted.

d. Wood forms that are to be removed after use shall have a form release agent applied to prevent the absorption of moisture and inhibit the bond between shotcrete and the form.

4. **Application:**

a. When applied, shotcrete shall have a temperature of at least 10 °C but not more than 30 °C. The ambient and surface temperature shall be 10 °C and rising. At ambient air temperatures above 30 °C, the Engineer may require placement to be made at night or during early morning hours.

b. Shotcrete to be applied to uneven and previously repaired surfaces shall first be applied to any deep hole, deeply excavated sections, corners, or areas where rebound cannot

escape or be blown free. The thickness of the shotcrete layer shall be such that no sloughing, sagging, tearing, or debonding will occur. Existing concrete shall be sandblasted within 24 hours of application and the surface shall be damp just prior to application.

c. Where a layer of shotcrete is to be covered by a succeeding layer, it shall be first allowed to develop its initial set. Then all loose, uneven, or excess material, glaze, and rebound shall be removed by brooming, scraping, or other means. Any surface deposits that take a final set shall be removed by sandblasting, and the surface cleaned with an air-water blast from the nozzle. Curing compounds shall not be applied to surfaces that will be covered by an additional layer of shotcrete.

d. Shooting wires, ground wires, or other devices acceptable to the Engineer shall be used to control the line, grade, and thickness of the shotcrete.

e. During the shotcrete application, the nozzle shall be held perpendicular to and, when possible, 1 to 1.5 meters away from the receiving surface and rotated steadily in series of small oval or circular patterns. Whenever possible, sections shall be gunned in one layer to the full design thickness. However, for multiple layers of reinforcement, gunning of one layer of shotcrete may be required for each layer of reinforcement.

f. When encasing reinforcement, the nozzle shall be held closer than normal and at a slight upward angle. The mixture may be wetter than normal, but not so wet that sloughing behind the reinforcement will occur.

g. Vertical surfaces shall be gunned starting at the bottom. Rebound or previously expended material shall not be incorporated in the applied layer, and all such material shall be removed from the surface and work area prior to final set and before placement of shotcrete on adjacent surfaces. Shotcrete shall not be placed if drying or stiffening of the mixture is occurring.

5. **Finishing:** Prior to the initial set, the shotcrete surface shall be scraped or cut with a trowel or metal template to obtain an even and aesthetically acceptable appearance. The final finishing shall be with a wet sponge unless otherwise specified. Trowel or float smoothing will not be allowed.

6. **Curing:** After gunning, the surfaces of shotcrete shall be protected from drying or cracking. When necessary, fogging shall be used prior to the application of moist curing or a curing compound. Shotcrete shall be moist cured for a period of at least 7 days or cured using a curing compound conforming to the requirements of Section 220. The rate of application shall be not less than 1 liter of curing compound per 2.4 square meters of surface. The color of the curing compound shall be approximately that of the existing concrete.

7. **Quality assurance and testing:**

   a. Preconstruction testing may be waived by the Engineer if it can be shown that the crew to be used is qualified and that the mixture has been successfully used in similar work.

      Test panels 600 millimeters x 600 millimeters x 100 millimeters deep containing steel reinforcement representative of that to be used on the project shall be prepared. Each crew shall gun two test panels with the mix design to be used on the project and for each gunning orientation to be encountered on the job. Panels will be cured in the field in the same manner as the structure for 1 day and transported to the laboratory, where curing shall be continued until time of testing. For shotcrete jobs of less than 18.5 square meters, the Contractor shall cut one of the test panels with a trowel or a metal template before the initial set, in the presence of the Engineer, to check visually for possible voids under the reinforcement. For larger jobs where specific evidence of good encasement of reinforcing bars is needed, the Contractor shall cut cores from the test panels after the concrete has hardened for at least 3 days. Cores shall be cut through the steel.

      The second panels for all jobs shall be used to determine the compressive strength of the applied shotcrete. Cores shall be 50 millimeters to 100 millimeters in diameter and shall be taken between the reinforcement and tested by the Department at the specified age in accordance with the requirements of ASTM C42.

   b. In-place shotcrete shall be of uniform quality and free from segregation, honeycombing, sand pockets, sand lenses, sagging, dry patches, overspray, rebound, or incomplete encasement of reinforcement. It shall also be free from delamination, cracking, or single voids with dimensions in excess of 6 millimeters.

The Department reserves the right to test any section and reject shotcrete that does not conform to the specification requirements in terms of test values, soundings, and visual examination. Cost of any additional testing of disputed shotcrete that results in rejection shall be borne by the Contractor.

The Contractor shall remove and replace or correct defective shotcrete to the satisfaction of the Engineer.

c. For compressive strength tests, one test panel shall be prepared for each day's production or for each 18.5 square meters of shotcreting by each crew using the same ingredients and gunning orientation as the shotcrete applied to the job. These panels shall be cured and delivered to the designated testing laboratory as earlier specified in this section.

Test values on such panels shall equal or exceed the required 28-day strength requirements. Should failures occur, acceptance of the material will be determined by tests on cores from the applied work. A minimum of three cores shall be taken from the area in question. The average compressive strength of the cores taken from the work shall equal or exceed the specified strength for the class of shotcrete applied, and no single core shall have a strength less than 85 percent of the specified value. If deemed necessary by the Engineer, the adequacy of bond between the existing concrete and the shotcrete shall be determined by pull-off tests in accordance with the requirements of ACI 503. A minimum bond strength of 1725 kilopascals will be accepted as satisfactory. Bond failure at less than 1725 kilopascals due to failure of existing concrete will not be cause for rejection. The cost of up to three pull-off tests will be the responsibility of the Contractor; additional pull-off tests will be the responsibility of the Department.

412.04—Measurement and Payment.

Volumes outlined by the completed excavation, formwork, and surfaces of the existing concrete will be measured prior to concrete placement so that quantities can be accurately computed.

Hydraulic cement concrete for the class specified will be measured and paid for in accordance with the requirements of Section 404.

Type A milling will be measured and paid for in square meters for the depth specified.

Types A, B, and C patching and concrete substructure or superstructure surface repair will be measured in square meters of surface area and will be paid for at the contract unit price per square meter. This price shall include furnishing and placing concrete to fill the prepared areas.

Epoxy-mortar patching will be measured in liters of epoxy-mixed system used as a binder for mortar in place and for priming prior to application of epoxy mortar and will be paid for at the contract unit price per liter.

Expansion joint removal, expansion joint reconstruction, and back wall reconstruction will be measured in meters and will be paid for at the contract unit price per meter. This price shall include furnishing and placing concrete to fill the prepared areas for expansion joint reconstruction and backwall reconstruction.

Saw cutting, when a pay item, will be measured in meters of concrete sawed and will be paid for at the contract unit price per meter.

Jacking and blocking of beams as required to complete beam seat repair, when a pay item, will be paid for on an each basis per beam end.

Furnishing latex and silica fume hydraulic cement concrete used in placing will be measured in cubic meters and will be paid for at the contract unit price per cubic meter. Measurement for furnishing latex hydraulic cement concrete produced by batch mixers will be determined by truck tickets, assuming a 95 percent yield; when produced by automatic mobile mixers, measurement will be by metered ticket. Measurement for furnishing silica fume will be by truck tickets, also assuming a 95 percent yield. Reductions in quantity for both latex and silica fume hydraulic cement concrete will be made for any volume used at the Contractor's option in lieu of hydraulic cement concrete used in deck repairs, for any unnecessary overruns such as overdepth milling, and for any waste.

Placing latex and silica fume hydraulic cement concrete will be measured and paid for at the contract unit price per square meter and paid for on a plan quantity basis, which will be full compensation for placing, finishing, and curing the latex or silica fume hydraulic cement concrete.

Crack repair will be measured in meters and will be paid for at the contract unit price per meter.

Removal of asphalt concrete overlay will be measured in square meters of surface area and will be paid for at the contract unit price per square meter.

Shotcrete, when specified as a pay item, will be measured in square meters of surface to which it is applied and will be paid for at the contract unit price per square meter or per cubic meter for the type specified.

These prices shall include cutting, drilling, hammering, and all other work involved in the complete removal and disposal of concrete and other materials necessary to provide for joining the new and old portions of the structure according to the plans or as directed by the Engineer. The contract unit price shall also include dowels or other approved anchoring devices, disposing of surplus material, cleaning and repairing reinforcing steel, and welded wire fabric, if necessary. If Class A shotcrete is used, the price shall also include steel or synthetic fibers.

Payment will be made under:

Pay Item	Pay Unit
Type A milling (depth)	Square meter
Type A patching	Square meter
Type B patching	Square meter
Type C patching	Square meter
Epoxy-mortar patching	Liter
Concrete substructure surface repair	Square meter
Concrete superstructure surface repair	Square meter
Expansion joint removal	Meter
Expansion joint reconstruction	Meter
Back wall reconstruction	Meter
Saw cutting	Meter
Jacking and blocking	
Furnishing (latex or silica fume) hydraulic cement concrete	Cubic meter
Crack repair	Meter
Removal of asphalt concrete overlay	Square meter
Pneumatically applied mortar	Square meter
Placing (latex or silica fume) hydraulic cement concrete	Cubic meter
Shotcrete (Class __)	Square meter or cubic meter

SECTION 413—DISMANTLING AND REMOVING EXISTING STRUCTURES OR REMOVING PORTIONS OF EXISTING STRUCTURES

413.01—Description.

This work shall consist of dismantling and removing all or portions of existing structures in accordance with these specifications and in reasonably close

conformity with the lines, grades, and details shown on the plans or as established by the Engineer.

413.02—Procedures.

(a) **Dismantling and Removing Existing Structure:** Dismantling and removing existing structures shall include removing the entire superstructure, substructure, and slope protection. The substructure shall be removed down to the stream bed or to an elevation of at least 0.6 meter below the natural ground or finished grade of embankment that is to remain in place. Removal shall include any part of the substructure or foundation piling that will interfere with the new construction. For bridges crossing streams under the jurisdiction of the U.S. Coast Guard, the substructure shall be removed to or below the bed of the stream as required by the Coast Guard.

1. **Dismantling structures for retention by Contractor:** Removed materials shall become the property of the Contractor and shall be removed from the project.

2. **Dismantling structures for retention by Department:** Dismantling shall be in accordance with a method approved by the Engineer and shall be such as to preserve the existing condition of materials.

   Units shall be match marked for re-erection according to an approved diagram provided by the Department.

   Material shall be stored as directed within 0.8 kilometer of the site of the existing structure.

(b) **Removing Portion of Existing Structure:** The portions to be removed shall be the areas designated on the plans. Concrete shall not be removed by blasting or other methods that may damage concrete or reinforcement that will remain in the completed structure. The mass of pneumatic hammers shall be not more than 40 kilograms for widening work or 14 kilograms for deck repair work. The use of tractor-mounted demolition hammers will not be permitted.

   Disturbed areas shall be uniformly graded to natural ground contours in a manner that will facilitate drainage and prevent impoundment of water.

413.03—Measurement and Payment.

Dismantling and removing an existing structure will be paid for at the contract lump sum price.

Removing a portion of an existing structure will be paid for at the contract lump sum price.

Payment will be made under:

Pay Item	Pay Unit
Dismantle and remove existing structure (B or Str. No.)	Lump sum
Remove portion of existing structure (B or Str. No.)	Lump sum

SECTION 414—RIPRAP

414.01—Description.

This work shall consist of placing the specified type of riprap in accordance with the plans and these specifications.

414.02—Materials.

(a) **Riprap** shall conform to the requirements of Section 204.

(b) **Sand** shall conform to the requirements of Section 202. Grading A, B, or C sand may be used in mortared or grouted riprap.

(c) **Mortar and grout** shall conform to the requirements of Section 218.

(d) **Geotextile bedding** shall conform to the requirements of Section 245.

(e) **Welded wire fabric** shall conform to the requirements of Section 223.

414.03—Procedures.

(a) **Dry Riprap:** The classes of dry riprap shall be as follows:

1. **Class I:** Stones shall have a mass from 20 to 70 kilograms each. At least 60 percent shall have a mass more than 45 kilograms, and approximately 10 percent may have a mass 20 kilograms or less.

2. **Class II:** Stones shall have a mass from 70 to 225 kilograms each. At least 50 percent shall have a mass more than 135 kilograms, and approximately 10 percent may have a mass 70 kilograms or less.

3. **Class III:** Stones shall have a mass from 225 to 700 kilograms each. At least 50 percent shall have a mass more than 400 kilograms, and approximately 10 percent may have a mass less than 225 kilograms.

4. **Class AI:** Stones shall have a mass from 10 to 35 kilograms each, except that approximately 10 percent may have a mass 10 kilograms or less and 10 percent may have a mass 35 to 45 kilograms.

Dry riprap shall be placed as follows:

1. **Grading:** Slopes shall be finished to a reasonably smooth and compact surface within a tolerance of 150 millimeters from the surface lines shown on the plans.

   Immediately prior to placement of riprap bedding, the prepared base will be inspected. Riprap or bedding shall not be placed until the prepared base has been approved.

2. **Bedding:** Riprap bedding shall be placed on the embankment to form a backing for riprap. Riprap bedding shall be spread uniformly on the prepared base. Compaction of the bedding material will not be required, but material shall be finished to a reasonably even surface, free from mounds or depressions.

   When geotextile bedding material is required, the entire perimeter of the material shall be turned down and buried at least 225 millimeters for anchorage. Adjacent strips of material shall run only up and down the slope and shall overlap at least 450 millimeters. Geotextile bedding material shall not be used on slopes greater than 1:1. If sewed, strips shall overlap at least 100 millimeters and shall be double stitched with a prayer seam, Type SSa 1. Damaged material shall be replaced or repaired with a patch of the same material overlapping the damaged area by at least 450 millimeters on all sides. Displaced material shall be repositioned, including, if necessary, removing and replacing riprap stone, at the Contractor's expense. Material shall be placed loosely so that positioning riprap will not stretch or tear it.

3. **Placing stones:** Riprap shall be placed on the embankment as soon as practicable after bedding has been finished, but no later than 15 days, in a manner that will produce a reasonably well-

graded mass of rock with the minimum practicable percentage of voids. Riprap shall be placed to its full course thickness in one operation and in a manner to avoid displacing underlying material. Riprap stone shall not be dropped onto fabric from a height greater than 300 millimeters. Smaller-sized material shall not be dropped onto fabric from a height greater than 900 millimeters. Larger stones shall be reasonably well distributed.

Finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Hand placing may be required to the extent necessary to secure the results specified and form uniform slopes.

A tolerance of ±1/4 of the thickness of the maximum-size stone from the lines and grades shown on the plans will be allowed in the finished surface. However, the extremes of such tolerance shall be not continuous over an area of more than 20 square meters. Riprap shall be keyed into the natural ground in an approved manner and to a depth equal to the bed thickness or to solid rock.

The desired distribution of various sizes of stones throughout the mass may be obtained by selective loading at the source, controlled dumping of successive loads during final placement, or a combination of these methods. Placing riprap by dumping into chutes or similar methods likely to cause segregation of the various sizes will not be permitted.

Riprap protection shall be maintained until the riprap is accepted by the Department. Displaced material shall be replaced to the lines and grades shown on the plans at the Contractor's expense.

(b) **Dumped Riprap:** The types of dumped riprap shall be as follows:

1. **Type I:** Core riprap shall be composed of compact angular pieces of derrick stone having a mass from 0.7 metric ton to 1.8 metric tons each, with an average mass of approximately 1 metric ton. Approximately 10 percent by mass may have a mass less than 0.7 metric ton.

2. **Type II:** Heavy riprap shall be composed of compact angular pieces of derrick stone having a mass from 2.7 to 9 metric tons each, with an average mass of approximately 3.6 metric tons. Approximately 10 percent by mass may have a mass less than 2.7 metric tons.

Dumped riprap shall be placed in the same manner described for dry riprap in (a) herein. Dumped riprap shall not be placed in layers.

(c) **Mortared Riprap for Slopes:** Stone shall be the same size as specified for dry riprap, Class II, and shall be selected to secure fairly large, flat-surfaced stones that will produce a true and even surface with a minimum of voids. Stone shall be placed on a slope not steeper than the natural angle of repose of the fill material. Fifty percent of the mass shall be broad flat stones placed with the flat surface uppermost and parallel to the slope. Stones shall be placed first and roughly arranged in close contact, with the larger stones placed near the base of the slope. Spaces between larger stones shall be filled with stones of suitable size, leaving the surface reasonably smooth and tight and conforming to the contour required. Stones shall be placed in a manner so as to ensure for plane surfaces a maximum variation from a true plane of not more than 30 millimeters in 1.2 meters. Warped and curved surfaces shall have the same accuracy as specified for plane surfaces.

As each larger stone is placed, it shall be surrounded by fresh mortar, and adjacent stones shall be shoved into contact. After larger stones are in place, spaces or openings between them shall be filled with mortar, and smaller stones shall then be placed by shoving them into position, forcing excess mortar to the surface, ensuring that each stone is carefully and firmly bedded laterally.

After the work is complete, excess mortar forced up shall be spread uniformly to fill surface voids completely. Surface joints shall then be pointed roughly with flush or shallow smooth-raked joints.

(d) **Grouted Riprap for Slopes:** Grout shall consist of 1 part hydraulic cement and 3 parts sand, thoroughly mixed with water to produce grout having a thick, creamy consistency.

Stones shall be of the same sizes and placed in the same manner as specified for dry riprap, Class I. Care shall be taken during placing to keep earth or sand from filling spaces between stones. After stones are in place, spaces between them shall be filled with grout from bottom to top and the surface swept with a stiff broom. Riprap shall not be grouted in freezing weather. In hot, dry weather, the work shall be protected from sunlight and kept moist for at least 3 days after grouting by the use of saturated burlap.

(e) **Erosion Control Stone:** Erosion control stone shall conform to the requirements of Section 414.03(a) for mass.

1. **Class I** dry rip rap shall be placed in a manner to present an irregular or rough surface. The depth shall be not less than 600 millimeters.

2. **Class II** dry rip rap shall be placed in a manner to present an irregular or rough surface. The depth shall be not less than 900 millimeters.

(f) **Erosion Control Riprap:** Riprap shall consist of sound, nonerodible shot rock or rock excavation, which may be obtained from within the typical section on the project. Erosion control riprap rock shall be not more than 400 millimeters in its greatest dimension and shall contain a sufficient percentage of smaller rocks to provide a reasonably dense mass with a thickness of at least 200 millimeters. Riprap shall be placed where shown on the plans or as directed by the Engineer in accordance with the requirements of Section 303.04(h).

(g) **Concrete Riprap in Bags:**

1. **Wet mixture:** Riprap shall consist of Class 10 concrete in suitable burlap bags except in brackish or tidal water, where concrete shall be Class 20. Bags shall have a mass approximately 50 kilograms when 2/3 filled with concrete. Each bag shall be securely tied and immediately placed in the work. When used for foundation protection, bags shall be placed in accordance with the provisions governing placement of stone riprap for foundation protection as specified. When used for slope protection, riprap shall be placed in conformance with the provisions governing placement of dry riprap.

2. **Dry mixture:** Riprap shall conform generally to the requirements for wet mixtures except that the mixture shall consist of the dry ingredients and the requirements for water, consistency, and air will be waived.

   Burlap or paper bags will be permitted. Riprap shall be a rectangular solid approximately 75 millimeters in thickness and shall have a mass of approximately 35 kilograms per bag. Paper bags shall be perforated throughout on approximate 25-millimeter centers and shall be of adequate seal, thickness, and strength to maintain the integrity of the riprap until setting of the concrete mixture. Bag compositions shall be such that bags will disintegrate without presenting environmental problems.

(h) **Stone Riprap for Foundation Protection:** Riprap for pier, abutment, and bridge spill slope protection shall conform to the requirements of the applicable specifications.

(i) **Concrete Slab Riprap for Stream Crossings:**

1. **Materials:** Riprap shall consist of Class 20 concrete, cast-in-place, 150 millimeters in thickness. Concrete shall have a consistency that will permit placement without the use of top forms.

   Welded wire fabric shall be 4.88-millimeter wire, spaced 150 millimeters center to center.

2. **Excavation and fine grading:** The finished embankment slope shall be reasonably smooth and dense. A trench shall be dug at the toe of the slope to accommodate the toe of the slab. Slab riprap shall not be placed until the slope has been approved by the Engineer.

3. **Construction methods:** Riprap shall be constructed in accordance with the applicable requirements of Section 404, except as modified herein, and shall be cured in accordance with the requirements of Section 316.04(j). Welded wire fabric shall be positioned at the center of the slab, shall run continuously throughout the slab, and shall lap approximately 150 millimeters at the edges of each sheet of fabric.

   The berm portion of the slab shall be placed on a slope of approximately 12:1, draining away from the abutment. Where the edge of the slab is placed against the abutment, the joint shall be sealed to a depth of at least 13 millimeters with hot-poured joint sealer conforming to the requirements of Section 212.

   The toe of the slab shall extend to an elevation at least 0.9 meter below the elevation of the toe of fill, and the lower edge of the slab shall be increased approximately 150 millimeters in thickness, tapering to its nominal thickness 900 millimeters up the slope from the lower edge of the slab. The tapering shall be on the underside of the slab. The slab shall be placed using one of the following methods:

   a. **Block method:** The slab shall be placed in alternate blocks having dimensions approximately 1.2 meters by 1.2 meters.

   b. **Strip method:** The slab may be placed in alternate, continuous strips having scored or formed joints perpendicular to construction joints. Strips shall be placed in alternating widths of 1.2 meters and 1.5 meters, or 1.4 meters each. Joints shall be at least 25 millimeters in depth

and spaced approximately 1.4 meters apart. The width of the joint shall be as small as possible.

Successive courses or strips shall not have joints that line up with the joints in the preceding courses or strips. Horizontal joints shall be normal to the slope. Joints shall be closed without filler.

After concrete is placed, it shall be consolidated and the surface struck off by means of a strike board. Concrete shall be float finished with a wooden or cork float. The surface shall not vary more than 13 millimeters under a 3-meter straightedge.

414.04—Measurement and Payment.

Dry riprap will be measured in square meters of surface area or metric tons as specified.

Mortared riprap will be measured in square meters of surface area.

Grouted riprap will be measured in square meters of surface area or metric tons as specified.

Stone riprap for foundation protection will be measured in square meters of surface area or metric tons as specified.

Dumped riprap will be measured in square meters of surface area or metric tons as specified.

Concrete riprap in bags will be measured in cubic meters.

Concrete slab riprap will be measured in square meters. When an optional riprap is used in lieu of concrete slab riprap, bedding material will not be measured for payment and the riprap will be paid for at the contract unit price for concrete slab riprap.

Erosion control riprap will be measured in square meters of surface area or metric tons as specified.

Riprap will be paid for at the contract unit price. This price shall include furnishing and placing riprap, including welded wire fabric, mortar, or grout; excavation; and riprap bedding.

Erosion control stone will be measured in square meters of surface area or metric tons as specified for the class specified and will be paid for at the contract unit price per square meter or metric ton. This price shall include excavating and backfilling and furnishing and placing dry riprap.

Payment will be made under:

Pay Item	Pay Unit
Dry riprap (Class and depth)	Square meter or metric ton
Mortared riprap (Depth)	Square meter
Grouted riprap (Depth)	Square meter or metric ton
Stone riprap (Depth)	Square meter or metric ton
Dumped riprap (Type and depth)	Square meter or metric ton
Concrete riprap in bags	Cubic meter
Concrete slab riprap	Square meter
Erosion control riprap (Depth)	Square meter or metric ton
Erosion control stone (Class, Standard)	Square meter or metric ton

SECTION 415—CONCRETE SLOPE PROTECTION

415.01—Description.

This work shall consist of furnishing and installing precast concrete blocks in a bed of coarse sand or installing a concrete slab on embankments at or near bridge abutments as shown on the plans or as specified by the Engineer.

415.02—Materials.

(a) **Precast concrete blocks** shall conform to the requirements of Section 222.

(b) **Mortar** shall be nonshrinking and shall conform to the applicable requirements of Section 218.

(c) **Foundation course** shall be Grading B sand conforming to the requirements of Section 202 or approved local material similar in nature.

(d) **Concrete** shall be Class 20 conforming to the requirements of Section 217.

(e) **Welded wire fabric** shall be No. 6 gage, 150 millimeters center to center each way, conforming to the requirements of Section 223.

(f) **Herbicide** shall conform to the requirements of Section 244.

415.03—Procedures.

(a) **Precast Concrete Block Slope Protection:** The subgrade shall be constructed at the required distance below the finished surface of the slope. Soft sections and unsuitable material shall be removed and replaced. The subgrade shall be compacted and shaped to a smooth, uniform surface.

The foundation course shall be spread on the subgrade to a depth of 150 millimeters and treated with an approved highly insoluble soil sterilent. Material shall be in a dry form and have a maximum solubility rate of 250 parts per million. Material shall be uniformly applied at the maximum rate recommended by the manufacturer.

Blocks shall be bedded in the foundation course perpendicular to the finished surface in straight rows, with the longest dimension horizontal. Blocks shall be placed with continuous joints extending horizontally on the face of the slope and with broken (staggered) joints extending perpendicular thereto, up or down the slope. Blocks shall be rammed until the surface is firm and conforms to the finished slope. Joints shall be filled with mortar.

Cast-in-place edging for block slope protection shall be placed as specified in (b) herein.

(b) **Concrete Slab Slope Protection:** The subgrade shall be prepared as for block slope protection. The cast-in-place concrete slab shall be 100 millimeters in thickness and shall be placed in accordance with the requirements of Section 414.03(i).

Except at railroad grade separations, the Contractor may provide a combination concrete slab and stone slope protection in lieu of the specified concrete slab slope protection. Protection shall be in accordance with the following:

1. Concrete portions, consisting of a paved ditch and a strip of concrete approximately 1 meter in width placed on the berm along the face of the abutment, shall be furnished as required for concrete slab slope protection. Stone shall be placed at a depth of 175 to 225 millimeters over the remaining area to be covered with slope protection.

2. The subgrade for concrete and stone shall be prepared in accordance with the requirements of Section 414.03(i). The portion of the slope to be protected with stone shall be treated with a herbicide in accordance with the requirements of (a) herein.

Care shall be taken to confine application to areas designated for sterilization.

3. Stone shall be crushed gravel or stone conforming to the requirements of Section 205.02. Sizes furnished shall be not smaller than the sizes specified in Table II-5 for aggregate size No. 1, and the pieces shall be not larger than 200 millimeters in their greatest dimension. Stone shall be in a sufficient range of sizes to create a stable and reasonably uniform slope.

The condition of the subgrade and method of placing stone shall be such that pieces of stone in contact with the subgrade shall be partially embedded where practicable. Stone immediately adjacent to concrete shall not project more than 75 millimeters above the concrete.

Approved splash blocks connecting with the paved ditch shall be provided under downspouts draining onto the slope protection.

415.04—Measurement and Payment.

Concrete slope protection will be measured in square meters of surface area and will be paid for at the contract unit price per square meter. If limits are not shown on the plans, measurements will be from the outside edge to outside edge, including curb, and from the edge of slope protection at abutment to the bottom of the curtain wall or outside edge of the paved ditch as appropriate. This price shall include the foundation course and treatment.

Payment will be made under:

Pay Item	Pay Unit
Concrete block slope protection	Square meter
Concrete slab slope protection (Depth)	Square meter

SECTION 416—WATERPROOFING

416.01—Description.

This work shall consist of furnishing and applying a waterproofing membrane on concrete bridge decks or other surfaces as shown on the plans.

416.02—Materials.

Epoxy-resin compounds and aggregates for surface application shall conform to the requirements of Section 243. Epoxy resin shall be Type EP-5, low viscosity.

416.03—Procedures.

Containers, tools, and mechanical equipment shall be free from solvents, loose material, and deposits of hardened material.

Epoxy resin shall not be applied when the concrete surface or the ambient air temperature is below 10 °C unless otherwise permitted by the manufacturer's instructions.

(a) **Surface Preparation:** Surfaces on which epoxy compounds are to be applied shall be free from grease, dirt, dust, paint, mill scale, curing compound, laitance, and other foreign material.

Concrete surfaces on which epoxy compounds are to be used shall be ground or sandblasted sufficiently to expose the sound concrete. Surfaces that are not to receive epoxy compounds shall be protected from sandblasting. Immediately following sandblasting, the surface shall be thoroughly cleaned.

Before epoxy compounds are applied to metal surfaces, surfaces shall be sandblasted to a bright metallic luster.

Wood surfaces shall be sanded to the texture of new wood.

(b) **Mixing:** Epoxy mortar shall be made by blending sand, epoxy resin, and hardener in accordance with the requirements of the manufacturer's instructions.

Batch sizes shall be limited to the maximum batch size recommended by the manufacturer. Mixed epoxy compounds shall be used within the manufacturer's specified pot life. Solvents or other materials shall not be added to the mixture.

(c) **Application:** Masking shall be used to form straight edges. Epoxy resin shall not be allowed to flow into or over expansion joints. The first coat of epoxy resin shall be applied at the rate of 1 liter per 2.7 square meters. Sand shall be broadcast into the wet epoxy in sufficient quantity, approximately 6 kilograms per square meter, to cover the epoxy completely. Sand shall be firmly embedded so that at least 95 percent of the deck area displays a sand surface after brooming. Brooming shall not be performed until the epoxy resin has cured

sufficiently to prevent tearing. After curing, unbonded sand shall be broomed from the surface and may be reused if uncontaminated. The second coat of epoxy resin shall be applied at the rate of 1 liter of epoxy per 6 square meters. Requirements pertaining to masking, epoxy, flow, sand broadcasting, percentage of embedment, curing, and brooming shall also apply to the second coat of epoxy resin.

At edges of the waterproofing system and at any point where it is punctured by appurtenances such as drains or pipes, suitable provisions shall be made to prevent water from getting between the waterproofing and the waterproofed surface.

The waterproofing system shall be extended as follows: 25 millimeters up faces of curbs, continuously across abutment back walls and at least 150 millimeters down the back of back walls, at least 300 millimeters onto approach slabs, and continuously across joints except expansion joints.

When applied to prestressed concrete slab and box beam units for new construction, application shall be made at the prestressing plant. Joints and damaged areas shall be waterproofed after erection.

(d) **Curing:** Curing time shall conform to the manufacturer's recommendations. During this time, both pedestrian and vehicular traffic shall be barred from freshly placed surfaces.

416.04—Measurement and Payment.

Waterproofing will be measured in square meters of completed deck surface covered between the beginning and end stations of the bridge. For applications other than bridge decks, waterproofing will be measured in square meters of completed surface as shown on the plans.

Waterproofing will be paid for at the contract unit price per square meter. When applied to prestressed concrete slab and box beam units at the plant, the cost of waterproofing will be paid for in accordance with the requirements of Section 405.

Payment will be made under:

Pay Item	Pay Unit
Waterproofing	Square meter

SECTION 417—DAMP-PROOFING

417.01—Description.

This work shall consist of furnishing and applying damp-proofing material to concrete surfaces in accordance with the plans and these specifications.

417.02—Materials.

Materials shall conform to the applicable requirements of Section 213.

417.03—Procedures.

(a) **Surface Preparation:** Surfaces shall be cleaned of loose, foreign material and shall be dry. The Engineer may require the surface to be scrubbed with water and a stiff brush, after which it shall be allowed to dry before application of primer.

(b) **Application:** The clean surface shall be brush painted or spray painted with at least two coats of primer, using at least 1.0 liter per 2.0 square meters of surface per coat. On the primed surface, one application of an asphalt seal coat shall be applied by brush, using at least 1.0 liter per 2.5 square meters.

Asphalt shall be confined to areas to be damp-proofed and shall not be dripped or spread on any other parts of the structure.

417.04—Measurement and Payment.

When a pay item, **damp-proofing** will be paid for at the contract unit price per square meter. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Damp-proofing	Square meter

SECTION 418—TIMBER STRUCTURES

418.01—Description.

This work shall consist of furnishing and erecting timber materials required to complete a structure in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans or as established by the Engineer.

418.02—Materials.

(a) **Lumber and Timber:** Lumber and timber shall conform to the requirements of Section 236.

(b) **Structural Shapes:** Rods, plates, shapes, and eyebars shall conform to the requirements of Section 226.

(c) **Castings:** Castings shall be cast steel or gray iron, as shown on the plans, conforming to the applicable requirements of Section 224.

(d) **Hardware:** Machine bolts, drift bolts, and dowels shall conform to the requirements of Section 226. Washers may be ogee gray iron or malleable castings or may be cut from mild steel plate as shown on the plans.

Machine bolts shall have square heads and nuts. Nails shall be cut or round wire of standard form. Spikes shall be cut, wire, or boat spikes as shown on the plans.

Nails, spikes, bolts, dowels, washers, and lag screws shall be black or galvanized, as specified on the plans.

Other hardware, except malleable iron connectors, shall be galvanized in accordance with the requirements of Section 233 or cadmium plated in accordance with the requirements of ASTM A165, Type OS.

(e) **Paint:** Paint shall conform to the requirements of Section 231.

418.03—Procedures.

(a) **Storing Material:** Lumber and timber on the work site shall be stored in stacks or ricks.

Material shall be stacked at least 300 millimeters above the ground surface and sloped. It shall be protected from weather by a suitable

covering. The ground underneath and in the vicinity of material shall be cleared of weeds and rubbish.

Untreated material shall be open stacked, and treated material shall be close stacked.

(b) **Treated Timber:** Treated timber shall be handled with rope slings without sudden dropping, breaking of outer fibers, or bruising or penetrating of the surface with tools such as cant hooks, peaveys, pikes, or hooks.

Cutting, framing, and boring of treated timbers shall be performed before treatment insofar as is practicable. When treated timbers are to be placed in water infested by marine borers, as determined by the Engineer, untreated cuts, borings, or other joint framings below the high water elevation shall be avoided.

Cuts in treated piles or timbers and abrasions, after having been carefully trimmed smooth, shall be brush coated with at least two applications of the preservative used in the treatment of the pile.

Bolt holes bored after treatment shall be treated with a preservative. After being treated, unfilled holes shall be plugged,

Whenever forms or temporary braces are attached to treated timber with nails or spikes, holes shall be filled by driving galvanized nails or spikes flush with the surface or by plugging as required for bolt holes.

(c) **Untreated Timber:** Ends, tops, and contact surfaces of sills, caps, floor beams, stringers, and bracing and truss units shall be thoroughly coated with two coats of preservative before assembly. The back faces of bulkheads and other timber that will be in contact with earth, metal, or other timber shall be similarly treated.

(d) **Treatment of Pile Heads:** After required cutting to receive caps and prior to placement of caps, pile heads shall be treated to prevent decay. Heads of timber piles shall be protected by one of the following methods, as indicated on the plans. If not otherwise indicated, Method A shall be used.

1. **Method A—zinc covering:** The sawed surface shall be brush coated with three applications of a preservative. Before the cap is placed, a sheet of 12 gage (0.7 millimeter) zinc shall be placed on each pile head. The sheet shall be of sufficient size to project at least 100 millimeters outside the pile and shall be bent down, neatly trimmed, and securely fastened to the face of the pile with large-headed galvanized roofing nails.

2. **Method B—fabric covering:** Heads of piles shall be covered with alternate layers of hot pitch and cotton fabric for waterproofing, using four applications of pitch and three layers of fabric. The cover shall measure at least 150 millimeters more in dimension than the diameter of the pile and be neatly folded down over the pile and secured by large-headed galvanized nails or by binding with at least seven complete turns of galvanized wire securely held in place by large-headed galvanized nails and staples. Edges of fabric projecting below the wire wrapping shall be trimmed to present a neat appearance.

(e) **Holes for Bolts, Dowels, Rods, and Lag Screws:** Holes for round drift bolts and dowels shall be bored with a bit 1.5 millimeters less in diameter than the bolt or dowel to be used. The diameter of holes for square drift holes or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit the same diameter as the bolt.

Holes for rods shall be bored with a bit 1.5 millimeters greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

(f) **Bolts and Washers:** A washer shall be used under bolt heads and nuts that would otherwise come in contact with wood. Bolts shall be checked after nuts have been finally tightened.

(g) **Countersinking:** Countersinking shall be performed wherever smooth faces are required. Recesses in horizontal surfaces shall be painted with a preservative and filled with hot pitch after the bolt or screw is in place.

(h) **Framing:** Lumber and timber shall be cut and framed to a close fit so that the joints will have an even bearing over the contact surfaces. Mortises shall be true to size for their full depth, and tenons shall fit snugly. Shimming will not be permitted in making joints, and open joints will not be accepted.

(i) **Pile Bents:** Preparing and driving piles shall be in accordance with the requirements of Section 403.

Piles for any one bent shall be carefully selected as to size to avoid undue bending or distortion of the sway bracing. Care shall be taken in distributing piles of varying sizes to secure uniform strength and rigidity in bents of any given structure.

Cutoffs shall be accurately made to ensure a uniform bearing between the cap and piles of a bent.

(j) **Framed Bents:**

1. **Mud sills:** Untreated timber used for mud sills shall be of heart cedar, heart cypress, redwood, or other durable timber. Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place.

2. **Concrete pedestals:** Concrete pedestals for the support of framed bents shall be finished so that sills or posts will take an even bearing. Dowels or anchor bolts at least 19 millimeters in diameter shall be set in pedestals when they are cast for anchoring sills or posts.

3. **Sills:** Sills shall have a true and even bearing on mud sills, piles, or pedestals. They shall be drift bolted to mud sills or piles with bolts at least 19 millimeters in diameter and extending into the mud sills or piles at least 150 millimeters. When possible, earth shall be removed from contact with sills so that there will be free air circulation.

4. **Posts:** Posts shall be fastened to pedestals with dowels at least 19 millimeters in diameter, extending at least 150 millimeters into the posts.

   Posts shall be fastened to sills by one of the following methods, as indicated on the plans: by dowels at least 19 millimeters in diameter, extending at least 150 millimeters into posts and sills, or by drift bolts at least 19 millimeters in diameter driven diagonally through the base of the post and extending at least 225 millimeters into the sill.

(k) **Caps:** Timber caps shall be placed, with ends aligned, in a manner to secure an even and uniform bearing over the tops of supporting posts or piles. Caps shall be secured by drift bolts at least 19 millimeters in diameter, extending at least 225 millimeters into the posts or piles. Drift bolts shall be in the approximate center of the post or pile.

(l) **Bracing:** Ends of bracing shall be bolted through the pile, post, or cap with a bolt at least 16 millimeters in diameter. Intermediate intersections shall be bolted or spiked with wire or boat spikes, as indicated on the plans. In all cases, spikes shall be used in addition to bolts.

(m) **Stringers:** Stringers shall be sized at bearings and placed in position so that knots near edges will be in the top portions of stringers.

Outside stringers may have butt joints with ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. Lapped ends of untreated stringers shall be separated at least 13 millimeters for the circulation of air and securely fastened by drift bolting where specified. Where stringers are two panels in length, joints shall be staggered.

Cross bridging between stringers shall be neatly and accurately framed and securely toenailed with at least two nails in each end. Cross-bridging units shall have full bearing at each end against the side of stringers. Cross bridging shall be placed at the center of each span.

(n) **Plank Floors:** Planks shall be surfaced on four sides (S4S).

Single-plank floors shall consist of a single thickness of plank supported by stringers or joists. Planks shall be carefully graded as to thickness and placed so that no two adjacent planks shall vary in thickness by more than 3 millimeters. Each plank shall be placed heart side down, firmly jacked together, and securely fastened to each joist.

(o) **Wheel Guards and Railings:** Wheel guards and railings shall be erected true to line and grade. Wheel guards, rails, and rail posts shall be surfaced on four sides (S4S). Wheel guards shall be laid in sections at least 3.7 meters in length.

(p) **Painting:** Rails and rail posts, untreated timber, or timber treated with a preservative shall be painted with three coats of paint.

Metal parts, except hardware, shall be given one coat of shop paint and, after erection, three coats of field paint.

Timber shall be painted with No. 11 paint.

418.04—Measurement and Payment.

Lumber and timber will be measured in units of cubic meters for materials placed in the finished structure and will be paid for at the contract unit price per cubic meter. Computations for lumber quantities will be based on nominal sizes, complete-in-place. No other allowance for waste will be made.

Structural steel will be paid for in accordance with the requirements of Section 407.

Painting timber structures, when a pay item, will be paid for at the contract lump sum price. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

These prices shall include preparing surfaces and preservative treatment.

Payment will be made under:

Pay Item	Pay Unit
Lumber (Treated or untreated)	Cubic meter
Painting timber structures	Lump sum

SECTION 419—BRIDGE CONDUIT SYSTEMS AND LIGHTING SYSTEMS

419.01—Description.

This work shall consist of furnishing and installing a bridge conduit system and a bridge lighting system in accordance with these specifications and in reasonably close conformity with the lines and details shown on the plans or as established by the Engineer.

419.02—Materials.

Conduit, boxes, and fittings shall be as specified in Section 238.

419.03—Procedures.

The Contractor shall verify or locate the origin of power sources when modifying or relocating existing electrical systems and shall advise the Engineer at least 48 hours prior to the anticipated time of de-energizing the electrical system. Workmanship shall conform to the standards of NEC and the requirements of the local power company.

Conduit, fittings, and electrical items shall be installed in accordance with the requirements of Section 700.

419.04—Measurement and Payment.

Bridge conduit systems, when a pay item, will be paid for at the contract lump sum price per structure. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Bridge lighting systems will be paid for at the contract lump sum price per structure.

Payment will be made under:

Pay Item	Pay Unit
Bridge conduit system (B or Str. No.)	Lump sum
Bridge lighting system (B or Str. No.)	Lump sum

SECTION 420—PREFORMED ELASTOMERIC JOINT SEALER

420.01—Description.

This work shall consist of furnishing and installing preformed elastomeric joint sealer in accordance with these specifications and in reasonably close conformity with the lines shown on the plans or as established by the Engineer.

420.02—Materials.

Material for preformed elastomeric joint sealer and lubricant adhesive shall conform to the requirements of Section 212. The joint sealer (to serve both as a filler and a sealer) shall be furnished in the form of an extruded compartmented tube.

420.03—Procedures.

(a) **Preparation of Joint:** The joint shall be formed to provide the nominal opening at the specified temperature as shown on the plans. Sides of the joint shall be parallel to each other. Edges of concrete or epoxy mortar adjacent to the joint shall be rounded to a radius of not more than 6 millimeters. A joint having an insufficient opening may be required to be sawed or ground to the proper size. If a joint opening is larger than specified, the Contractor may furnish a larger-size sealer up to 6 millimeters in its uncompressed width as determined by the Engineer. If the joint opening is larger than that which will accommodate the larger sealer, the end of the slab shall be cut back at least 150 millimeters and rebuilt with Class 30 concrete to obtain the required joint opening. The cost of such additional work or material shall be borne by the Contractor unless designated in the Contract as a pay item.

Before placement of sealer, the joint shall be thoroughly cleaned by brushing, compressed air, or other means so that it is free from dust, oil, grease, or other foreign materials.

(b) **Installation:** Sealer shall be installed using methods and procedures recommended by the manufacturer of the sealer. A lubricant adhesive shall be used. During installation, the sealer shall not be subjected to lengthwise stretching. The length to be installed shall be measured prior to installation and cut or marked to indicate the installed length.

No splices will be permitted in joint sealers for lengths less than 15 meters. For lengths greater than 15 meters, one splice will be permitted for each additional 15 meters. Splices shall be made by the manufacturer at the manufacturing plant. Longitudinal joint sealers may be field spliced where intersected by transverse joints. Field splices shall be sealed with a sealant recommended by the manufacturer.

The top surface of the sealer after installation shall be 9 millimeters ± 1.5 millimeters below the surface of the adjacent roadway.

420.04—Measurement and Payment.

Preformed elastomeric joint sealer, when a pay item, will be measured in meters along the pavement surface from out to out of the deck slab, complete-in-place, and will be paid for at the contract unit price per meter. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Preformed elastomeric joint sealer (Width)	Meter

SECTION 421—ELASTOMERIC EXPANSION DAMS

421.01—Description.

This work shall consist of furnishing and installing elastomeric expansion dams in accordance with these specifications and in reasonably close conformity with the lines, elevations, and locations shown on the plans or as established by the Engineer.

421.02—Materials.

Materials shall conform to the requirements of Section 212.

421.03—Procedures.

Working drawings showing the complete details and dimensions of the dam and other pertinent information, such as required special shop fabrication necessary for installation of practical leakproof joints, shall be submitted to the Engineer for review in accordance with the requirements of Section 105.02. The Contractor shall provide a factory-trained representative on the job site prior to and during the initial installation of the expansion dam.

Dams shall consist of elastomeric material and metal components arranged to provide for expansion and contraction movement of the bridge deck.

Expansion and contraction movements between adjacent spans of the bridge deck shall be compensated for entirely by deformation of the elastomer component, without detriment to it, and shall cause no appreciable change in the elevation of the deck surface. The opening between the rigid portions of dams at the roadway level shall be not more than 90 millimeters at maximum opening.

Dams shall seal the deck surface, gutters, curbs, and parapets to prevent water and other contaminants from seeping onto the substructure.

Dams shall have a continuous elastomeric membrane. Field-vulcanized joints for each dam may be permitted in accordance with plan details.

Dams shall be cast in place, with top surfaces parallel to the bridge deck. Concrete shall be placed beneath the dam in a manner to prevent the formation of air pockets in the concrete.

Final sealing of the finished dam shall be completed as soon as possible after installation. Bolt cavities shall be wire brushed and filled with sealant. Edges of the dam, exposed ends, and other areas of possible leakage shall be filled with sealant. Sealant shall be smoothed, and any excess scraped off before the initial set.

421.04—Measurement and Payment.

Elastomeric expansion dams will be measured in meters of dam, complete-in-place, for the movement range specified and will be paid for at the contract unit price per meter. The movement range will be 0 to 50 millimeters, 50 to 75 millimeters, and 75 to 100 millimeters. When not a pay item, the cost

thereof shall be included in the price for other appropriate pay items. This price shall include furnishing, installing, components, and anchoring devices.

Payment will be made under:

Pay Item	Pay Unit
Elastomeric expansion dam (Movement range)	Meter

SECTION 422—NAVIGATION LIGHTS

422.01—Description.

This work shall include furnishing, installing, and wiring navigation lights complete and ready for service on structures shown on the plans or as directed by the Engineer.

422.02—Materials.

(a) **Conduit, boxes, and fittings** shall conform to the requirements of Section 238.

(b) **Conductors and electrical components** shall conform to the requirements of Section 238. No. 8 single-conductor wire shall be used from the connection at the service pole to the first junction box on the stucture, and No. 10 single-conductor wire shall be used for other wiring.

422.03—Procedures.

(a) **Electrical Service:** Power will be furnished within 30 meters of the end of the bridge by 120/240-volt single-phase, 60-hertz, three-wire service. The Contractor shall furnish and install a wood pole on which the power company will terminate its service lines. The Contractor shall install service entrance equipment on the wood pole in accordance with the requirements of Standard SE-8. The safety switch shall be rated at 30 amp, 240 volts, two pole, solid neutral 120 volt AC and fused for 15 amps.

(b) **Conduit, Boxes, and Fittings:** These shall be installed in accordance with the requirements of Section 700.

(c) **Lights:** Lights shall be furnished and installed in accordance with the latest rules and regulations for lighting bridges furnished by the U.S. Coast Guard and shall be subject to their approval. Materials and workmanship shall conform to the standards of NEC and the requirements of the local power company. Lights shall be equipped with an automatic lamp changer with a capacity of four lamps and a step-down transformer to operate standard low-voltage prefocused lamps. Lights shall be arranged to be turned on and off automatically so that they will burn continuously from sunset to sunrise.

Lights shall be controlled by a photoelectric control. The control shall operate a two-pole, 30-amp, normally open, magnetic relay mounted in a NEMA 3R control center cabinet. The control for the lights shall be mounted on the service pole.

422.04—Measurement and Payment.

Navigation lights will be paid for at the contract lump sum price, wherein no measurement will be made. This price shall include furnishing and installing conduit, conductor cable, service entrance equipment, junction boxes, navigation lights, lamp changer, photoelectric control and step down transformer, control center cabinet and safety switch.

Payment will be made under:

Pay Item	Pay Unit
Navigation lights	Lump sum

Division V

INCIDENTAL CONSTRUCTION

SECTION 501—UNDERDRAINS

501.01—Description.

This work shall consist of constructing underdrains, using pipe, aggregate, and geotextile fabric, in accordance with these specifications and in reasonably close conformity to the lines and grades shown on the plans or as designated by the Engineer.

501.02—Materials.

(a) **Pipe** shall conform to the requirements of Section 232.

(b) **Aggregate** shall conform to the requirements of Section 202 or 203.

(c) **Geotextile drainage fabric** shall conform to the requirements of Section 245.

501.03—Procedures.

(a) **Installing Pipe:** Perforated pipe shall be placed with the perforations down. Pipe sections shall be joined with appropriate couplings. Semiround underdrain pipe shall be placed with the rounded section down.

Wherever the depth of the trench is modified to a lesser depth than shown on the standard drawings, concrete or corrugated pipe shall be used.

Pipe shall be placed with the bell end upgrade. Open joints shall be wrapped with tar paper.

Upgrade ends of pipe, except for combination underdrains, shall be closed with suitable plugs. Where an underdrain connects with a manhole or catch basin, a suitable connection shall be made through the wall of the manhole or catch basin.

Geotextile drainage fabric shall be installed in accordance with the requirements of Section 504.03.

After the pipe installation has been approved by the Engineer, aggregate backfill material shall be placed and compacted. Pipe and covering at open joints shall not be displaced during subsequent operations.

(b) **Combination Underdrain Outlets:** Nonperforated pipe shall be placed in the trench with sections securely joined. After pipe installation has been approved by the Engineer, the trench shall be backfilled with aggregate material in layers not more than 150 millimeters in depth and thoroughly compacted.

501.04—Measurement and Payment.

Underdrains and combination underdrains will be measured in meters, complete-in-place, and will be paid for at the contract unit price per meter. The contract unit price for underdrains installed at depths greater than that shown in the standard drawings will be increased 20 percent for each 300-millimeter increment of increased depth. No adjustment in the contract unit price will be made for an increment of depth less than 150 millimeters. When drains are to be placed under pavement that was not constructed under the Contract, the contract unit price shall include removing and replacing pavement.

Outlet pipe for underdrains will be measured in meters, complete-in-place, and will be paid for at the contract unit price per meter.

Geotextile drainage fabric, when a pay item, will be measured and paid for in accordance with the requirements of Section 504.

These prices shall include geotextile drainage fabric when not a pay item, excavating, backfilling, disposing of surplus and unsuitable material, and installing outlet markers.

Payment will be made under:

Pay Item	Pay Unit
Underdrain (Standard)	Meter
Combination underdrain (Standard)	Meter
Outlet pipe	Meter

SECTION 502—INCIDENTAL CONCRETE ITEMS

502.01—Description.

This work shall consist of constructing curbs, gutters, combination curbs and gutters, paved ditches, paved flumes, bridge drainage aprons and chutes, concrete median barriers, median strips, sign islands, and directional island curbs in accordance with these specifications and in reasonably close conformity to the lines and grades shown on the plans or as established by the Engineer.

502.02—Materials.

(a) **Hydraulic cement concrete** shall conform to the requirements of Section 217. With the approval of the Engineer, the design of the mixture may be modified to accommodate the placement equipment to be used.

(b) **Asphalt concrete** shall conform to the requirements of Section 211.

(c) **Preformed joint filler** shall conform to the requirements of Section 212. Material shall be approximately 13 millimeters in thickness and shall have a width and depth equal to those of the incidental structure.

(d) **Curing materials** shall conform to the requirements of Section 220.

(e) **Reinforcing steel** shall conform to the requirements of Section 223, Grade 300 or 400.

(f) **Rubble stone** shall conform to the requirements of Section 205.

(g) **Grout** shall conform to the requirements of Section 218.

(h) **Foundation course** shall be aggregate No. 68 conforming to the requirements of Section 203.

(i) **Dry filler** shall consist of aggregate conforming to the requirements of Section 202 or 203, as applicable.

(j) **Seed** shall conform to the requirements of Section 244.

(k) **Topsoil** shall conform to the requirements of Section 244.

502.03—Procedures.

The foundation shall be constructed to the required elevation. Unsuitable material shall be removed and replaced as directed by the Engineer. The subgrade shall be thoroughly compacted and shaped to provide a uniform, smooth surface. The foundation for hydraulic cement concrete items shall conform to the specified density of the course and shall be moist when concrete is placed.

Forms shall be straight, free from warp, and of such construction that there will be no interference with the inspection of grade and alignment. Forms shall extend the entire depth of the item and shall be braced and secured so that no deflection from alignment or grade will occur during concrete placement. Radial forms shall be sufficiently flexible or otherwise designed to provide a smooth, uniform, curved surface of the required radius. Face forms shall be removed as soon as concrete has attained sufficient set for the curb to stand without slumping.

The exposed surface shall then be smoothed by the use of a suitable finishing tool.

Transverse joints for crack control shall be provided at the following locations and times:

1. at approximately 6-meter intervals
2. at the gutter where the curb and gutter tie to the gutter apron of drop inlets
3. when time elapsing between consecutive concrete placements exceeds 45 minutes.

No section shall be less than 2 meters in length.

Crack control joints may be formed by using one of the following methods:

1. removable 3-millimeter-thick templates
2. scoring or sawing for a depth of not less than 20 millimeters when using a curb machine
3. approved "leave-in" type insert
4. other approved methods that will successfully induce and control the location and shape of the transverse cracks

The joint at the gutter where the curb and gutter ties to the apron gutter of the drop inlet shall be formed by scoring or sawing.

Expansion joints shall be formed at intervals of approximately 30 meters, all radii points at concrete entrances and curb returns, and no less than 2 meters and no more than 3 meters from drop inlets.

Hyraulic cement concrete shall be sufficiently consolidated to produce a closed surface. Edges shall be rounded to a 6-millimeter radius.

Exposed surfaces immediately adjacent to the roadway, except concrete median barrier, shall be given a light broom finish. Concrete median barrier shall be given a Class 1 finish in accordance with the requirements of Section 404.07(a). Paved ditches and paved flumes shall be given a coarse or roughened texture. Other exposed surfaces shall be given a rough wood float finish. Mortar used in the removal of surface irregularities shall be prepared in accordance with the requirements of Section 218.

Local irregularities in the face and top of curbs shall be not more than 10 millimeters in 3 meters. Vertical alignment shall be sufficiently uniform and regular to ensure complete drainage.

Immediately following finishing operations, hydraulic cement concrete shall be cured and protected in accordance with the requirements of Section 316.04.

(a) **Hydraulic Cement Concrete Curbs, Gutters, Combination Curbs and Gutters, Paved Ditches, and Paved Flumes:** Where standard mountable curb or combination curb and gutter with mountable curb is specified, adjacent curbs of standard entrance gutter and standard connection for streets shall be modified to provide a mountable shape corresponding to the standard mountable shape.

Where integral curb is specified, the curb shall be placed simultaneously with or immediately after placement of the slab. The time period between slab and curb placement shall be not more than 45 minutes except as hereinafter specified. The surface of the slab on which the curb is to be placed shall be roughened, and the concrete shall be placed so as to secure a bond between the slab and curb.

When authorized by the Engineer, the Contractor may construct the integral curb by providing steel dowels 16 millimeters in diameter, 175 millimeters in length, to be embedded in the slab at 900-millimeter intervals. Dowels shall be placed so as to extend at least 50 millimeters into the curb. While the slab is still plastic, it shall be roughened to a depth of approximately 13 millimeters below the screeded surface for the full width of the curb.

Within 3 to 7 days, the Contractor shall backfill curb, gutter, and combination curb and gutter to the required elevation with approved material. Backfill material shall be compacted with curbs and gutters remaining plumb.

(b) **Asphalt Concrete Curbs and Paved Ditches:** The curb shall be placed on a clean dry surface. Immediately prior to placement of the asphalt mixture, a tack coat of asphalt shall be applied to the surface at a rate between 0.02 and 0.07 liter per square meter of surface. Asphalt shall be prevented from spreading outside the area to be occupied by the curb.

Asphalt concrete curb shall be placed by a self-propelled automatic curb machine or a paver having curbing attachments to form a satisfactorily compacted curb of a uniform texture, shape, and density. The Engineer may permit construction of curbs by other means when short sections or sections with short radii are required. The resulting curbs shall conform in all respects to curbs produced by a curb machine.

Sealing or painting shall be performed only on curbs that are clean, dry, and cooled to ambient temperature.

Asphalt concrete paved ditches shall be placed and compacted so as to provide a smooth, uniform, and dense texture.

(c) **Grouted Rubble Gutter:** Aggregate for the foundation course shall be spread on the subgrade to a depth of at least 100 millimeters.

Gutter stones shall be bedded in the foundation course perpendicular to the finished surface, flat side up, in straight rows, with the longest dimension perpendicular to the center line of the gutter. Joints shall be broken in a satisfactory manner, and the width of interstices in the dry gutter shall be not more than 25 millimeters.

Stones shall be rammed until the surface is firm and conforms to the finished grade and cross section. Joints shall then be filled with dry filler to within 100 millimeters of the top of stones, and the surface shall be rammed to ensure proper compaction of filler. After irregularities have been corrected, cement grout shall be poured and broomed into joints and over stones. Additional grout shall be applied and brooming shall be continued until grout remains flush with the top of stones.

(d) **Concrete Median Barriers:** Concrete median barriers shall be constructed in accordance with the requirements specified herein and in Sections 512, 404, and 410.

Concrete median barriers shall be constructed within an allowable tolerance of ±10 millimeters for overall depth and overall width, ±5 millimeters for the width of the upper portion of the barrier, and ±5 millimeters per 3 meters for horizontal alignment.

After the specified curing time has elapsed, concrete median barriers for roadways shall be backfilled to the required elevation with approved material. Material shall be thoroughly tamped in layers not more than 150 millimeters in depth before compaction. Delineators shall be installed on median barriers in accordance with the requirements of Section 702.03.

(e) **Median Strip Slabs, Directional Island Curbs, and Curbs for Median Strips:** The area between curbs of earth medians and directional island curbs shall be filled with embankment material, firmly compacted, and brought to a grade approximately 50 millimeters below the top of curbs. The final 50 millimeters shall be backfilled with approved topsoil. Sufficient material shall be placed between curbs to compensate for settlement, thus leaving the earth slightly higher than the curbs. Seed shall be applied in accordance with the requirements of Section 603.03.

(f) **Hydraulic Cement Concrete Sign Islands:** Sign islands shall be constructed in accordance with the requirements of Section 504.03(a) except that joints for crack control and expansion shall be provided at locations that coincide with joints in underlying, adjacent, or integral rigid pavement or other structures.

502.04—Measurement and Payment.

Standard concrete curbs, radial curbs, standard combination curb and gutter, radial combination curb and gutter, and asphalt concrete curbs will be measured in meters along the face of the curb, complete-in-place, and will be paid for at the contract unit price per meter. The price shall include modifying curbs for standard entrance gutters, standard street connection pavement, and standard median strips. Where the curb or curb and gutter is adjacent to drop inlets, the contract unit price for the drop inlets shall include that part of the curb or curb and gutter within the limits of the structure.

Where there is no excavation within the limits of the curb, gutter, combination curb and gutter, or median barrier other than that necessary for its construction, the contract unit price shall include excavating, backfilling, compacting, and disposing of surplus and unsuitable material. Where excavation is necessary for the roadway, the part within the limits of the curb, gutter, combination curb and gutter, or median barrier section will be paid for as regular excavation in accordance with the requirements of Section 303.06.

Standard, radial, entrance, and grouted rubble gutters; paved ditches; paved flumes; street connection pavement; and bridge drainage aprons and chutes will be measured in square meters of surface area, complete-in-place, and will be paid for at the contract unit price per square meter. The price for grouted rubble gutter shall include rubble stone, grout, foundation course, and filler. When pipe drain ditch liner is substituted for standard paved ditch at the Contractor's option, payment will be made at the contract unit price for the standard paved ditch specified. When pipe drain ditch liner is specified on the plans, payment will be made at the contract unit price per meter, complete-in-place.

The cost of excavation below the finished grade or below the slope surface of cut or fill sections that is necessary for installing and backfilling paved ditches and flumes shall be included in the contract unit price for the paved ditch or flume. Undercut excavation below the neat lines of paved ditches in cut sections, including replacement backfill for undercut excavation and excavation above the upper lateral limits of paved ditches and paved flumes that are outside the normal plan earthwork limits, will be measured and paid for in accordance with the requirements of Section 303.06.

Ditch flume connector will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include excavation when required, dowels, welded wire fabric, reinforcing steel, anchor lugs, curtain walls, and concrete.

Cattle guards will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

Energy dissipators will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

Median barriers, including delineators, will be measured in meters along the center line of barriers and will be paid for at the contract unit price per meter.

Curb-cut ramps will not be measured for separate payment but will be measured in the units specified for their components.

Median strips will be measured in square meters or meters as specified and will be paid for at the contract unit price per square meter or meter.

Sign islands will be measured in units of each or square meters, complete-in-place, exclusive of posts and signs, and will be paid for at the contract unit price per each or per square meter.

Directional island curbs will be measured in meters along the face of the curb and will be paid for at the contract unit price per meter.

Embankment material between curb lines will be measured and paid for in accordance with the requirements of Section 303.06 except as specified below.

When there is no excavation or construction other than that necessary for constructing median strips, sign islands, or directional island curbs, the contract unit price shall include excavating, removing existing pavement, disposing of surplus and unsuitable material, backfilling, and compacting. When excavation or demolition of pavement is necessary for the adjoining roadway, that portion within the limits of the median strip, sign island, or directional island curb will be paid for as regular excavation or demolition of pavement in accordance with the requirements of Sections 303.06 and 508.03, respectively.

These prices shall include applying topsoil and seed.

Payment will be made under:

Pay Item	Pay Unit
Curb (Type and standard)	Meter
Combination curb and gutter (Type and standard)	Meter
Gutter (Type and standard)	Square meter
Paved ditch (Standard)	Square meter
Pipe drain ditch liner (Standard)	Meter
Paved flume (Standard)	Square meter
Energy dissipator (Standard)	Each

Entrance gutter (Standard)	Square meter
Street connection pavement (Standard)	Square meter
Median barrier (Standard)	Meter
Bridge drainage apron and chute (Standard)	Square meter
Median strip (Standard width)	Meter or square meter
Sign island (Standard)	Each or square meter
Directional island curb (Standard)	Meter
Cattle guard (Standard)	Each
Ditch flume connector (Standard)	Each

SECTION 503—RIGHT-OF-WAY MONUMENTS

503.01—Description.

This work shall consist of erecting right-of-way monuments in accordance with the requirements of the standard drawings at locations shown on the plans or as designated by the Engineer.

503.02—Materials.

Right-of-way monuments shall conform to the requirements of Section 219.

503.03—Procedures.

Monuments shall be placed at locations designated on the plans or by the Engineer. Backfill shall be thoroughly compacted in a manner that will not displace the monument.

503.04—Measurement and Payment.

Right-of-way monuments will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include excavating and backfilling.

Payment will be made under:

Pay Item	Pay Unit
Right-of-way monument (Standard)	Each

SECTION 504—SIDEWALKS, STEPS, AND HANDRAILS

504.01—Description.

This work shall consist of constructing sidewalks, steps, and handrails on steps or walls in accordance with these specifications and in reasonably close conformity to the lines and grades shown on the plans or as established by the Engineer.

504.02—Materials.

(a) **Concrete** shall be Class 20 conforming to the requirements of Section 217.

(b) **Reinforcing steel** shall conform to the requirements of Section 223.

(c) **Curing materials** shall conform to the requirements of Section 220.

(d) **Preformed joint filler** shall conform to the applicable requirements of Section 212. Material shall be approximately 13 millimeters in thickness and shall have a width and depth equal to those of the structure.

(e) **Asphalt concrete** shall conform to the requirements of Section 211.

(f) **Rails and posts** shall conform to the requirements of Section 232.02(c)4.b. Rails shall be of standard mass, and posts shall be extra strong pipe.

(g) **Geotextile drainage fabric** shall conform to the requirements of Section 245.

504.03—Procedures.

(a) **Sidewalks:** The foundation shall be shaped and compacted to a firm, even surface.

Unsuitable material shall be removed and replaced with approved material as directed by the Engineer.

When geotextile drainage fabric is required, the designated area shall be cleared of debris prior to fabric installation. Large holes shall be filled with sandy, coarse material, and sharp contours and rises shall be leveled. Adjacent strips of geotextile drainage fabric shall be overlapped at least 300 millimeters. If fabric is torn or punctured, it shall be repaired with the same type of fabric. A patch shall be placed over

the damaged area with an overlap of at least 300 millimeters in all dimensions at the Contractor's expense.

Forms shall be straight, free from warp, and of sufficient strength to resist the pressure of concrete without springing and shall extend for the full depth of concrete. Forms shall be braced and stacked so that they will remain in horizontal and vertical alignment until their removal. Where practicable, forms shall be placed at least 30 meters in advance of concrete placement. Forms shall be cleaned of foreign matter and oiled before concrete is placed.

1. **Hydraulic cement concrete sidewalk:** The foundation shall be thoroughly moistened immediately prior to concrete placement. Concrete shall be placed in forms by methods that will prevent segregation. Concrete shall be spread to the full depth and brought to grade by screeding and straightedging. Concrete shall be spaded adjacent to forms to prevent a honeycomb appearance, and the surface shall be floated with a wooden float to produce a surface free from irregularities. The final finish shall be obtained with an approved hand float that will produce a uniform surface texture. Light metal marking rollers or light brooming may be used to hide trowel marks. Outside edges of the sidewalk slab and joints shall be edged with an edging tool having a radius of 5 millimeters.

   Transverse expansion joints shall be constructed at intervals of approximately 30 meters, except for closures. Slabs shall be at least 1 meter in length. Slabs shall be separated by transverse preformed joint filler, 13 millimeters in thickness, that extends from the bottom of the slab to approximately 5 millimeters below the top surface.

   The slab between expansion joints shall be divided into sections approximately 1.5 meters in length by transverse control joints formed by a jointing tool, trowel, or other approved means. Transverse control joints shall also be provided when the time period between consecutive concrete placements is more than 45 minutes. Control joints shall extend into concrete for at least 5 millimeters of the depth and shall be approximately 3 millimeters in width. Where slabs are more than 2 meters in width, control joints shall be formed longitudinally to obtain secure uniform blocks that are approximately square. Transverse control joints shall also be installed where the corners of the drop inlets project into the sidewalk.

   Construction joints shall be formed around appurtenances extending into and through the sidewalk. Preformed joint filler 6 millimeters thick shall be installed in these joints except that joint filler shall not be used adjacent to drop inlets. An expansion

joint shall be formed and filled with 6 millimeters of preformed joint filler no less than 1.8 meters and no more than 3 meters from drop inlets. Preformed joint filler shall also be installed between concrete sidewalk and any adjacent fixed structure that is not tied to the sidewalk with steel dowels.

Where the sidewalk is constructed in conjunction with adjacent curb, expansion joints in the curb and sidewalk shall coincide. Where such construction is adjacent to existing curb, the expansion joint shall coincide, where practicable.

Where existing or proposed structures are within the limits of the sidewalk area, concrete around them shall be scored in a block approximately 200 millimeters wider than the maximum dimension of the structure at the sidewalk elevation.

Preformed joint filler shall be securely fastened.

The Engineer may drill cores from the completed slab to make depth measurements. Sections showing a deficiency of more than 10 millimeters shall be removed and replaced to the specified depth at the Contractor's expense.

Immediately following finishing operations, concrete shall be cured and protected in accordance with the requirements of Section 316.04. Sidewalks shall not be opened to pedestrian traffic for the first 5 days. Vehicular traffic shall be excluded for the first 14 days or until the minimum design compressive strength is attained, whichever is the lesser time.

When liquid membrane-forming compound is used, heavy concentrations of compound that will not properly set and that may be tracked into homes or businesses shall not be used.

2. **Asphalt concrete sidewalk:** When specified on the plans, a layer of bedding material consisting of approved aggregate conforming to the grading requirements of No. 8 aggregate shall be placed in layers not more than 100 millimeters in depth, loose measurement, and thoroughly compacted.

   Asphalt concrete shall be placed in forms in one or more courses to provide the specified depth when compacted. Compaction shall be accomplished by means of a hand-operated or power roller of a type and weight acceptable to the Engineer. Tamping by hand will be permitted in areas inaccessible to a roller. The method of compaction shall produce a smooth, dense, uniformly compacted sidewalk.

(b) **Hydraulic Cement Concrete Steps:** Hydraulic cement concrete steps shall be constructed in accordance with the requirements of Sections 404 and 406. The tread portion of steps shall be given a light broom texture. Finished concrete shall be cured and protected in accordance with the requirements of Section 316.04.

(c) **Handrails:** Standard or special fittings shall be used, or joints may be welded. If joints are welded, exposed joints shall be finished by grinding or filing to give a neat appearance.

Metal items, including rails, posts, and fittings, shall be galvanized in accordance with the requirements of Section 233 except for metal posts and rails fabricated from pregalvanized material whose ends and other exposed areas are satisfactorily repaired with a material conforming to the requirements of Section 233.

When rails are placed on a mortar rubble wall, the wall shall be capped with 350 millimeters of Class 20 concrete.

504.04—Measurement and Payment.

Hydraulic cement concrete sidewalks will be measured in square meters of finished surface, complete-in-place, and will be paid for at the contract unit price per square meter. Each structure located within the limits of the sidewalk having an area greater than 1 square meter will be excluded in computing the square meters of sidewalk.

Asphalt concrete sidewalks will be measured in metric tons of asphalt mixture placed and will be paid for at the contract unit price per metric ton.

If regular excavation is not shown in the sidewalk area, the contract unit price for sidewalks shall include excavating, removing existing sidewalk, and disposing of surplus and unsuitable material. When the sidewalk area is located in the cross-sectional area for roadway excavation, excavation within the sidewalk area will be paid for at the contract unit price for regular excavation.

Bedding material will be measured in metric tons or cubic meters in accordance with the requirements of Section 109 and will be paid for at the contract unit price per metric ton or cubic meter.

Concrete steps will be measured in cubic meters of concrete and kilograms of reinforcing steel, complete-in-place, and will be paid for at the contract unit price per cubic meter of concrete and per kilogram of reinforcing steel.

Handrails will be measured in meters along the top rail, complete-in-place, and will be paid for at the contract unit price per meter. This price shall include

concrete placed on mortar rubble walls when the wall is not included in the Contract.

Geotextile drainage fabric will be measured in square meters to the limits shown on the plans or as directed by the Engineer, complete-in-place, and will be paid for at the contract unit price per square meter. Overlaps, overwidths, and waste fabric will not be measured. This price shall include preparing the surface, furnishing and installing fabric, overlaps and repair work, and excavating and backfilling toe-ins.

Payment will be made under:

Pay Item	Pay Unit
Hydraulic cement concrete sidewalk (Depth)	Square meter
Asphalt concrete sidewalk	Metric ton
Bedding material	Metric ton or cubic meter
Concrete, Class 20, Miscellaneous	Cubic meter
Reinforcing steel	Kilogram
Handrail (Standard)	Meter
Geotextile drainage fabric (Type)	Square meter

SECTION 505—GUARDRAIL AND STEEL MEDIAN BARRIERS

505.01—Description.

This work shall consist of furnishing and constructing guardrail and steel median barriers and installing reuse galvanized guardrail in accordance with the plans and these specifications and in reasonably close conformity to the lines and grades shown on the plans or as designated by the Engineer.

505.02—Materials.

(a) **Guardrail components** shall conform to the requirements of Section 221.

(b) **Median barriers and posts** shall conform to the requirements of the Contract for the materials specified on the plans. Posts may be furnished with as many as six holes so that posts for installation of standard guardrail and steel median barrier may be used interchangeably.

(c) **Concrete** shall be Class 20 conforming to the requirements of Section 217 except that mixing by hand for guardrail terminal posts will be permitted.

(d) **Reinforcing steel** shall conform to the requirements of Section 223.

(e) **Delineators** shall conform to the requirements of Section 235.

505.03—Procedures.

The use of more than one type of post on a continuous line of guardrail will not be permitted.

Rail and elements shall be erected and aligned in a manner that will result in a smooth, continuous, taut installation.

Guardrail delineators shall be installed in accordance with the requirements of Section 702.03. Spring cable end assemblies (compensating device) shall be provided with a permanent match mark (hacksaw cut or file mark) on the bolt shaft or spring stop and shall be referenced to the outer assembly to denote the neutral position. Cable slack shall be eliminated by tightening the steel turnbuckle cable assembly at the end opposite the compensating device until the device is compressed 90 millimeters. Cables with a compensating device at each end shall be tightened such that neither end indicates less than the required tension. The assembly shall remain compressed for at least 2 weeks and then loosened, and each cable shall be readjusted to the same required tension. The required tension shall be determined by tightening the turnbuckle at the end opposite the compensating device and displacing the match mark in accordance with the following:

Ambient Air Temperature (°C)	Match Mark Displacement (mm)	Required Tension (N)
–18- –8	90	7,000
–7-3	75	6,000
4-17	65	5,000
18-26	50	4,000
27-37	25	3,000
38-49	25	2,000

Anchor assemblies shall be installed on firm earthen foundations, backfilled with suitable material in 100 to 150 millimeter layers, and thoroughly compacted by tamping or rodding. Stress loads shall not be placed on anchor assemblies until concrete has cured for at least 28 days or has attained a compressive strength of at least 20 megapascals per square meter as determined by field control cylinders in accordance with the requirements of Section 404.03.

On beam guardrail anchors, nuts on anchor bolts shall be tightened to a snug tight fit as defined in Section 407.06 to ensure flush contact between the beam and concrete base throughout the length of the anchor assembly.

Post holes shall be backfilled to the ground line with approved material placed in layers not more than 100 millimeters in height. Each layer shall be compacted by tamping.

Steel posts may be driven provided the method used will not damage the posts.

Concrete posts that are chipped or cracked will be rejected.

Wood posts shall be sawed to the dimensions shown on the plans within a tolerance of 2 percent for length and 5 millimeters scant. Wood posts may be driven, but posts that are damaged during installation shall be replaced at the Contractor's expense. If it is necessary to saw off the tops of wood posts to achieve a uniform and neat appearance, the amount sawed off shall be not more than 75 millimeters. Tops of sawed posts shall be brush coated with three heavy applications of the preservative used in treating the posts. Each application shall be given sufficient time to penetrate the wood. Painting wood posts will not be required. Dirt and other foreign matter shall be removed after installation.

Galvanized items shall be handled and stored in accordance with the requirements of Section 233. After erection, the threaded portion of fittings with fasteners and cut ends of bolts and galvanized surfaces that have been abraded or damaged shall be repaired in accordance with the requirements of Section 233.03.

Reuse guardrail that has maintained its original shape and is suitable for reuse may be used. When necessary, reuse guardrail shall be rebored to the dimensions shown on the standard drawings. Reuse guardrail that is damaged or lost because of the Contractor's negligence shall be replaced at the Contractor's expense.

Reuse guardrail posts and blockouts may be used provided they conform to the requirements of the standard drawings and these specifications.

The Contractor shall ensure that guardrail and barriers are kept clean during application of fertilizer, lime, tack coats, primer, or other material that cannot be readily cleaned from the guardrail or barrier.

505.04—Measurement and Payment.

Guardrail will be measured in meters and will be paid for at the contract unit price per meter. Beam guardrail will be measured in meters from center to center of end posts. Cable guardrail will be measured from center to center of concrete anchor assemblies, complete-in-place. Guardrail that is mounted flush to a structure will be measured along the length of the guardrail

from the center of the bolt group. Shop-curved or field-curved guardrail installed on a radius of 50 meters or less will be measured in meters of radial steel beam guardrail or radial steel median barrier.

The price for reuse guardrail shall include transporting and storing; repairing and installing salvaged guardrail beam; and furnishing and placing guardrail posts, blockouts, and hardware.

Steel median barriers will be measured in meters from center to center of end posts and will be paid for at the contract unit price per meter.

Intermediate anchorage assemblies will be measured in units of each and will be paid for at the contract unit price per each.

Terminal treatment for beam guardrail that terminates in back of the ditch line will be measured in meters along the regular guardrail section from center of end post (center of bolt group when guardrail is mounted flush to a structure) to the ditch line. The terminal section in back of the ditch line will be measured from the ditch line to center of end post.

Terminal treatment for beam guardrail, cable guardrail, and steel median barriers terminating on the roadway side of the ditch line will be measured in units of each and will be paid for at the contract unit price per each.

Reuse guardrail terminal will be measured in units of each or per meter for the standard and type specified and will be paid for at the contract unit price per each or per meter for the standard and type specified. This price shall include transporting and storing; repairing and installing salvaged beam; and furnishing and placing guardrail posts, blockouts, concrete, and hardware.

Fixed object attachments for guardrail will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing guardrail connectors, rubrail, and additional posts with blockouts and providing holes to facilitate attachment.

Special design guardrail bridge attachments will not be measured for payment but will be paid for at the contract lump sum price per structure. This price shall include furnishing and installing terminal connectors and additional posts with blockouts.

Cable barricades will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing posts, cable, signs, and padlocks.

When specified as a separate bid item guardrail terminal site preparation will be measured in units of each per site and will be paid for at the contract unit price per each site.

The price for guardrail terminal site preparation shall include clearing and grubbing; furnishing, hauling, and placing fill material; benching existing slopes; and restoration of site including seeding.

These prices shall include excavating; backfilling holes; installing delineators; repairing damaged surfaces; furnishing, galvanizing, and erecting units; furnishing concrete anchor assemblies; and preboring.

Payment will be made under:

Pay Item	Pay Unit
Guardrail (Standard)	Meter
Reuse guardrail (Standard)	Meter
Radial guardrail (Standard)	Meter
Guardrail terminal (Standard and type)	Meter or each
Intermediate anchorage assembly	Each
Median barrier (Standard)	Meter
Radial median barrier (Standard)	Meter
Median barrier terminal (Standard and type)	Each
Cable barricade (Standard)	Each
Fixed object attachment (Standard)	Each
Special design guardrail bridge attachment (B or Str. No.)	Lump sum
Reuse guardrail terminal (Standard and type)	Meter or each
Guardrail terminal site preparation (Standard)	Each

SECTION 506—RETAINING WALLS

506.01—Description.

This work shall consist of constructing rubble and hydraulic cement concrete retaining walls in accordance with the plans and these specifications and in reasonably close conformity to the lines and grades shown on the plans or as established by the Engineer.

506.02—Materials.

(a) **Dry rubble and mortar rubble retaining walls** shall be constructed of stone conforming to the requirements of Section 204 and mortar conforming to the requirements of Section 218.

(b) **Hydraulic cement concrete retaining walls** shall be constructed of concrete conforming to the requirements of Section 217.

(c) **Reinforced concrete crib walls** shall be constructed of precast concrete units. Concrete shall conform to the requirements of Section 217 except that No. 7 aggregate may be used in lieu of No. 57 aggregate. Crib units shall be free from cracks, depressions, spalls, patched or plastered surfaces or edges, and any other defects that might impair their strength or durability.

(d) **Drain pipe** shall conform to the requirements of Section 232.

(e) **Reinforcing steel** shall conform to the requirements of Section 223, Grade 300 or 400.

(f) **Porous backfill** shall conform to the requirements of Section 204.

(g) **Granular backfill within crib walls** shall be any material available within the project limits consisting of sand, sandy loam, gravel, rock, or a combination thereof. Materials containing a high percentage of fines, such as clay and silt soils, shall not be used.

(h) **Piles** shall conform to the requirements of Section 403.

506.03—Procedures.

Excavation, backfill, and foundation exploration shall conform to the requirements of Section 401.

Concrete construction shall be performed in accordance with the requirements of Section 404. Immediately following finishing operations, concrete shall be cured and protected in accordance with the requirements of Section 404.03.

(a) **Dry Rubble and Mortar Rubble Retaining Walls:** Stones shall not be placed in freezing weather or when stone contains frost.

Each stone shall have a thickness of at least 200 millimeters, a width of at least 1 1/2 times the thickness, and except for headers, a length at least equal to 1 1/2 times the width. The thickness of courses, if varied, shall diminish from the bottom to the top of the wall.

Header stones in the heart of the wall shall be the same size as in the face and shall extend at least 300 millimeters into the core or backing. They shall occupy at least 1/5 of the face area of the wall and shall be evenly distributed. Header stones in walls 600 millimeters or less in thickness shall extend entirely through the wall.

Stones shall be roughly squared on joints, beds, and faces. Selected stone, roughly squared and pitched to line, shall be used at angles and ends of walls.

Stones shall be placed to line and in courses roughly leveled. Bottom or foundation courses shall be composed of large, selected stones. Courses shall be placed with bearing beds parallel to the natural bed of the material.

Shaping or dressing of stone shall be performed before stone is placed in the wall. Dressing or hammering that will loosen the stone will not be permitted after placement.

1. **Dry rubble retaining walls:** Face joints shall be not more than 25 millimeters in width.

   Each stone shall have a firm bearing on the underlying course at no fewer than three points. Open joints, both front and rear, shall be chinked with spalls fitted to take firm bearing on their top and bottom surfaces and shall have a firm bearing throughout the length of the stone.

2. **Mortar rubble retaining walls:** Each stone shall be cleaned and thoroughly wetted with water before it is placed, and the bed that is to receive it shall be cleaned and moistened. Stones shall be bedded in freshly prepared mortar. Mortar joints shall be full, and stones shall be carefully settled in place before mortar has set. Spalls will not be permitted in beds. Joints and beds shall not have an average thickness of more than 25 millimeters.

   Whenever possible, face joints shall be properly pointed before mortar has set. Joints that cannot be pointed shall be prepared for pointing by raking them out to a depth of 50 millimeters before mortar has set. Face surfaces of stones shall not be smeared with mortar forced out of joints.

   Vertical joints in each course shall break joints with those in adjoining courses by at least 150 millimeters. A vertical joint shall not be located directly above or below a header.

   If a stone is moved or a joint is broken, the stone shall be taken up, mortar shall be thoroughly cleaned from the bed and joints, and stone shall be placed in fresh mortar.

   Joints that are not pointed at the time stone is placed shall be thoroughly wetted with clean water and filled with mortar. Mortar shall be driven into joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done. In

hot or dry weather, pointed masonry shall be protected from the sun and kept wet by saturated burlap for at least 3 days after completion.

After pointing is completed and mortar has set, the wall shall be thoroughly cleaned and left in a neat, orderly condition.

(b) **Concrete Retaining Walls:** Concrete retaining walls shall be constructed in accordance with the requirements of Sections 403, 404, and 406.

(c) **Reinforced Concrete Crib Walls:** Crib units that are damaged during erection shall be removed and replaced at the Contractor's expense.

Granular backfill shall be used inside and approximately 600 millimeters in back of and beyond each end of a crib. Backfilling for the crib wall shall follow closely the erection of successive tiers of units. The wall shall not be placed higher than 1 meter above the backfilled portion. Backfill shall be placed carefully to avoid distorting the crib wall.

506.04—Measurement and Payment.

Standard retaining walls will be measured in cubic meters, complete-in-place, within the limiting dimensions shown on the plans, and will be paid for at the contract unit price per cubic meter. This price shall include rubble stone, concrete, joint material, and weep holes.

Concrete and reinforcing steel for special design retaining walls will be measured and paid for in accordance with the requirements of Sections 404.08 and 406.04, respectively.

Reinforced concrete crib walls will be measured in cubic meters of the net volume of concrete in crib units, complete-in-place, and will be paid for at the contract unit price per cubic meter. This price shall include concrete and reinforcing steel.

Granular backfill will be measured and paid for as regular excavation in accordance with the requirements of Section 303.06.

Porous backfill for retaining walls will be measured and paid for in accordance with the requirements of Section 401.04.

Piles for retaining walls will be measured and paid for in accordance with the requirements of Section 403.08.

Excavation for retaining walls will be measured in accordance with the requirements of Section 401.04 and will be paid for at the contract unit price

per cubic meter. This price shall include excavation, foundation exploration, sheeting and shoring, placing and compacting backfill and disposal of surplus material, and porous backfill when not specified as a separate pay item.

Payment will be made under:

Pay Item	Pay Unit
Retaining wall (Standard)	Cubic meter
Concrete crib (Standard)	Cubic meter
Retaining wall excavation	Cubic meter

SECTION 507—FENCES

507.01—Description.

This work shall consist of constructing and grounding new fence in accordance with these specifications and in reasonably close conformity to the lines and grades shown on the plans or as established by the Engineer.

507.02—Materials.

(a) **Materials for fences** shall conform to the requirements of Section 242.

(b) **Staples** shall be 3.77-millimeter galvanized strand wire and shall be at least 40 millimeters in length for soft wood posts and at least 25 millimeters in length for hardwood posts.

507.03—Procedures.

Old fences that are not to be salvaged, trees, stumps, logs, and other debris that will interfere with new fence construction shall be removed and disposed of as directed by the Engineer.

If rock is encountered before the specified post depth is reached, posts shall be placed approximately 900 millimeters in depth or 450 millimeters into rock, whichever is less. The diameter of holes prepared for setting posts in rock shall be at least 75 millimeters greater than the larger cross-sectional dimension of the post. If rock is encountered during installation of gates, corners, or brace posts, posts shall be placed in concrete.

Except where rock is encountered, post and braced post anchor devices may be used in lieu of placing post and braces in concrete. Anchor devices shall be fabricated of steel having a yield strength of at least 200 megapascals or of other metal approved by the Engineer; shall have a thickness of not less than that specified for the post or 3 millimeters, whichever is greater; and shall be galvanized in accordance with the requirements of Section 233.

Post and braced post anchor devices, together with the post, shall develop at least 80 percent of the resistance to horizontal and rotational displacement of individual post and braced post assemblies set in concrete when the load is gradually applied to the fence fabric at midheight. The Contractor shall demonstrate that the performance of post and braced post anchor devices will be comparable to that of concrete when such devices are proposed for use in lieu of concrete. The use of post and braced post anchor devices in lieu of concrete and the demonstration of comparable performance shall be at the Contractor's expense.

(a) **Standard Chain Link Fences:** Metal posts for chain link fences shall be set in Class 20 concrete footings. Posts set in concrete footings shall not be disturbed for at least 7 days following the initial set of concrete and for at least 14 days when the average air temperature for the week following placement is below 10 °C.

Each span shall be attached independently at pull and corner posts. Ends of fabric rolls and other sections to be spliced shall be joined by weaving a single strand of the fabric wire into ends of the fabric to create a continuous pattern of mesh. Fabric shall be stretched taut and securely fastened to each post and rail. Fastenings at ends, gates, corners, and pull posts shall be with stretcher bars and metal bands.

(b) **Standard Fences:** Wood posts shall be set with the larger end down. Backfill around wood posts shall be thoroughly compacted in layers approximately 150 millimeters in thickness. Wood posts may be driven provided they are not damaged.

Metal posts shall be driven.

Wire shall be stretched taut and securely fastened to each post. Unless a splice can be provided that will develop a strength comparable to the strength of the wire, splicing will be permitted only at posts. Each horizontal strand of wire shall be wrapped around the end of the gate post and securely fastened by winding it about the wire leading to the post.

A new fence shall be joined to an existing fence at the beginning and end of the new fence and at points where cross fences intersect the new fence.

Wood fence posts shall be installed so that tops form a regular grade line. Tops of posts that are sawed after driving shall be brush coated with three heavy applications of the preservative used to treat the posts. Each application shall be given sufficient time to penetrate the wood.

Gates shall be erected at locations shown on the plans or where designated by the Engineer. If preferred by the property owner and approved by the Engineer, gates and fences similar in type to that which exist may be substituted for the gate shown on the standard drawings.

Surplus excavated material and other debris resulting from erecting fences shall be removed, and the site shall be left in a neat, orderly condition.

The Contractor shall be responsible for damage caused to or by livestock straying through areas where an old fence has been removed and is to be replaced with a new fence.

(c) **Pedestrian Fences for Bridges:** The frame for pedestrian fences for bridges shall be bonded internally wherever possible to maintain continuity. Electrical grounding shall conform to the requirements of Section 410.03(b).

507.04—Measurement and Payment.

Fences will be measured in meters of fence fabric, complete-in-place, along the top of the fence from outside to outside of end posts for each continuous run of fence, exclusive of gates, and will be paid for at the contract unit price per meter of fence fabric. This price shall include clearing, leveling, and preparing terrain at the fence level; line posts; attaching to posts; grounding; and disposing of surplus and unsuitable material.

Line and corner braces will be measured in units of each and will be paid for at the contract unit price per each. This price shall include posts, braces, concrete, and dowels.

Water gates, Types I and II, will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include fittings.

Water gate, Type III, will be measured in meters of gate between inside edges of end posts, complete-in-place, and will be paid for at the contract unit price per meter. This price shall include end posts and anchor block assemblies.

Pedestrian fences will be measured in meters along the top of the wall, complete-in-place, and will be paid for at the contract unit price per meter. This price shall include posts, fabric, braces, ties, and grounding.

Payment will be made under:

Pay Item	Pay Unit
Fence (Standard)	Meter
Corner brace unit (Standard)	Each
Line brace unit (Standard)	Each
Pedestrian fence (Height)	Meter
Gate (Standard and length)	Each
Water gate (Standard)	Each or meter

SECTION 508—DEMOLITION OF PAVEMENT AND OBSCURING ROADWAY

508.01—Description.

This work shall consist of demolition of pavement and obscuring roadway to restore areas that are no longer needed for highway use in accordance with these specifications and in reasonably close conformity to the lines and contours shown on the plans or as established by the Engineer.

508.02—Procedures.

(a) **Demolition of Pavement Structures:**

1. Hydraulic cement concrete pavement shall be demolished as follows:

   a. Pavement shall be broken into pieces and either used in fill areas as rock embankment in accordance with the requirements of Section 303 or disposed of at locations selected by the Contractor and approved by the Engineer; *or*

   b. Material within the proposed roadway prism and more than 1 meter below the subgrade may be broken into pieces not more than 450 millimeters in any dimension, sufficiently displaced to allow for adequate drainage, and left in the roadway prism.

2. Asphalt concrete pavement that does not overlay or underlie hydraulic cement concrete pavement shall be removed as follows:

   a. Pavement shall be removed and used in the work as designated on the plans or as directed by the Engineer; *or*

b. When approved by the Engineer, pavement shall be removed and disposed of at locations selected by the Contractor.

3. Cement stabilized courses underlying pavement designated for demolition shall be disposed of in accordance with (a)1.a. or (a)1.b. herein.

4. Aggregate underlying pavement designated for demolition, except hydraulic cement concrete pavement disposed of in accordance with (a)1.b. herein, shall be salvaged and used for maintenance of traffic or, when approved by the Engineer, disposed of in accordance with (a)2.a. herein.

(b) **Obscuring Roadway:**

1. Areas outside construction limits consisting of asphalt concrete or hydraulic cement concrete pavement demolished in accordance with (a) herein shall be conditioned in accordance with the following:

   a. Tops of slopes that do not contain rock shall be rounded for a distance of not more than 3 meters but not less than 1.5 meters (where sufficient right of way exists) beyond the point of intersection of the existing slope and the natural ground surface. The depth of the rounding shall be not more than 0.6 meter below the original surface of slopes.

   b. Disturbed areas that are to receive vegetation shall be scarified or plowed, harrowed, and shaped.

   c. Clearing and grubbing shall be performed in accordance with the requirements of Section 301.

2. Areas outside construction limits consisting of pavement structures, other than asphalt concrete or hydraulic cement concrete, that are designated for obscuring roadway shall be conditioned in accordance with (b)1. herein. Prior to the obscuring, pavement structures shall be removed in accordance with the applicable requirements of (a) herein.

508.03—Measurement and Payment.

Demolition of cement-stabilized, hydraulic cement concrete, and asphalt concrete pavement and shoulder structure courses or a combination thereof will be measured in square meters based on the width of the widest course and will be paid for at the contract unit price per square meter. Demolition of hydraulic cement-stabilized, hydraulic cement concrete, and asphalt concrete

pavement courses located beyond the existing pavement structure will also be measured for payment.

Obscuring roadway will be measured in units of 100 square meters computed to the nearest 1/10 unit and will be paid for at the contract unit price per unit. The area measured will be entirely outside the construction limits of the new roadway, as evidenced by slope stakes. Areas disturbed by the operations, including tops of slopes to be rounded, will be included in the measurement. Removing pavement structures other than hydraulic cement stabilized, hydraulic cement concrete, and asphalt concrete pavement structures in accordance with (b) 2. herein will be measured as regular excavation in accordance with the requirements of Section 303 or as lump sum grading on minimum plan and no plan projects. Clearing and grubbing will be paid for in accordance with the requirements of Section 301.

Payment will be made under:

Pay Item	Pay Unit
Demolition of pavement	Square meter
Obscuring roadway	Unit

SECTION 509—PATCHING HYDRAULIC CEMENT CONCRETE PAVEMENT

509.01—Description.

This work shall consist of removing designated areas of defective hydraulic cement concrete pavement and unstable subbase material, replacing subbase material where required, and replacing pavement with high-early-strength hydraulic cement concrete in accordance with these specifications and in reasonably close conformity to the original lines and grades or those established by the Engineer.

509.02—Materials.

(a) **Hydraulic cement concrete** shall conform to the requirements of Section 217 for Class 20 paving concrete except that the compressive strength shall be at least 20 megapascals within 24 hours. The accelerated strength gain shall be achieved by the use of 475 ± 30 kilograms per cubic meter of Type III cement conforming to the requirements of AASHTO M-85 and approved air-entraining, accelerating, and water-reducing admixtures conforming to the requirements of Section 215. If calcium chloride is permitted as an accelerating admixture, it shall

be limited to 2 percent by mass. The air content shall be 6 ± 2 percent. The water/cement ratio shall be not more than 0.42 by mass.

The Contractor shall prepare a sufficient number of trial batches in the presence of the Engineer to verify the strength and workability of the mixture design when required. The continued adequacy of the mixture design and minimum compressive strength will be verified monthly by the Engineer.

(b) **Asphalt concrete** shall conform to the requirements of Section 211 except that material may be accepted by certification and visually inspected at the job site.

(c) **Subbase material** shall conform to the requirements of Section 208.

(d) **Preformed asphalt joint filler and joint sealer** shall conform to the requirements of Section 212.

(e) **Curing material** shall conform to the requirements of Section 220.

(f) **Reinforcing steel** shall conform to the requirements of Section 223.

509.03—Procedures.

Where the existing joint dowel assembly is to be removed, existing concrete shall be saw cut and removed at least 300 millimeters on each side of transverse joints. Undisturbed portions of pavement adjacent to the area to be patched shall be left with straight, vertical sides. In areas from which concrete has been removed, the subbase shall be dressed, brought to grade, and mechanically compacted. Dowels and assemblies shall be removed and disposed of off the project.

Saw cuts shall not extend into adjacent concrete pavement except when repairs are to be extended at that location. Saw cuts shall be straight, neat, vertical, and parallel or perpendicular to the center line as required.

Unsuitable subbase shall be removed, disposed of, and replaced in accordance with the requirements of Section 307 or 308, whichever is applicable. Where soil cement subbase is present and sound, excavation below the top of the soil cement line and under adjacent slabs will not be required.

Preformed asphalt joint filler shall be installed in accordance with the requirements of Section 316.04(g)2.

Joint material and reinforcing steel shall be placed in accordance with the following:

1. **Patches less than 3 meters in length:** Preformed asphalt joint filler shall be placed flush against the run-off side of the adjacent pavement.

2. **Patches greater than 3 meters in length:** Preformed asphalt joint filler shall be placed flush against sides of the adjacent pavement.

3. **Patches 6 meters in length or greater:** Patches shall conform to the requirements of the applicable reinforced concrete pavement standards.

4. **Load transfer devices used in initial construction:** Load transfer devices shall be left intact, straightened, and used for tying in the replaced slab or shall be replaced with an approved load transfer device.

5. **Joints:** Rounded or beveled transverse joints shall be provided adjacent to the undisturbed pavement to allow installation of sealant at a depth of at least 6 millimeters but not more than 13 millimeters.

The excavated area shall be thoroughly cleaned and moistened before concrete is placed.

Full-depth forms shall be of sufficient strength to support plastic concrete without deformation.

Existing pavement shall not be removed if removal will result in concrete being placed when the air temperature is below 13 °C. The concrete temperature at the time of placement shall be at least 21 °C but not more than 35 °C.

Concrete shall be placed on the subgrade and consolidated so that it fills the area of the patch. Concrete shall be finished in accordance with the requirements of Section 316.04(h) except that the final surface shall have a texture similar to that of the adjoining pavement.

As soon as concrete is finished and prior to its initial set, the patch and existing pavement for a distance of 2.4 meters shall be tested by means of a 3-meter straightedge placed parallel to the center line of the road surface. Irregularities in the patch in excess of 5 millimeters shall be corrected.

Immediately after it has been textured, concrete shall be covered with wet burlap and PE film. An insulating blanket shall be placed over the PE film whenever the air temperature is below 18 °C during the curing period. Curing shall continue until immediately before opening to traffic but will not be required beyond 24 hours.

Transverse joints at pavement repair locations shall be cleaned and resealed in accordance with the requirements of Section 316.04(m).

Asphalt concrete shoulders that are damaged during repair operations shall be reconstructed within 24 hours after completion of a patch in accordance with the requirements of Section 315 with full-depth SM-2A asphalt concrete to match the finished grade. If traffic is to be permitted on the patch prior to reconstruction of the shoulder, the shoulder shall be temporarily repaired to prevent any hazardous condition.

Traffic shall be maintained in accordance with the requirements of Section 512 or as directed by the Engineer.

509.04—Measurement and Payment.

Patching hydraulic cement concrete pavement will be measured in square meters of pavement surface area, complete-in-place, and will be paid for at the contract unit price per square meter. This price shall include saw cutting pavement full depth; removing and disposing of existing concrete; preparing subgrade; furnishing and installing preformed asphalt joint filler; placing, finishing, and curing special design concrete; trial batches; cleaning and resealing joints; repairing shoulders; sealing joints; and reinforcing steel.

Payment will be made under:

Pay Item	Pay Unit
Patching hydraulic cement concrete pavement	Square meter

SECTION 510—RELOCATING OR MODIFYING EXISTING MISCELLANEOUS ITEMS

510.01—Description.

This work shall consist of removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating existing items or items furnished by the Department or others, including, but not limited to, right-of-way monuments, guardrail, riprap, drainage structures, traffic control devices, water or sanitary sewer facilities, and other items designated on the plans.

510.02—Materials.

The principal materials to be used in this work shall be those salvaged.

Items shall be constructed, adjusted, modified, or reconstructed with the same type of material as used in the original construction.

The suitability of existing material for salvage, modification, or reuse will be determined by the Engineer.

New, salvaged, or refurbished materials necessary for resetting, relaying, adjusting, modifying, or relocating the item specified shall conform to the requirements of the applicable specifications for items of the same character and type. Salvaged or refurbished materials shall be in good working condition, which shall include cleaning, repainting, and refinishing to the approximate original condition.

510.03—Procedures.

Materials designated for salvage shall be carefully removed, dismantled, cleaned, and stockpiled in areas where they will not be damaged or shall be delivered to the storage area. Material that is not designated for salvage shall be disposed of in an approved disposal area. Items designated for relocation, relaying, adjustment, modification, or installation shall be installed in accordance with the applicable specifications or as directed by the Engineer.

510.04—Measurement and Payment.

Removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating designated items will be measured by the unit specified in the Contract in accordance with the plans and the applicable sections of these specifications and will be paid for at the contract unit price for the specified item. This price shall include loading, unloading, and transporting furnished materials; cleaning, repainting, and refinishing salvaged items; removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating designated items; salvaging or disposing of surplus and unsuitable material; excavating; trenching; backfilling; preparing foundation; reconnecting components for electrical and electronic items; revising wiring diagrams or schematics; and restoring disturbed areas.

Payment will be made under:

Pay Item	Pay Unit
Remove, reset, relay, adjust, install, modify, reconstruct, relocate existing (Item or standard)	Each, meter, square meter, cubic meter, or lump sum

SECTION 511—ALLAYING DUST

511.01—Description.

This work shall consist of applying either moisture, calcium chloride, or both on areas designated by the Engineer for the purpose of allaying dust.

511.02—Procedures.

The Contractor shall furnish a truck(s) equipped with a water tank having a capacity of at least 3,750 liters and pumps for furnishing, loading, and applying water to the roadway.

Equipment and operators shall be available at all times.

Calcium chloride conforming to the requirements of Section 239 shall be applied at the rate specified on the plans or by the Engineer.

The Contractor shall plan and prosecute the work so as to expedite completion of the pavement structure as soon as is practicable.

511.03—Measurement and Payment.

Allaying dust will be measured and paid for on the basis of the time the truck is in service on this work or per metric ton of calcium chloride. Loading time allowed for payment shall be not more than 30 minutes per 3,750 liters of water. Truck hours shall be evidenced by daily time reports submitted by the Contractor and approved by the Engineer. This price shall include water and calcium chloride.

When in-place base material is used as a riding surface to maintain traffic or as a haul route, truck hours or metric tons of calcium chloride used for allaying dust will be paid for in accordance with the provisions herein.

Payment will be made under:

Pay Item	Pay Unit
Allaying dust	Hour or metric ton

SECTION 512—MAINTAINING TRAFFIC

512.01—Description.

This work shall consist of maintaining and protecting traffic through areas of construction, maintaining public and private entrances and mailbox

turnouts, constructing and obliterating detours, and protecting the traveling public within the limits of the project and over detours that are not a part of the state highway system in accordance with these specifications and the requirements of the *MUTCD*.

512.02—Materials.

(a) **Materials** salvaged from the roadway shall be used in the maintenance of traffic insofar as possible. Material shall conform to the requirements of the applicable specifications.

(b) **Signalization, barricades, channelizing devices, safety devices, and pavement markings** shall conform to the requirements of Division VII of these specifications and the *MUTCD*, except the construction of Type III barricades shall be in accordance with the plans. Reflective surfaces shall conform to the requirements of Sections 235, 247, and 702 as applicable.

(c) **Temporary pavement markers** shall conform to the requirements of Section 235.

(d) **Construction pavement markings** shall conform to the requirements of Sections 231 and 246.

512.03—Procedures.

Traffic shall be maintained and protected in accordance with the requirements of Sections 104.04 and 107.10. Work shall be scheduled and performed so as to provide minimum interference with and maximum protection to traffic. The Contractor's personnel, equipment, machinery, tools, and supplies shall be kept clear of active traffic lanes except as necessary for prosecuting active work. Material that is spilled or tracked onto the traveled pavement during prosecution of the work shall be promptly removed.

The structural integrity and alignment of barricades and safety devices shall be maintained at all times. Reflectorized surfaces and warning lights shall be maintained in a clean and visible condition at all times. Barricades, barriers, and other safety devices shall be inspected at least daily, and deficiencies shall be immediately corrected. Safety and protective devices furnished by the Contractor will remain the property of the Contractor and shall be removed from the project site upon completion of the work or as directed by the Engineer.

(a) **Signs:** The Department will furnish temporary sign panels necessary for maintenance of traffic, including those outside of the construction limits, to the Contractor for installation. The Contractor shall furnish wood posts and hardware for use with the temporary sign panels. The

Contractor shall be responsible for covering, uncovering, or removing and reinstalling existing signs that conflict with the signs needed for maintenance of traffic. The Contractor shall also furnish and install flags for the temporary sign panels as directed by the Engineer. Signs shall be installed and attached to supports in accordance with WSP-1 of the *Road and Bridge Standards*. Size and number of wooden supports shall be in accordance with the plans. When allowed by the Engineer, the Contractor may furnish portable stands for mounting the temporary sign panels. Portable stands shall accommodate signs of all standard shapes, including octagonal and triangular, and have a flagholder that will accommodate three flags as an integral part of the unit. The portable stand shall have adjustable legs capable of adjusting to uneven surfaces. While supporting a 1.49-square meter rigid sign panel, the stand shall withstand 80 kph winds without tipping over or rotating more than ±5 degrees about its vertical axis without the use of tie downs or ballast of any kind. The complete unit shall not exceed 18 kilograms. The Contractor shall erect, maintain, move, and be responsible for the security of sign panels furnished by the Department and shall ensure an unrestricted view of sign messages for the safety of traffic.

(b) **Flagger Service and Pilot Vehicles:** The Contractor shall provide flaggers in accordance with the requirements of Section 104.04(c).

(c) **Electronic Arrows:** Electronic arrows shall be electronic flashing or sequential amber arrows having dimmer controls and shall be mounted on suitable trucks or trailers. The Contractor shall maintain and move electronic arrows as needed for traffic control.

(d) **Warning Lights:**

1. **Type A flashing lights** shall be used for advance warning signs and hazardous locations and shall be in operation during hours of darkness and low visibility. A Type A flashing light shall be installed on concrete traffic barrier service at the break point between the transition and tangent sections.

2. **Type B flashing lights** shall be used when specified on the plans for advanced warning signs and extremely hazardous locations and shall be in operation at all times.

3. **Type C steady burn lights** shall be used when specified on the plans for channeling traffic and may be placed on Group 2 channelizing devices and traffic barrier service. Lights shall be placed at intervals of 24 meters along tangent sections and 12 meters along bridges, transitions, and curves with radii less than 1,750 meters. Lights shall be in operation from 30 minutes before

sunset until 30 minutes after sunrise, on heavy overcast days, in fog, and during periods of darkness or low visibility as directed by the Engineer.

(e) **Channelizing Devices:** Channelizing devices shall be spaced as follows:

	Tangent Sections		290-Meter Radius Curve or Less and Transitions	
Speed (km/h)	0-55	56+	0-55	56+
Spacing (m)	12	24	6	12

1. **Group 1 devices** shall consist of tubular delineators or cones approximately 900 millimeters in height for interstate and other limited access roadways and approximately 700 millimeters in height for other roadways. Group 1 devices shall be used as temporary channelizing devices. When used during hours of darkness, they shall be provided with reflectorized collars or sleeves.

2. **Group 2 devices** shall be drums or vertical panels. Drums shall be round, or round with no more than one flat side, made from plastic, have a cross-sectional width no less than 450 millimeters in any direction, and conform to the *MUTCD*. Drums shall be designed to allow for separation of ballast and drum upon vehicular impact, but not from wind and vacuum created by passing vehicles. Drums of two-piece design (drum and associated base) shall be in accordance with the manufacturer's recommendations, utilize sufficient amounts of enclosed sand at the base to provide stable drum support. The base shall not be greater than 125 millimeters in height. Two-piece drums may also utilize a flared drum foundation and collar of not more than 125 millimeters in height and of suitable shape and mass to provide stable support. One-piece drums may be used provided they meet the above requirements. Open-top drums will not be allowed. Vertical panels shall be mounted on posts conforming to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.*

(f) **Traffic Barrier Service:** Barrier service shall be of sufficient length to protect traffic and personnel in construction areas.

The Contractor shall continuously prosecute the work until completion once a barrier is in place. If the Contractor does not, the Department may cause him to discontinue operations in other areas on the project and concentrate efforts behind the traffic barrier service. When construction work is completed to the extent that traffic barrier service

is no longer required as determined by the Engineer, devices shall be removed.

Neither workers nor equipment shall traverse areas confined by traffic barrier service and travel lanes except as approved by the Engineer and then only with adequate flagger service to safeguard workers and traffic in advance of and at the point the traffic barrier service is opened. Barrier openings for construction access may be provided only along tangent sections or along the inside of curved sections and shall be limited to the minimum length required for equipment access. The normal pavement alignment at the barrier opening shall be maintained with removable pavement marking. At ingress openings, the exposed end of the barrier service shall be provided with a temporary impact attenuator as approved by the Engineer. At egress openings, the exposed end shall be transitioned as dependent on the posted speed for traffic. The transition flare rate shall be 6:1 at 40 kilometers per hour and shall be decreased approximately one increment for each additional 5 kilometers per hour increment added to the posted speed up to 16:1 at 90 kilometers per hour. An impact attenuator will not be required at the exposed end of egress openings in barrier service provided the deflection angle between the pavement edge and ends of the barrier service openings is 20 degrees or more.

Delineators shall be installed on traffic barrier service in accordance with the requirements of Section 702. Barrier vertical panels shall be installed on top of the concrete barrier service. Reflectorized sheeting shall be in accordance with the requirements of Section 247. Design and installation of barrier vertical panels shall be in accordance with the *Virginia Work Area Protection Manual.*

The Contractor shall maintain the structural integrity of the barrier and its alignment while it is in use and shall maintain warning lights, delineators, and other devices in a clean and visible condition at all times.

1. **Guardrail barrier service and terminal treatments** shall be installed in accordance with the requirements of Section 505 except that the offset distance shall be as specified by the Engineer. The Contractor may reuse guardrail used for traffic barrier service guardrail for permanent installation provided the guardrail material conforms to the requirements of Section 505 and the standard drawings and is acceptable to the Engineer. Marred galvanized surfaces shall be repaired in accordance with the requirements of Section 233.

2. **Concrete barrier service** shall be installed in accordance with the plans and standard drawings or as directed by the Engineer. When

barrier terminates at a guardrail, fixed object attachments connecting the barrier to the guardrail shall be installed in accordance with the applicable standard for fixed object attachment. Installation shall include additional guardrail posts and attachments as required. Concrete barrier connections shall be snug to prevent motion between sections.

Precast concrete parapet for precast concrete parapet traffic barrier service shall be anchored as shown on the plans. Anchor holes in bridge decks shall be drilled with a rotary impact drill or other approved equipment that will prevent damage to the deck. Anchor holes shall be located so as to avoid cutting reinforcing steel. Upon removal of the parapet, anchor holes shall be cleaned and filled with Type EP-4 or EP-5 epoxy mortar conforming to the requirements of Section 243.

Parapet used for concrete parapet traffic barrier service will not be permitted for permanent installations on bridge structures.

Barrier used for concrete traffic barrier service may be installed in permanent locations provided the barrier conforms to the applicable requirements for its use and is acceptable to the Engineer.

(g) **Impact Attenuator Service:** Impact attenuator service shall be installed at locations shown on the plans or designated by the Engineer. A modified Type III object marker shall be installed on impact attenuators.

(h) **Temporary Signalization:** When specified on the plans, the Contractor shall install and maintain temporary signalization equipment. The Contractor shall submit to the Engineer a plan for installing and maintaining signals that shall also depict the Contractor's intent for maintaining traffic flows, including phase sequencing and timings. The Contractor's design shall conform to the requirements of the applicable sections of these specifications and standard drawings. New, salvaged, or refurbished materials may be used. However, new materials shall be used for temporary signalization equipment when it is specified on the plans or in the Contract that such equipment is to become the property of the Department after project completion. Materials shall conform to the requirements of the applicable specifications and standard drawings except that controllers which are not designated to become the property of the Department after project completion will need to conform only to the requirements of NEMA TS-1 and controller cabinet accessory and auxiliary equipment need include only an NEMA conflict monitor and equipment necessary to produce and monitor the phasing required. The Contractor shall receive approval of the plan from the Engineer prior to beginning work that would necessitate installing the proposed temporary signalization.

Temporary signalization that is not specified on the plans but is installed by the Contractor for his convenience shall be installed at his expense and shall be approved through the process described herein. Maintenance and operation of these temporary signals shall be the responsibility of the Contractor.

The Contractor shall make arrangements with the local utility company for temporary electrical service with the exception of temporary service for existing signals that are relocated or adjusted. The Contractor shall also be responsible for the costs of connections and disconnections and energy costs. Arrangements and payment for temporary service for existing signals that are relocated or adjusted will be made by the Department. If electrical service is not available, the Contractor shall provide a generator capable of continuously operating for at least 24 hours. The Contractor shall demonstrate the signal's operational procedures and reliability to the Engineer for approval prior to beginning work necessitating use of the equipment.

Signal equipment designated in the Contract or on the plans to be turned over to the Department at project completion shall be delivered by the Contractor to a designated site.

(i) **Construction Pavement Markings:** Construction pavement markings shall be installed at reversible crossovers, at locations shown on the plans, and at hazardous locations as directed by the Engineer. Construction pavement markings on asphalt concrete pavement shall be Type B (Class I, II, or III), C, or D. For installation of Type B, Class II, markings, the pavement surface shall be at least 30 days old. Construction pavement markings on hydraulic cement concrete pavement shall be Type B (Class II or III), C, or D. Construction pavement markings shall conform to the requirements of Table VII-1 except Type B, Class II, will be allowed for use on asphalt concrete pavements as construction pavement markings. Construction pavement markings shall be applied in accordance with the manufacturer's recommendations. Type D markings shall be used on final roadway surfaces or in areas where traffic patterns are subject to change before pavement is resurfaced. Type B or C markings shall be used on areas where the roadway is to be resurfaced prior to changes in the traffic pattern or where pavement is to be demolished and traffic patterns will not change before demolition.

Temporary pavement markers shall be installed with construction pavement markings in accordance with (k) herein.

(j) **Eradicating Pavement Markings:** Markings that may conflict with desired traffic movement, as determined by the Engineer, shall be eradicated as soon as is practicable: either immediately prior to the

shifting of traffic or immediately thereafter and prior to the conclusion of the workday during which the shift is made.

Eradication shall be performed by grinding, blasting, or a combination thereof. Grinding shall be limited to removal of material above the pavement surface except when removing thermoplastic markings from asphalt concrete pavement, which may be removed by grinding alone. Blasting shall be used on both asphalt concrete and hydraulic cement concrete pavements to remove all other types of markings. Other methods may be submitted for approval by the Engineer.

The Contractor shall contain eradication residue and have engineering controls in place, such as vacuum assisted methods, in compliance with the Occupational Safety and Health Administration's standards as detailed in 29 CFR 1926.62, 1926.103 and 1910.94.

When markings are removed for lane shifts, 100 percent of the marking shall be removed.

(k) **Temporary Pavement Markers,** shall be installed with Type B, C, and D construction pavement markings in work zones that will encroach upon the traveled roadway for a period of more than two days, except that construction pavement markings placed as edge lines beside concrete barriers outside of transition areas will not require temporary pavement markers.

Temporary pavement markers shall be installed in transition areas on 6- meter centers and in all other areas on 12-meter centers. Temporary pavement markers shall be located in alignment with the pavement markings. Where double line pavement markings separating traffic are installed, two-way markers shall be installed on each line. The Contractor may install two one-way markers in lieu of each two-way marker at no additional cost to the Department.

Temporary pavement markers shall be installed with a hot applied bitumen adhesive except epoxy may be used on hydraulic cement concrete roadways and non-final surfaces of asphalt concrete roadways. Damage created in the pavement by removal of markers shall be repaired in kind by the Contractor at no additional cost to the Department.

(l) **Detours:** Where temporary structures are necessary, they shall be designed and provided by the Contractor and of sufficient strength, width, and design to accommodate the volume and character of traffic using the highway. Temporary structures crossing waterways shall provide necessary hydraulic openings to accommodate the flow of the waterway. Temporary structure designs shall be submitted to the Engineer for review.

When a detour is no longer required, as determined by the Engineer, it shall be promptly removed, and the materials shall be disposed of as approved or directed by the Engineer. The Contractor shall design and provide temporary drainage facilities of adequate size to carry the normal flow of the existing drainage or waterway.

(m) **Aggregate Material:** Aggregate material shall be placed at crossovers, private entrances, mailbox turnouts, and where specified by the Engineer.

(n) **Construction Pavement Message Markings:** Markings shall be installed at locations designated on the plans and as determined by the Engineer and shall consist of messages in accordance with the requirements of Section 704. Construction pavement message marking material shall conform to the requirements for construction pavement markings.

Work performed in conjunction with Sections 512.03(i), (j), (k), and (n) shall be in accordance with Section 704 except as noted herein.

Replacement and correction of ineffective work zone traffic control devices shall be accomplished in accordance with the American Traffic Safety Service Association's (ATSSA) *Quality Standards For Work Zone Traffic Control Devices*. The section entitled "Evaluation Guide Pavement Tape & Paint" shall also be used for Type B, Class I, II, and III, materials when used as construction pavement markings.

512.04—Measurement and Payment.

Flagger service will be measured in hours as authorized or approved by the Engineer except when used for the Contractor's convenience, such as for ingress and egress for moving construction equipment or materials. In such cases, payment will not be made for flagger service. Flagger service will be paid for at the contract unit price per hour. This price shall include paddles and safety equipment.

Pilot vehicles will be measured in hours of actual use, as required by the Engineer, and will be paid for at the contract unit price per hour. This price shall include vehicles, necessary warning devices, drivers, fuel, and maintenance.

Electronic arrows will be measured in hours of actual use, as required by the Engineer, and will be paid for at the contract unit price per hour. This price shall include arrow panels, fuel, maintenance, and a truck or trailer having flashing amber warning lights.

Warning lights for use on Group 2 channelizing devices and sign panels will be measured in days of actual use for the type specified and will be paid for at the contract unit price per day. This price shall include maintaining, relocating,

and removing. Warning lights installed on traffic barrier service will not be measured for separate payment, but the cost thereof shall be included in the meter price bid for traffic barrier service.

Group 1 channelizing devices will not be measured for separate payment. The cost thereof shall be included in the price for other appropriate pay items.

Group 2 channelizing devices will be measured in days of actual use, as required by the Engineer, and will be paid for at the contract unit price per day. A day shall consist of at least 8 hours of use in a 24-hour period. This price shall include maintaining and relocating.

Traffic barrier service will be measured and paid for at the contract unit price per meter per location. This price shall include warning lights, delineators, barrier vertical panels, fixed object attachments, patching restraint holes, maintaining, and removing when no longer required. When fixed object attachments are used on traffic barrier service in locations where existing guardrail is in place, this price shall include restoring existing guardrail to its original condition. When traffic barrier service is moved to a new location as directed or approved by the Engineer, the relocation will be measured for separate payment. Payment for traffic barrier service will not be made until the work behind the barrier is actively pursued. Payment for traffic barrier service will be made in accordance with the following:

1. An initial payment of 65 percent of the contract unit price will be made when the barrier is placed and work behind the barrier is actively pursued.

2. The remaining 35 percent of the contract unit price will be paid upon completion of work and removal of the barrier.

Traffic barrier service guardrail terminal will be measured and paid for in units of each or meters, as applicable, which price shall include furnishing, installing, and removing when no longer needed. When traffic barrier service guardrail terminal is moved to a new location, as directed or approved by the Engineer, the relocation will be measured for separate payment.

Impact attenuator service will be measured in units of each and will be paid for at the contract price per each. Impact attenuators used with barrier openings for equipment access will not be measured for separate payment.

Temporary signalization will be paid for on a lump sum basis. This price shall include, but not be limited to, poles; span wire; conduit; conductor cable; traffic signal heads; hanger assemblies; necessary control items; maintaining, adjusting, and aligning equipment; electrical service; utility company costs; and removing and delivering equipment.

Construction pavement markings will be measured in meters and will be paid for at the contract price per meter. This price shall include marking materials,

preparing the surface, adhesive, and maintaining and removing Type D markings when no longer required.

Construction pavement message markings will be measured in units of each and will be paid for at the contract unit price per each. This price shall include marking materials, preparing the surface, adhesive, and maintaining and removing Type D markings when no longer required.

Temporary pavement markers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing pavement markers; surface preparation; adhesive; maintaining and replacing lost or damaged markers; and removing the pavement markers and adhesive when no longer required.

Eradication of pavement markings will be measured in meters of a 150-millimeter width or portion thereof. Widths that exceed a 150-millimeter increment by more than 13 millimeters will be measured as the next 150-millimeter increment. Eradication of pavement markings will be paid for at the contract unit price per meter. This price shall include removing pavement line and message markings and disposing of residue.

Traffic barrier service guardrail terminal will be measured and paid for in units of each or meters, as applicable, which price shall include furnishing, installing, and removing when no longer needed. When traffic barrier service guardrail is moved to a new location, as directed or approved by the Engineer, the relocation will be measured for separate payment.

Type III barricades will be measured in units of each and will be paid for at the contract bid price per each. This price shall include fabrications, lumber, chevron panels, reflective sheeting, maintaining, relocating to new locations, and removing when no longer required.

Wood posts, hardware, and portable stands used for installation of the temporary sign panels furnished by the Department and covering, uncovering, or removing and reinstalling existing signs that conflict with the signs needed for maintenance of traffic will not be measured for separate payment. The cost thereof shall be included in the price for other appropriate pay items.

Temporary detours will be measured in meters along the center line of the detour or by individual components with the quantities shown on the plans as maintenance of traffic items, in which the components will be measured in accordance with the applicable specifications. This price shall include removing and restoring. When a pay item, temporary detour will be paid for at the contract unit price per meter. This price shall include excavating, aggregate materials,

drainage items, grading, asphalt, maintaining, removing detour, disposing of surplus and unsuitable material, and restoring property.

Aggregate material will be measured in metric tons and will be paid for at the contract unit price per metric ton for the type specified. This price shall include preparing the grade and furnishing, placing, maintaining, and removing material as required.

The cost of installing, maintaining, relocating, and storing sign panels, hardware, and posts furnished by the Department; furnishing, installing, maintaining, and relocating portable stands or other sign supports and hardware; and furnishing, installing, and maintaining flags shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Flagger service	Hour
Pilot vehicle	Hour
Electronic arrow	Hour
Warning light (Type)	Day
Group 2 channelizing device	Day
Traffic barrier service (Type and/or standard)	Meter
Traffic barrier service guardrail terminal (standard)	Each or meter
Impact attenuator service (Type)	Each
Temporary signalization	Lump Sum
Construction pavement marking (Type and width)	Meter
Construction pavement message marking (Type and message)	Each
Eradication of existing pavement marking	Meter
Temporary pavement marker ([ ]-way)	Each
Temporary detour (Standard and type)	Meter
Crusher run aggregate (No.)	Metric ton
Traffic barrier service guardrail terminal (Standard)	Each or meter
Type III barricade	Each

SECTION 513—MOBILIZATION

513.01—Description.

This work shall consist of performing preparatory operations, including moving personnel and equipment to the project site; paying bonds and insurance premiums; and establishing the Contractor's offices, buildings, and other facilities necessary to allow work to begin on a substantial phase of the Contract.

513.02—Measurement and Payment.

Mobilization will be paid for at the contract lump sum price. This price shall include demobilization.

Payment for mobilization up to the limitations specified hereinafter will be made in two equal installments. The first installment of 50 percent of the contract lump sum price will be made on the first progress estimate following partial mobilization and initiation of construction work. The second installment will be made on the next progress estimate following completion of substantial mobilization, including erection of the Contractor's offices and buildings. Completion of erection of materials processing plants, if any, will not be required as a condition for the release of the second installment.

If the original contract lump sum price exceeds the limit stated hereinafter, the excess will be included on the semifinal estimate as follows:

More Than	To and Including	Limit
$ 0	$ 200,000	10% of total contract amount
200,000	1,000,000	$20,000 plus 7.5% (of total contract amount minus $200,000)
1,000,000	More	$80,000 plus 5% (of total contract amount minus $1,000,000)

No additional payment will be made for demobilization and remobilization because of shutdowns, suspensions of work, or other mobilization activities.

When not shown as a pay item, the cost of mobilization shall be incuded in the price bid for other appropriate items.

Payment will be made under:

Pay Item	Pay Unit
Mobilization	Lump sum

SECTION 514—FIELD OFFICE

514.01—Description.

This work shall consist of furnishing, erecting, equipping, and maintaining a field office of the type specified for the exclusive use of Department Engineers and Inspectors at a location on the project approved by the Engineer.

514.02—Procedures.

The field office and equipment shall remain the property of the Contractor. The field office shall be separated from buildings and trailers used by the Contractor and shall be erected and functional as an initial operation. Failure to have the field office functional when work first begins on the project shall result in withholding payment of the Contractor's monthly progress estimate. The field office shall be operational throughout the duration of the project and shall be removed upon completion and final acceptance of the project.

The field office shall be weatherproof, tightly floored and roofed, constructed with an air space above the ceiling for ventilation, and supported above the ground. The width of the field office shall be at least 2.4 meters, and the floor-to-ceiling height shall be at least 2.25 meters. If a trailer is provided for the field office, its width shall be at least 2.25 meters and the floor-to-ceiling height shall be at least 2.0 meters. The inside walls and ceiling shall be constructed of plywood, masonite, gypsum board, or other suitable materials. The exterior walls, ceiling, and floor shall be insulated.

Type I field offices shall have a floor space of at least 46 square meters and shall be equipped with the following:

No	Item
1	Double-pedestal desk (approximately 1525 by 850 millimeters), at least 1.30 square meters
1	Plan and drafting table (approximately 750 by 2400 millimeters) with adjustable stool
1	Computer table having a minimum size of 1200 by 750 by 725 millimeters
1	Plan rack for 610 by 915 millimeter drawings with 6 plan clamps
1	Printing calculator
2	Metal 4-drawer file cabinet, 380 millimeter drawer width
2	2-drawer fire protection file, 380 millimeter drawer width, minimum UL rating of Class 350
6	Office chairs with a minimum of two having casters
2	Wastebaskets
1	Pencil sharpener

1	Copy machine (216 x 279 millimeter copies)
1	Answering machine

Type II field offices shall have a floor space of at least 37 square meters and shall be equipped with the following:

No	Item
1	Double-pedestal desk (approximately 1525 by 850 millimeters), at least 1.30 square meters
1	Plan and drafting table (approximately 750 by 1800 millimeters) with adjustable stool
1	Computer table having a minimum size of 1200 by 750 by 725 millimeters
1	Plan rack for 610 by 750 millimeter drawings with 6 plan clamps
1	Printing calculator
1	Metal 4-drawer file cabinet, 380 millimeter drawer width
2	2-drawer fire protection file, 380 millimeter drawer width, minimum UL rating of Class 350
4	Office chairs with a minimum of two having casters
1	Wastebasket
1	Pencil sharpener
1	Copy machine (216 x 279 millimeter copies)
1	Answering machine

Type III field offices shall have a floor space of at least 18.5 square meters and shall be equipped with the following:

No	Item
1	Double-pedestal desk approximately 1050 by 750 millimeters, 0.80 square meter minimum
1	Plan and drafting table approximately 750 by 1800 millimeters with adjustable stool
1	Computer table having a minimum size of 1200 by 750 by 610 millimeters
1	Plan rack for 610 by 915 millimeter drawings with 6 plan clamps
1	Metal 4-drawer file cabinet, 380 millimeter drawer width
2	2-drawer fire protection file, 380 millimeter drawer width, minimum UL rating of Class 350
3	Office chairs with a minimum of two having casters
1	Wastebasket
1	Pencil sharpener
1	Answering machine
1	Printing calculator

(a) **Windows and Doors:** The field office shall have at least three windows, with blinds, each having an area of at least 0.35 square

meter, capable of being easily opened and secured from the inside. Types I, II, and III, field offices shall have at least two exterior passage doors. Doors shall be at least 760 millimeters in width and 1980 millimeters in height. Screens for windows and doors shall be provided. Exterior passage door(s) shall be equipped with lock(s), and at least two keys shall be furnished the Engineer or Inspector.

(b) **Steps:** Steps shall conform to the requirements of the State Building Code and shall be maintained free from obstructions.

(c) **Storage Facility for Nuclear Gage:** The field office shall be furnished with an outside storage facility for the Department's nuclear gage, which shall not be located within 3 meters of any other structure.

(d) **Lighting, Heating, and Air Conditioning:** The field office shall have satisfactory lighting, electrical outlets, heating equipment, an exhaust fan, and an air conditioner connected to an operational power source. At least one of the light fixtures shall be a fluorescent light situated over the plan and drafting table. Electrical current and fuel for heating equipment shall be furnished by the Contractor.

(e) **Fire Extinguishers:** The Contractor shall furnish and maintain one fire extinguisher for each required exterior passage door. Fire extinguisher(s) may be chemical or dry powder, UL Classification 10-B:C (minimum), suitable for Type A:B:C: fires, and shall be mounted and maintained in accordance with OSHA Safety and Health Standards.

(f) **Toilets:** A toilet conforming to the requirements of the state and local boards of health or other bodies or courts having jurisdiction in the area shall be provided. When separate facilities for men and women are not available, a sign with the words "Rest Room" (with letters at least 25 millimeters in height) shall be placed over the doorway, and an adequate positive locking system shall be provided on the inside of the doorway. Inside toilets shall be connected to a potable water supply. In the event a potable water supply is not provided, bottled water with cups shall be provided for drinking and washing.

(g) **Utilities:** Except for telephone service, the Contractor shall make arrangements for necessary utility connections, maintain utilities, pay utility service fees and bills, and make arrangements for final disconnection of utilities. The Contractor shall also furnish a telephone in each field office and permit the work necessary to install it.

(h) **Storage Facility for Test Equipment**: The field office shall be provided with a storage facility, separate from the office for storage of test equipment, other than the nuclear gage. The facility shall have a minimum floor space of 6 square meters and shall be weatherproof, be tightly floored and roofed and have a tamper-resistant key-operated lock.

(i) **Miscellaneous Items:** The field office shall also include the following:

1. A certification that the office is free of asbestos and other hazardous materials.

2. A broom, dust pan, mop and bucket, and general cleaning supplies.

3. An all-weather maintained parking area for four vehicles, including graveled access to the paved surface.

(j) **Fire Resistant Vault:** In addition to the specified equipment for either Type 1, 2, or 3 field office, the Contractor shall furnish a fire resistant vault, which shall be suitable for storing at least 50 mylar (600 mm x 900 mm) "As Built Plans" sheets in the horizontal or vertical flat position. The fire resistant vault shall have a minimum UL rating of Class 350. All costs for the fire resistant vault shall be included in the price for the field office.

514.03—Measurement and Payment.

Compensation for use of the field office will be based on the time it is used, expressed in calendar months. This price shall include erecting, maintaining, and removing the field office. Payment will not be made for any month during which the office is furnished for less than 15 calendar days or for any time in excess of the time limit established in the Contract as extended in accordance with the requirements of Section 108.09.

Installation and service fees for the telephone will be paid for by the Department.

Payment will be made under:

Pay Item	Pay Unit
Field office (Type)	Month

SECTION 515—PLANING PAVEMENT

515.01—Description.

This work shall consist of planing rigid or flexible pavement to the designated depth in preparation for pavement repair or pavement overlay.

515.02—Procedures.

Planing shall be performed with a pavement planing machine of a type that has operated successfully on work comparable to that specified in the Contract.

Equipment and vehicles in use under traffic shall operate flashing or rotating amber lights. In addition, trail vehicles shall be equipped with electronic flashing or sequential amber arrows.

Irregularities and high spots shall be eliminated. The pavement surface shall be planed to the designated grade or gradient of approximately 2 percent or as directed by the Engineer. Superelevated curves shall be planed as directed by the Engineer. Where the pavement is to be resurfaced, a 25-millimeter shoulder shall be cut along the gutter line to eliminate the necessity of feathering the edge of the new surface. Pavement cuttings shall be disposed of in accordance with the requirements of Section 106.04.

The planed surface shall be free from gouges, grooves, ridges, soot, oil film, and other imperfections and shall have a mosaic appearance suitable as a riding surface.

(a) **Hot Planing Methods:** Hot planing equipment shall be a self-propelled machine capable of heating, planing, and removing flexible pavement to the required depth, profile, and cross section. The machine shall be capable of cutting to a depth of at least 12 millimeters per pass and shall have an integral loader to pick up cuttings from the roadway and discharge them into a truck in a single operation. Planing machine burners shall use a heating fuel that will not cause aggregates or asphalt to be coated with soot or oil.

(b) **Milling and Cold Planing Methods:** Milling and cold planing equipment shall be capable of cutting to a depth of 50 millimeters in flexible pavement and 12 millimeters in rigid pavement while leaving a uniformly cut roadway surface capable of handling traffic prior to overlay placement. The ground speeds of the machine and the cutting equipment shall be independent. The machine shall have a self-contained water system for the control of dust and fine particles. The width of the machine shall allow controlled traffic.

515.03—Measurement and Payment.

Planing will be measured in square meters of pavement surface per 25 millimeters of depth and will be paid for at the contract price per square meter per 25 millimeters. This price shall include vehicles, safety equipment, warning devices, and removing and disposing of existing pavement.

Payment will be made under:

Pay Item	Pay Unit
Flexible pavement planing	Square meter
Rigid pavement planing	Square meter

SECTION 516—DEMOLITION OF BUILDINGS AND CLEARING PARCELS

516.01—Description.

This work shall include disconnecting utilities, demolishing building(s), removing materials from the right of way, and removing improvements and material unsuitable for use in roadway embankments from vacant parcels and other areas within the right of way.

516.02—Procedures.

(a) **Utilities:** The Contractor shall make necessary arrangements and perform necessary work, in accordance with local ordinances involved with disconnecting or interrupting public utilities or services. These shall include, but not be limited to, gas, water, sewer, electricity, and telephone.

(b) **Demolition:** The Contractor will be notified in writing when buildings are ready for demolition. Demolition shall include removing and disposing of materials from buildings and appurtenances down to the ground lines.

The Contractor may use buildings designated for demolition for project-related office space or storage or as a field office for Department personnel. If the Contractor elects to use any building scheduled for demolition, he shall obtain approval from the Engineer in writing prior to occupancy. The Contractor shall assume all personal and property liability associated with such buildings and shall protect and save the State harmless from any and all damages and claims associated with such buildings.

Buildings, materials resulting from their removal, and improvements on the property shall become the property of the Contractor at the time of their removal and shall be disposed of outside and away from the parcel site. Nothing herein shall be construed as giving the Contractor

any rights in and to the buildings in the Contract except for their demolition or for the purposes permitted herein. The Contractor shall have no right to sell or lease the buildings. The Department does not warrant or guarantee the existence or continued existence of any materials that are a part of the demolition item(s), nor will it be responsible in any way thereof to the Contractor.

(c) **Clearing Parcels:** Parcels shall not be cleared until buildings have been demolished or removed.

Clearing parcels shall include disposing of materials from noncombustible foundations down to and including floor slabs, basement slabs, and any improvement designated for removal but not listed as a pay item. Combustible debris and rubble, including fences, posts, or pillars, shall also be removed from the right of way or from within limits of easements obtained for removing buildings that may be partially outside the right of way.

The Contractor shall limit the cutting or removing of trees and shrubs to those necessary for completion of the work as approved by the Engineer. Trees or shrubs that are cut shall be removed from the right of way. The Contractor shall not enter or encroach on any parcel that is not included in the Contract. Underground tanks shall be closed and removed, and the area backfilled. Cisterns, septic tanks, and other openings, including basements, shall be demolished, and the area shall be backfilled with materials suitable for use in roadway embankments as defined in Section 303.

Wells shall be closed in accordance with the regulations of the State Department of Health, Virginia Water Control Board, and local jurisdictions.

516.03—Measurement and Payment.

Demolition of buildings will be paid for at the contract lump sum price. This price shall include coordinating and performing utility work, disposing of materials, and cleaning up. The Contractor shall also take into consideration the salvage value of any material removed and shall include the same in the lump sum price.

Clearing parcels will be paid for at the contract lump sum price. This price shall include disposing of materials, closing wells, backfilling, and cleaning up. The limits of payment shall be from the construction limits to the right-of-way or easement line.

Closing wells will be measured and paid for on an each basis, which price shall include chlorination, cement grout or bentonite grout, or other material as

applicable; backfilling; and filing of abandonment documents with the Health Department. The Contractor shall execute and file abandonment documents in accordance with the requirements of Section 107.01.

Payment will be made under:

Pay Item	Pay Unit
Demolition of building (Parcel no.) (D no.)	Lump sum
Clearing parcel (Parcel no.)	Lump sum
Closing well	Each

SECTION 517—UTILITY COORDINATOR

517.01—Description.

This work shall consist of furnishing a Utility Coordinator whose primary responsibility shall be to act as a liaison between the Contractor and owners of utilities within the limits of and adjacent to the project in accordance with these specifications and Section 105.07 or as directed by the Engineer.

517.02—Procedures.

The Contractor shall furnish the Engineer the name, address, and telephone number of the Utility Coordinator. The Utility Coordinator shall be present at the preconstruction conference. The Utility Coordinator shall

1. be readily available at all times for coordination and timely completion of work

2. be knowledgeable concerning techniques of utility adjustments

3. exercise the principles of good public relations

4. ascertain the location of utilities within and adjacent to the project limits and determine the location, type, and owner of existing utility facilities that are in close proximity to or in conflict with project construction

5. determine from the utility owner(s) the method and time frame for each utility adjustment and assist in planning and scheduling the affected construction operations for timely completion of work

6. include findings and schedulings in the initial monthly report to the Engineer

7. coordinate the Contractor's construction operations with planned utility adjustment(s) and maintain complete and accurate records to document coordination and progress of the utility owner's adjustment(s)

8. submit separate monthly reports to the Engineer concerning the progress of utility adjustments for each utility owner

Prior to final acceptance, the Utility Coordinator shall submit a certification to the Engineer stating that utility adjustments have been satisfactorily completed or that an appropriate explanation has been submitted therewith.

517.03—Measurement and Payment.

The Utility Coordinator will be paid for at the contract lump sum price. This price shall include all costs incurred for the Utility Coordinator and preparing and furnishing utility reports.

Payment for the Utility Coordinator will be made in four equal installments. The first payment of 25 percent of the contract lump sum price will be made on the first monthly progress estimate. The second payment of 25 percent will be made when 1/3 of the original contract time limit has expired. The third payment of 25 percent will be made when 2/3 of the original contract time limit has expired. The fourth and final payment of the remaining 25 percent will be made with the semifinal progress estimate regardless of whether the construction time period is shorter or longer than the original contract time limit.

Payment will be made under:

Pay Item	Pay Unit
Utility coordinator	Lump sum

SECTION 518—TRAINEES ON CONSTRUCTION PROJECTS

518.01—Description.

This work shall consist of providing the training specified herein as part of the Contractor's EEO affirmative action program.

518.02—Procedures.

The Contractor shall provide each trainee with a copy of a specific program and, upon completion of the training program, a certificate showing the type

and duration of training satisfactorily completed. The Contractor shall maintain records and furnish periodic reports documenting his compliance with the requirements herein.

(a) **Number of Trainees:** The number of trainees to be trained for this contract shall be as specified. If the Contractor sublets a portion of the Contract, he shall determine how many, if any, of the trainees are to be trained by the subcontractor. The Contractor shall retain the primary responsibility for meeting training requirements imposed by this specification. The Contractor shall ensure that these training requirements are made applicable to the subcontract. Where feasible, 25 percent of apprentices or trainees in each occupation shall be in their first year of apprenticeship or training.

(b) **Distribution of Trainees:** The number of trainees shall be distributed among the work classifications on the basis of the Contractor's needs and the availability of journeymen in the various classifications within a reasonable area of recruitment. Prior to beginning construction, the Contractor shall submit to the Department for approval the number of trainees to be trained in each selected classification on a form furnished by the Department entitled "Contractor's Selected Work Classification and Training Program." The Contractor shall specify the starting time for training in each classification. The Contractor will be credited for each trainee employed by him under the Contract who is currently enrolled or becomes enrolled in an approved program.

(c) **Minorities and Women:** Training and upgrading of minorities and women toward journeymen status are primary objectives. The Contractor shall make every effort to enroll minority and female trainees (e.g., by conducting systematic and direct recruitment through public and private sources likely to yield minority and female trainees to the extent such persons are available within a reasonable area of recruitment). The Contractor shall demonstrate the steps he has taken in pursuance thereof prior to a determination as to whether or not he is in compliance with the requirements herein. This training commitment shall not be used to discriminate against any applicant for training, whether a member of a minority group or not.

(d) **Use of Journeymen:** No employee shall be employed as a trainee in any classification in which the person has successfully completed a training course leading to journeyman status or has been employed as a journeyman. The Contractor shall satisfy this requirement by including appropriate questions on the employee application or by other suitable means. The Contractor's records shall document the findings in each case.

(e) **Length and Type of Training:** The minimum length and type of training for each classification will be established in the training program selected

by the Contractor and approved by the Department. The Department will approve a program if it is reasonably calculated to meet the EEO obligations of the Contractor and qualify the average trainee for journeymen status in the classification concerned by the end of the training period. Apprenticeship programs registered with the U.S. Department of Labor, Bureau of Apprenticeship and Training, or with a state apprenticeship agency recognized by the Bureau and training programs approved but not necessarily sponsored by the U.S. Department of Labor, Manpower Administration, Bureau of Apprenticeship and Training, will also be considered acceptable provided they are being administered in a manner consistent with the EEO obligations of contracts. Approval or acceptance of a training program shall be obtained from the Department prior to the commencement of work on the classification covered by the program.

Training shall be provided in the construction crafts rather than in secretarial skills. Training is permissible in lower management positions, such as office engineers, estimators, and timekeepers, where the training is oriented toward construction applications. Training in the laborer classification will be permitted provided significant and meaningful training is provided and is approved by the Department. Offsite training will be permitted if the training is an integral part of an approved training program and does not comprise a significant part of the overall training.

(f) **Commencement of Training:** It is normally expected that a trainee will begin training on the project as soon as is feasible after the start of the work that requires the skill involved and will remain on the project as long as training opportunities exist in the work classification or until the trainee has completed the training program. It is not required that all trainees be on board for the entire duration of the Contract. The number trained will be determined on the basis of the total number enrolled under the Contract for a significant period.

(g) **Payment to Trainees:** Trainees shall be paid at least 60 percent of the appropriate prevailing minimum journeyman's rate for the first half of the training period, 75 percent for the third quarter of the training period, and 90 percent for the last quarter of the training period unless apprentices or trainees in an approved existing program are enrolled as trainees on the project. In such case, the appropriate rates approved by the Department in connection with the existing program shall apply to all trainees being trained for the same classification who are covered by these requirements.

518.03—Measurement and Payment.

Except as otherwise noted herein, the Contractor will be paid $3.00 per hour for each employee who is trained in accordance with and for at least the minimum

period specified in the approved training program. When approved by the Engineer, the Contractor will be paid for training persons in excess of the number specified. This payment will be made even though the Contractor receives additional training program funds from other sources provided such other source does not specifically prohibit the Contractor from receiving other payment. Payment for offsite training will be made to the Contractor only where he does one or more of the following: contributes to the cost of the training, provides the instruction to the trainee, or pays the trainee's wages during the offsite training period.

If, in the judgment of the Contractor, a trainee becomes proficient enough to qualify as a journeyman before the end of the prescribed training period and the Contractor so employs the trainee, full credit and full payment to the Contractor will be made provided that the period of training given and the length of employment as a journeyman in the classification for which trained are equal to, or in excess of, the training period set forth in the approved training program. If the period of training given plus the period employed as a journeyman does not equal or exceed the training period set forth in the approved training program, the Contractor will be paid $3.00 per hour for each hour the trainee was trained and employed as a journeyman by the Contractor.

If less than the full training specified in the approved training program is provided and a trainee is not employed by the Contractor as a journeyman in the classification for which trained, payment to the Contractor will be made at $3.00 per hour for each hour of training completed. No payment will be made to the Contractor if the failure either to provide the required training or to hire the trainee as a journeyman is caused by the Contractor and there is evidence of a lack of good faith on the part of the Contractor in meeting the requirements herein.

SECTION 519—SOUND BARRIER WALLS

519.01—Description.

This work shall consist of furnishing and constructing precast concrete, metal, or plywood sound barrier walls in accordance with these specifications and approved working drawings and in reasonably close conformity to the lines, grades, and details shown on the plans or as established by the Engineer.

519.02—Materials.

The Contractor may furnish either metal or concrete sound barrier walls. Walls shall conform to the requirements of the applicable specifications.

Soundwall panels shall provide a transmission loss of at least 23 dB(A) when tested in accordance with ASTM E90 using the typical truck noise spectrum and shall have vibration-free joints.

(a) **Concrete** shall conform to the requirements of Section 217 and shall be Class 35 for precast, prestressed, or post-tensioned panels. Post footings shall be Class 20.

(b) **Reinforcing steel** shall conform to the requirements of Section 223 for Grade 400.

(c) **Steel piles** shall conform to the requirements of Section 228.

(d) **Steel H-post, W-shaped post, and girts** shall conform to the requirements of Section 226 and shall be galvanized in accordance with ASTM B695, Class 110. The portion of steel piles that serves as a post shall be galvanized in accordance with AASHTO M111 (ASTM A123) or ASTM B695, Class 110, above the finished grade and to a point 0.6 meter below the finished grade. Painting of posts shall be in accordance with the requirements of Section 411.

(e) **Structural tubing posts** shall conform to the requirements of ASTM A500 and shall be galvanized in accordance with ASTM A123.

(f) **Steel post, girts, and support angles** specified to be weathering steel shall conform to the requirements of ASTM A588 or ASTM A242.

(g) **Support angles (except weathering steel), channels, and plates** shall conform to the requirements of Section 226 and shall be galvanized in accordance with AASHTO M111 or ASTM A153.

(h) **Asphalt mastic** shall conform to the requirements of Section 232.

(i) **Miscellaneous hardware** shall conform to the following: Anchor bolts shall conform to the requirements of ASTM A307 and shall be galvanized in accordance with ASTM A153. Bolts, nuts, and washers shall conform to the requirements of ASTM A307, Grade A, or ASTM A325 and shall be galvanized in accordance with ASTM A153 or ASTM B695, Class 110. Self-drilling screws shall be Class 410 stainless steel conforming to the requirements of FS QQ-S-763 and shall be cadmium coated in accordance with ASTM B766. Nails and lag screws shall be galvanized in accordance with ASTM A153.

(j) **Caulking sealant** shall conform to the requirements of FS TT-S-00230, TT-S-001543, or TT-S-001657. Exposed caulking shall be color-pigmented similar to the color of finished panels or as approved by the Engineer.

(k) **Steel flashings and caps** shall be of the same material and thickness as the metal panels. Protective coating requirements shall be the same as those for panels.

(l) **Elastomeric pads** shall conform to the requirements of ASTM D1056, Grade 1B3 C1, 1B4 C1, or 1B5 C1. Adhesives shall conform to the manufacturer's recommendations.

(m) **Interlocking panels** shall conform to the following: Metal panels shall be of a cold-formed configuration providing sufficient structural strength and integrity to prevent warpage or distortion. The covering width of the panel face shall be at least 300 millimeters. Each panel shall have a male and female rib providing a friction interlock connection with adjacent panels. The friction interlock connection shall provide sufficient connection strength to support its own mass without the use of external fasteners when two connected panels are held in the vertical and horizontal positions. Panels shall be at least 0.759-millimeter steel in accordance with ASTM A446, Grade B. Panels shall be galvanized in accordance with ASTM A525, G-90 weight. The soundwall panel or finish shall be embossed so as to minimize light reflectance under wet conditions.

(n) **Protective color coating** for metal panels shall be System No. 1 or System No. 2 as specified on the plans. When the system is not specified, System No. 1 shall be furnished. The coating system shall be semigloss in accordance with the Federal Standard Number(s) specified on the plans or as approved by the Engineer.

1. **System No. 1** shall be either PVF plastic film (PVF_1) or urethane coating. System No. 1 coatings shall have an abrasion index of at least 16 liters per 0.025 millimeter in accordance with ASTM D968, shall be resistant to permanent graffiti markings, and shall produce an impervious finish free from cracks and crazings.

    a. **PVF_1** shall have a thickness of at least 0.038 millimeter per coated side and shall be applied at the factory to the thoroughly cleaned and pretreated galvanized steel in accordance with ASTM D2092, Method F. The PVF_1 film shall be pigmented to obtain optimum color performance and shall be laminated to the steel with heat and adhesive to produce a uniform, durable coating.

    b. **Urethane coating** shall be an acrylic or polyester material with a chromate-bearing epoxy prime coat, shall have a thickness of at least 0.03 millimeter per coated side, and shall be applied at the factory to the thoroughly cleaned, pretreated, and galvanized steel sheets. The urethane coating shall be inorganically pigmented to obtain optimum color

performance and oven cured under quality controlled conditions to produce a uniform and durable coating.

2. **System No. 2** shall be PVF (at least 70 percent resin) enamel (PVF_2) with a dry film thickness of at least 0.025 millimeter per coated side and shall be applied at the factory to thoroughly cleaned and pretreated galvanized steel in accordance with ASTM D2092, Method F. The PVF_2 enamel shall be pigmented to obtain optimum color performance and oven baked under quality controlled conditions to produce a uniform, durable coating free from cracks and crazings.

(o) **Wood** shall be Douglas fir or Southern pine, grade designation C-C plugged EXT, and shall bear the APA, TECO, or PTL quality test grade mark. If test grade marks are not visible after panel fabrication, certification shall be provided attesting that the sheeting complies with the required grade designation. The exterior of panels shall be textured on one side in accordance with APA Texture 1-11, minimum Grade 18-W. When specified on the plans, the opposite side shall be rough sawed in accordance with APA Series 303-18 S/W. After the sheeting has been textured, it shall be pressure treated with CCA, ACA, or penta LPG with a net retention or an equivalent of at least 4 kilograms per cubic meter in accordance with the requirements of Section 236. Blooming shall be removed at the treatment plant. The moisture content of plywood sheeting shall be not more than 19 percent at the time of delivery to the project.

(p) **Timber posts** shall be rough-sawed Southern pine No. 1 Dense SR or Douglas fir with a fiber stress in bending of at least 10.5 megapascals in accordance with the requirements of Section 236 and shall be pressure treated with CCA, ACA, or penta LPG to a net retention or an equivalent of at least 9.6 kilograms per cubic meter in accordance with the requirements of Section 236. Blooming shall be removed at the treatment plant.

(q) **Lumber materials** shall be kiln-dried Southern pine No. 2 or Douglas fir with a fiber stress in bending of at least 7.5 megapascals in accordance with the requirements of Section 236. Lumber shall be pressure treated with CCA, ACA, or penta LPG to a net retention or an equivalent of at least 6.4 kilograms per cubic meter in accordance with the requirements of Section 236. Blooming shall be removed at the treatment plant. The moisture content of lumber shall be not more than 19 percent at the time of delivery.

(r) **Wood stain** shall conform to the requirements of FS TT-S-708 except that the requirement for pentachlorophenol will be waived and the color pigmentation shall be modified to be similar to the Federal Standard Color Number specified on the plans or as approved by the Engineer.

When a color number is not specified on the plans, the color shall be similar to Federal Standard No. 595-30118.

519.03—Procedures.

Piles shall be driven in accordance with the requirements of Section 403 except that the tolerance for the position of a single steel H-pile shall be ±13 millimeters. Piles for sound barrier walls shall not be driven on Saturdays, Sundays, or holidays or between 4:30 P.M. and 8:00 A.M. on other days. The portion of posts from the finished grade to the bottom end and the portion of the H-pile lapped with posts shall be painted with asphalt mastic after splicing. Voids between posts and piles created by the use of shims for plumbing posts shall be caulked prior to the application of asphalt mastic.

Joints and connections shall be secured so as to be structurally sound with no visible openings for sound transmission and shall not be a secondary source of noise attributable to vibration. The top face of the sound barrier wall shall be aligned to maintain a continuous appearance and shall not deviate from true alignment by more than 13 millimeters in 3 meters.

Disturbed areas shall be graded and seeded in accordance with the requirements of Section 603.

(a) **Precast Sound Barrier Wall:** Absorptive and reflective precast concrete panels and concrete post footings shall be constructed in accordance with the requirements of Section 404 or 405, except that patching of panels will not be allowed. Panels having deficiencies such as cracking, crazing, scaling, efflorescence, or segregation, or panels having mottling of pigment, stain, or finish will be rejected. The roadway side of the panel shall have a rustic board, fractured fin, or other finish as specified, and the property side of the panel shall have a fuzzy raked or other finish as specified on the plans. In addition, the color of the wall, if applicable, shall be approved by the Engineer. Disturbed areas shall be graded to maintain proper drainage and shall be seeded in accordance with the requirements of Section 603.

(b) **Metal Sound Barrier Wall:** The Contractor shall submit to the Engineer five copies of certifications from an independent testing laboratory certifying that the design of the sound barrier wall panel will provide the minimum sound transmission loss specified herein.

The Contractor may furnish the galvanized post and girts with the protective color-coating system specified for panels, thereby

eliminating the related flashing covering, provided posts and girts conceal threads of bolts and screws.

The Contractor may furnish fixed bolted connections in lieu of welded connections provided he submits load calculations for the specific bolted connections and uses a safety factor of at least 3. Self-drilling screws may be used for locations where forces from the facial wind load will cause the shaft of the self- drilling screw to be in shear and not in tension.

Cut, marred, or scratched surfaces shall be repaired in accordance with the manufacturer's recommendations.

(c) **Plywood Sound Barrier Wall:** For solid-panel design, the Contractor may furnish textured, glued, double-panel plywood sections 16 millimeters in thickness or textured single-panel plywood sections 29 or 32 millimeters in thickness. When post spacings on the plans are on 2.35-meter centers and the Contractor proposes to furnish single-panel sections, panels shall be tongued and grooved along the 2.4- meter edges in accordance with APA standards and stamped accordingly. Panels shall be installed longitudinally with the tongue in the up position and shall be tightly stacked to prevent openings at joints.

For a hollow-core panel design, the Contractor may furnish glue-laminated box panels provided the facial design is the same and the wind load capacity is equal to or greater than that of the plan design.

Two coats of wood stain shall be applied by spray, brush, or roller.

519.04—Measurement and Payment.

Sound barrier walls will be measured in square meters of surface from the finished grade to the sound attenuation line shown on the plans and from end to end of the wall, complete-in-place, and will be paid for at the contract unit price per square meter. This price shall include grading, seeding, disposing of surplus and unsuitable material, restoring property, and construction outside the grade or sound attenuation line.

Payment will be made under:

Pay Item	Pay Unit
Sound barrier wall	Square meter

SECTION 520—WATER AND SANITARY SEWER FACILITIES

520.01—Description.

This work shall consist of furnishing and installing necessary materials for water distribution systems and sanitary systems in accordance with these specifications and in reasonably close conformity to the dimensions, lines, and grades shown on the plans or as established by the Engineer.

520.02—Materials.

(a) **Pipe, fittings, and flanges** shall conform to the requirements of Section 232.

(b) **Gaskets and joint materials** shall conform to the requirements of Section 212.

(c) **Casing pipe** shall be 2.03-millimeter-thick corrugated metal half-circle pipe conforming to the requirements of Section 232 except as modified for securing interlocked or nested connections.

(d) **Concrete blocks** shall conform to the requirements of Section 222.

(e) **Bricks** shall conform to the requirements of Section 222.

(f) **Hydraulic cement mortar** shall conform to the requirements of Section 218.

(g) **Concrete** shall conform to the requirements of Section 217 and shall be Class 20.

(h) **Reinforcing steel** shall conform to the requirements of Section 223.

(i) **Curing material for concrete** shall conform to the requirements of Section 220.

(j) **Timber skids** shall conform to the requirements of Section 236, and the preservative and treatment shall conform to the requirements of Section 236.

(k) **Valves** shall conform to the requirements of AWWA C500, C504, C506, C507, C508, or C509 for the types and features specified.

(l) **Fire hydrants** shall conform to the requirements of AWWA C502 or C503 with the various features specified.

(m) **Water meters** shall conform to the requirements of AWWA C700, C701, C702, C703, C704, C706, C707, C708, or C710 for the type and features specified. Each meter shall be furnished with a meter box.

(n) **Corporation stops** shall be made of bronze or red brass conforming to the requirements of ASTM B62. The fitting design and thread dimension shall conform to the requirements of AWWA C800. The working pressure of the corporation stop shall be equal to that of the water main to which it is attached.

(o) **Castings** shall conform to the requirements of Section 224.

(p) **Nonshrink waterproof grout** shall conform to the requirements of Section 218.

(q) **Aggregate** shall conform to the requirements of Section 203. Aggregate for drain fields shall be No. 5.

520.03—Procedures.

The Contractor shall be responsible for anticipating and locating underground utilities and obstructions in accordance with the requirements of Section 105.07.

When construction appears to be in close proximity to existing utilities, the trench(es) shall be opened a sufficient distance ahead of the work or test pits made to verify the exact locations and inverts of the utility to allow for changes in line or grade.

Connections to existing lines shall be made only after the proposed line is completed and approved by the Engineer. Connections shall be made in the minimum time possible with minimum interruption of service. Work and interruptions in existing service shall be scheduled with the utility owner.

Existing water and sewer lines and appurtenances and manholes not required in the completed system shall be abandoned as directed by the Engineer. Abandoned materials shall become the property of the Contractor, unless otherwise noted on the plans, upon satisfactory replacement with the new installation. Abandoned pipe that is not removed shall be cleaned of debris and plugged at open ends with Class 20 concrete.

Existing manholes that are not required in the completed system shall be removed to at least 600 millimeters below the proposed subgrade or natural ground line and shall be filled with approved backfill in accordance with the requirements of Section 302.03(a) 2.g.

Disturbed property shall be restored prior to final acceptance. Restoration shall include, but not be limited to, replacing shrubbery, sod, or topsoil,

including lime, fertilizer, seed, and mulch; replacing paved or finished surfaces with similar materials; and performing other work in accordance with the requirements of Section 107.12.

Sidewalks and streets shall be kept open for passage. The Contractor shall provide and maintain adequate and safe passage over excavations to accommodate pedestrians or vehicles as directed by the Engineer.

(a) **Protecting Water Supplies:** During the course of construction, the Contractor shall protect water supply facilities within the construction limits from contamination by sewage. The Contractor shall use the following criteria to govern the installation of water and sewer facilities in proximity of each other:

1. **Parallel separation:** Except as specified hereinafter, water lines shall be placed at least 3 meters horizontally from existing or proposed sanitary sewer lines, combination sewer lines, and sanitary sewer manholes. Sanitary sewer lines shall be placed at least 3 meters horizontally from existing and proposed water lines. This distance shall be measured from edge to edge. If local conditions prevent a lateral separation of 3 meters, a water line may be placed closer than 3 meters to a sewer line or a sewer line may be placed closer than 3 meters to a water line if the top of the sewer pipe is at least 450 millimeters below the bottom of the water line. Where the vertical separation cannot be obtained, the sewer shall be constructed of mechanical joint water pipe. Gravity sewers shall be pressure tested, in place, to 0.35 megapascal without leakage prior to backfilling. Force main sanitary sewer shall be pressure tested in accordance with the requirements of Section 520.04(c).

2. **Crossings:** Water and sewer lines that cross shall be placed to provide a separation of at least 450 millimeters between the bottom of the water line and the top of the sewer line. Where this vertical separation cannot be obtained, the sewer shall be constructed of mechanical joint or other approved water pipe for at least 3 meters on each side of the crossing.

   Sanitary sewers and combined sewers crossing over a water line shall have a vertical separation of at least 450 millimeters between the bottom of the sewer and the top of the water line. The support shall be adequate to prevent excessive deflection of joints and the settling on and breaking of the water line. The water or sewer line shall be centered at the point of the crossing so that joints will be equidistant and as far from each other as practicable.

   Water lines shall not pass through or come in contact with any part of a sanitary sewer, combined sewer, or sanitary sewer manhole.

The Contractor shall immediately notify the Engineer if he becomes aware that the work will result in the violation of these criteria. Upon such notification, the Engineer will issue instructions concerning remedial measures.

(b) **Excavation:** Excavation, backfill, and compaction shall be performed in accordance with the requirements of Section 302 except that stone larger than 25 millimeters in diameter shall not be used in backfill until the pipe has a cover of at least 300 millimeters. The remainder of backfill to the original ground or to within 300 millimeters of the finished subgrade shall not include stone larger than 250 millimeters in its greatest dimension. Pipe lines installed outside the roadway shall be backfilled in 200-millimeter layers and compacted to approximately 85 percent of the theoretical maximum density.

Trenches for pipe lines shall be excavated generally along straight lines, and bottoms shall be uniformly graded as required. Bedding material shall be placed in accordance with the plans. Where the trench bottom is in rock, it shall be excavated to at least 200 millimeters below the bottom of the pipe and backfilled with approved local or commercial bedding material. Pipe shall have a uniform bearing on a solid foundation for its entire length. Where pipe foundations are yielding, pipe shall be bedded on at least 200 millimeters of approved local or commercial bedding material. Bell holes, where applicable, shall be of sufficient size to ensure the making of proper joints.

Trenches below the grade line of the pipe shall be dewatered during installation of pipe lines.

When work is not in progress for any reason, lines shall be securely closed.

Where adjacent pavements are to be retained, pavement removed for pipe line trenches shall be replaced in kind with equal or better material or as otherwise specified. After backfilling, the Contractor shall maintain a smooth riding surface until pavement repairs are completed.

(c) **Inspecting Pipe and Fittings:** Pipe and fittings shall be inspected for cracks and defects before they are lowered into the trench. Faulty pipe and fittings shall be removed from the site.

(d) **Placing Pipe:** Water mains shall have a cover of at least 900 millimeters, and water service lines shall have a cover of at least 600 millimeters. Pipe, fittings, valves, hydrants, and accessories shall be carefully lowered into the trench to prevent damage to materials, protective coatings, and linings. Materials shall not be dropped or dumped into the trench.

If pipe, fittings, valves, hydrants, or accessories are damaged during handling, the damage shall be immediately brought to the Engineer's attention. The Contractor shall then submit to the Engineer, for approval, a method for repairing the damaged item. Damaged items shall be repaired as approved by the Engineer or shall be removed from the project.

Lumps, blisters, and excess coating shall be removed from ends of pipes that are to be joined. The inside of the bell and the outside of the spigot shall be wire brushed, wiped clean, dry, and free from oil and grease before pipe is placed. Foreign material shall be kept from entering pipe during placement.

As each length of pipe is placed in the trench, the spigot end shall be centered in the bell and the pipe forced home and brought to the correct line and grade. Pipe shall be secured in place with approved backfill material tamped under it except at bells. Precautions shall be taken to prevent dirt from entering the joint space. If it becomes necessary to deflect water main pipe during construction, the amount of deflection shall not exceed the manufacturer's recommendation.

(e) **Cutting Pipe:** Pipe for fittings or closure pieces shall be cut in a neat and orderly manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. The lining of the pipe shall not be damaged. Flame cutting of ductile iron or cast iron pipe with an oxyacetylene torch will not be permitted.

(f) **Joining of Pipe**: Gasket and joint lubricant for water facilities shall be a nontoxic, tasteless, odorless substance that will not support bacteria. Gasket end joint lubricant for sewer facilities shall be as recommended by the manufacturer or as approved by the Engineer. Pipe that is not furnished with a depth mark shall be marked before assembly to assure that the spigot end is inserted to the full depth of the joint. Field cut pipe lengths shall be filed or ground to resemble the spigot end of such pipe as manufactured.

1. **Ductile iron pipe** shall be joined in accordance with AWWA C-111 and AWWA C-600.

2. **Steel pipe** shall be joined by field welding unless otherwise specified on the plans. Pipe ends shall be in accordance with AWWA C-206 for type of field joint specified. Field welded joints shall be in accordance with AWWA-206; flanged joints shall be in accordance with AWWA C-207; and rubber gasket joints shall be in accordance with AWWA M11.

3. **Galvanized steel pipe** shall be joined by fittings in accordance with the manufacturer's recommendation.

4. **Copper pipe or tubing** shall be joined by fittings in accordance with the manufacturer's recommendation.

5. **PVC pipe** shall be joined by gasketed bell and socket joints in accordance with AWWA C-900.

6. **Concrete pipe** for water facilities shall have joints of the round rubber gasket type, unless otherwise specified, using either a bell and spigot joint or a double spigot and sleeve joint. Either joint shall be so that when the pipe is laid and the joint completed, the gasket will be confined within a groove or by shoulders on the bell and spigot. The contact surface in the joint shall be such as to not cause cutting of the rubber gasket during installation.

   Concrete pipe for sewer facilities shall be joined by using rubber gaskets. The gasket shall be continuous and fit snugly into the annular space between the overlapping surfaces of the assembled pipe joint to form a flexible watertight seal. The annular space between the gasket bearing surface of the assembled and centered joint shall be more than 75% of the uncompressed thickness of the applied gasket including the manufacturer's tolerances of the joint and gasket.

7. **Vitrified clay pipe** shall be joined with compression joints in accordance with ASTM C-12 and manufacturer's recommendation.

8. **PE pipe** shall be joined in accordance with AWWA C-901 and the manufacturer's recommendation.

9. **ABS pip**e shall be joined with a solvent cement joint in which pipe solvent cements into a coupling socket to form the joint. Primer for priming solvent cement joints shall be MEK (methylethyl ketone) and the cement shall be MEK containing a minimum of 20 percent by weight of dissolved ABS. Type OR joint is a mechanical-seal joint in which a gasket shall be compressed between the pipe and the bell coupling to form the joint closure.

(g) **Plugs, Caps, Tees, and Bends:** Plugs, caps, tees, and bends shall be anchored with reaction backing. Backing shall be concrete reaction blocks, metal reaction harnesses, or a combination thereof. Concrete shall be placed in accordance with the requirements of Section 404 and cured in accordance with the requirements of Section 316.04(j). Metal harness tie rods and clamps shall be of adequate strength to prevent movement and shall be galvanized or rustproofed by approved means.

(h) **Encasement Pipe:** Encasement pipe shall be installed in accordance with the requirements of Section 302.

(i) **Casing Pipe and Concrete:** Casing pipe and concrete shall be constructed in accordance with plan details and the applicable requirements of Sections 302, 303, 316, and 406, with the half-circle sections of casing pipe nested or interlocked to obtain a satisfactory union of the two sections of pipe. Prior to installation, existing pipe to be encased shall be cleaned and foreign material removed.

(j) **Valves, Valve Boxes, and Manholes:** The valve box shall not transmit shock or stress to the valve and shall be centered and plumb over the wrench nut of the valve with the box cover flush with the surface of the finished pavement. Manholes shall be constructed to permit minor valve repairs and protect the valve and pipe from impact where they pass through the walls.

(k) **Fire Hydrants:** Wherever a hydrant is set in pervious soil, drainage shall be provided at the base of the hydrant by placing coarse gravel or crushed stone mixed with coarse sand from the bottom of the trench to at least 150 millimeters above the waste opening in the hydrant and to a distance of 300 millimeters around the elbow.

Wherever a hydrant is set in clay or other impervious soil, a drainage pit 600 millimeters in diameter and 900 millimeters in depth shall be excavated below each hydrant. The pit shall be filled compactly with coarse gravel or crushed stone mixed with coarse sand under and around the elbow of the hydrant to a level 150 millimeters above the waste opening. The drainage pit shall not be connected to a sewer.

(l) **Installing Corporation Stops:** Corporation stops shall be installed while the main is under pressure and at a 45-degree angle to the horizontal plane.

(m) **Concrete Encasement:** Concrete encasement shall be constructed in accordance with the requirements of Sections 302, 303, 316.04(j), 404, and 406.

(n) **Water Meters and Yokes:** The meter box shall not transmit shock or stress to the meter and shall be centered and plumb over the meter. The top of the box shall be flush with the surrounding surface.

(o) **Jacked Encasement Pipe:** Jacked encasement pipe shall be installed in accordance with the requirements of Section 302.03(a)1.

(p) **Sanitary Service Lateral Connection:** Connection shall be performed by approved methods prior to installation using wyes, bends, adapters, cleanouts, and necessary pipe. Existing service laterals shall mate with the new fitting, adapter, or pipe to produce a watertight joint.

(q) **Sanitary Manholes and Manhole Frames and Covers:** These items shall be constructed in accordance with the requirements of Section 302.03(c). A secure bond between the pipe and manhole wall shall be obtained. Flexible insert gaskets shall be used to obtain a watertight joint. The gasket style and composition shall be subject to the approval of the Engineer. Precast wall sections shall be seated with flexible joint sealant for their full circumference. Lift holes, defects, joints between sections, and frames and covers shall be sealed with nonshrink waterproof grout.

(r) **Sanitary Drop Connections:** Connections shall be constructed in accordance with the requirements of Sections 302, 303, 404, and 406.

(s) **Sewer Cleanouts:** Cleanouts shall be constructed in accordance with the requirements of Sections 302, 303, 404, and 406.

(t) **Conveying Sewage:** When it is necessary to contain or pump sewage during the adjustment of or connection to existing sewers, sewage shall be carried by a watertight conveyor to sewers or manholes approved by the Engineer or shall be disposed of in accordance with local and state health codes. Sewage shall not be allowed to flow onto or over any open surface.

(u) **Manhole Frame and Covers, Valve Boxes, and Other Castings:** When located within the paved roadway, shoulder, or sidewalk, these shall be constructed within a tolerance of ±15 millimeters of the finished grade.

(v) **Reconstruct Existing Sanitary Manhole:** This shall consist of the removal of the existing manhole to the point indicated on the plans or directed by the Engineer. Reconstruction shall be accomplished by using existing units and pavement rings or new units and adjustment rings to attain the proposed finished grade.

520.04—Testing.

Water and sewer mains, appurtenances, and materials shall be tested for leakage after installation. Testing shall be performed in the presence of the Engineer. The Contractor shall provide water, plugs, equipment, tools, labor, materials, and incidentals necessary to perform the testing. If any section of a main or manhole under test shows leakage in excess of that specified, the Contractor shall make necessary repairs or replacements at his own expense. Testing shall be repeated until satisfactory results are obtained. Visible leaks shall be repaired regardless of the amount of allowable leakage.

(a) **Water Mains and Appurtenances:** New water mains and appurtenances shall be tested for leakage using the hydrostatic pressure

test method in accordance with Section 4 of AWWA C600 and the following:

1. The duration of each test shall be at least 2 hours. Sections of main with concrete reaction backing shall not be tested until at least 5 days after the backing is placed. If the backing is high-early-strength concrete, the test may be performed 2 days after backing is placed.

2. Testing of tie-ins with existing mains shall be performed under the normal working pressure of the main involved. Visible leakage at these points will not be allowed during a period of at least 2 hours.

3. The hydrostatic test pressure shall be 700 kilopascals or 1.5 times the working pressure, whichever is greater, based on the elevation of the lowest point in the line or section under test and shall be corrected to the elevation of the test gage. The Contractor shall ascertain the specific working pressure of the water main from the utility owner. Leakage loss shall not exceed the allowable leakage (L) as determined by the following formula:

$$Lm = \frac{SD\sqrt{P}}{715{,}317}$$

where Lm is the allowable leakage in liters per hour; S is the length of pipe tested in meters; D is the nominal inside diameter of the pipe in millimeters; and P is the average test pressure during the leakage test in kilopascals.

(b) **Gravity Sanitary Sewers:** Leakage shall be not more than 470 liters per 25 millimeters of pipe diameter per kilometer per day (24 hours) for pipe up to and including 600 millimeters in diameter and not more than 11,265 liters per kilometer per day for pipe more than 600 millimeters in diameter for any section of the system, including manholes, when subjected to at least 1.2 meters of head above the line crown at the upstream manhole of the section being tested.

1. **Infiltration test:** When in the opinion of the Engineer the trench or excavation is sufficiently saturated as a result of natural ground water, tests may be made on the basis of infiltration. The Contractor shall measure the flow of water at the nearest downgrade manhole. Three series of measurements shall be made at not less than 1-hour intervals, and the results shall be reduced to an average. The average for a 24-hour period shall then be computed. If the pipe line or manholes fail to meet the test requirements, leaks shall be repaired and defective pipe and manholes shall be replaced at

the Contractor's expense. The test shall be repeated until satisfactory results are obtained.

2. **Exfiltration test:** An exfiltration test shall be performed when the trench or excavation is dry and infiltration will not occur. The test shall be conducted as follows: The pipe shall be plugged at the lower manhole. The line and manhole shall be filled with water to a 1.2 meter level or to the top of the straight section if the manhole is less than 1.2 meters in height. The water shall stand until the pipe has reached maximum absorption and until trapped air has escaped (at least 4 hours). After maximum absorption has been reached, the manhole shall be filled to the original level. After 1 hour has elapsed, the difference in the level shall be recorded in terms of liters. The 24-hour loss shall then be computed. If the pipe line system and manholes fail to meet test requirements, leaks shall be repaired at the Contractor's expense. The test shall be repeated until satisfactory results are obtained.

3. **Air test:** In lieu of the infiltration or exfiltration test for leakage, the Contractor may test the sewers by using low air pressures. In the event low air pressure tests are used, the manholes shall be tested by exfiltration. Inflatable stoppers shall be used to plug all lines into and out of the manhole being tested. The stoppers shall be positioned in the lines far enough from the manhole to ensure testing of those portions of the lines not air tested. The manhole shall then be filled with water to the top, and a 12-hour soaking period shall be allowed prior to test measurement. The manhole shall be refilled to a mark, and at the end of 1 hour, the amount of leakage should be measured. Leakage shall not exceed 1.9 liters per hour. If the manhole fails to meet test requirements, leaks shall be repaired at the Contractor's expense. The test shall be repeated until satisfactory results are obtained. The low air pressure test shall be in accordance with the following:

   a. After backfilling and prior to air testing, the Contractor shall eliminate discernable water leaks and remove debris. Tests shall be conducted from manhole to manhole or from manhole to terminus. Personnel shall not be allowed in manholes once testing has begun.

   b. Immediately before testing, the Contractor shall provide securely braced test plugs at each manhole and a suitable means of determining the depth of the ground water level above the inverts.

   c. The Contractor shall slowly add air to the portion of the pipe being tested until the internal air pressure is at a test pressure of 27.5 kilopascals above the invert or ground water table,

whichever is greater, or until the pressure is equal to the hydraulic gradient, whichever is greater. If the test plug shows leakage, as determined by the Engineer, the Contractor shall relieve the pressure for at least 2 minutes. The Contractor shall then disconnect the hose and compressor. If the pressure decreases to 24.5 kilopascals, the amount of time shall be recorded for the pressure to drop from 24.1 to 17.2 kilopascals. The minimum allowable holding times will be as specified herein. Pipes that fail to maintain minimum holding times will not be accepted. Repairs, replacement, and retesting as specified by the Engineer shall be performed at the Contractor's expense.

The minimum allowable holding time for a 200-millimeter sanitary sewer pipe that is required for the pressure to drop from 24.1 to 17.2 kilopascals is:

Line Length (m)	**Time (sec)**
7.5	18
15.0	35
22.5	53
30.0	70
37.5	88
45.0	106
52.5	123
60.0	141
67.5	158
75.0	176
82.5	194
90.0	211
105.0	227
120.0	227

The minimum allowable holding time for a 300-millimeter sanitary sewer pipe that is required for the pressure to drop from 24.1 to 17.2 kilopascals is:

Line Length (m)	**Time (sec)**
7.5	40
15.0	79
22.5	119
30.0	158
37.5	198
45.0	238
52.5	277

60.0	317
67.5	340
75.0	340
82.5	340
90.0	340
105.0	340
120.0	340

(c) **Force Main Sanitary Sewers:** Leakage shall not exceed the allowable leakage (L) as determined by the following formula:

$$Lm = \frac{SD\sqrt{P}}{715{,}317}$$

where Lm is the allowable leakage in liters per hour; S is the length of pipe tested in meters; D is the nominal inside diameter of the pipe in millimeters; and P is the average test pressure during the leakage test in kilopascals.

The hydrostatic test pressure shall be maintained for at least 30 minutes at 700 kilopascals or 1.5 times the working pressure, whichever is greater, based on the elevation of the lowest point in the line or section under test, and shall be corrected to the elevation of the test gage. The Contractor shall ascertain the specific working pressure of the force main from the utility owner. Visible leaks shall be satisfactorily repaired regardless of the amount of allowable leakage.

(d) **Offsets of Existing Pipe:** Offsets will not be subjected to hydrostatic pressure testing unless specified on the plans. After installation and connection to the existing mains, the offset shall be placed in service and left uncovered for visual inspection for at least 2 hours. Visible leaks shall be repaired to the satisfaction of the Engineer prior to acceptance of the offset. Offset of existing pipe for water mains shall be disinfected in accordance with AWWA C-651, Section 9.

520.05—Disinfecting Water Mains.

New, relocated, and modified water mains and accessories shall be disinfected prior to tie-ins in accordance with AWWA C651.

If the initial disinfection fails to yield satisfactory samples, disinfection shall be repeated until satisfactory samples have been obtained. After each group of samples is taken, the Contractor shall submit a written report to the Engineer that states the results of the tests.

520.06—Measurement and Payment.

Excavation and replacement of pavement removed for pipe trenches will not be measured for separate payment unless otherwise shown. However, minor structure excavation will be measured and paid for in accordance with the requirements of Section 303.06. When excavation is required below the proposed trench bottom, necessitating additional bedding material, the bedding will be measured and paid for in accordance with the requirements of Section 302.04.

Water mains, water service lines, sanitary sewer pipe, and sanitary sewer force mains will be measured in meters of pipe through all valves and fittings, complete-in-place, and will be paid for at the contract unit price per meter. This price shall include excavating; testing; disinfecting; backfilling; compacting; dewatering; disposing of surplus and unsuitable material; sheeting and shoring; bedding material; installing pipe; connecting to existing lines or manholes; fittings less than 400 millimeters in diameter; reaction blocking; concrete anchor block; watertight welds; restrained joints; abandoning or removing lines, manholes, and other appurtenances; and restoring property. Pipe of one size, except for cast iron and ductile iron pipe, shall be combined into one contract item for the respective size of water main and sanitary sewer pipe. The salvage value of abandoned materials shall accrue to the Contractor and shall be reflected in the contract unit price for the respective replacement facility.

Encasement pipe and casing pipe and concrete will be measured in meters, complete-in-place, and will be paid for at the contract unit price per meter. This price shall include excavating, dewatering, sheeting and shoring, blocking, installing pipe, grouting, concrete encasement, reinforcing steel, masonry blocks, watertight bulkheads, backfilling, compacting, disposing of surplus and unsuitable material, and restoring property.

Jacked encasement pipe will be measured and paid for in accordance with the requirements of Section 302.04. This price shall include excavating, backfilling, disposing of surplus and unsuitable material, sheeting and shoring, blocking, bulkheads, and jacking.

Concrete encasement will be measured in meters of encased pipe or cubic meters of concrete, complete-in-place, and will be paid for at the contract unit price per meter or cubic meter. This price shall include excavating, sheeting and shoring, concrete, reinforcing steel, backfilling, compacting, and disposing of surplus and unsuitable material.

Sanitary service lateral connections will be measured in meters, complete-in-place, from the center line of the sewer main to the point of connection of sanitary service lateral and will be paid for at the contract unit price per meter. This price shall include excavating, backfilling, compacting, disposing of

surplus and unsuitable material, sheeting and shoring, connecting to existing service lateral, and restoring property.

Sanitary drop connections will be measured in meters (vertical measure), complete-in-place, from the invert of the upper inlet pipe to the invert of the lower inlet pipe and will be paid for at the contract unit price per meter. This price shall include pipe and fittings, concrete, reinforcing steel, connections to sewer lines and manholes, excavating, bedding material, backfilling, compacting, disposing of surplus and unsuitable material, and restoring property.

Sanitary sewer manholes, frames and covers, and watertight frames and covers will be measured and paid for in accordance with the requirements of Section 302.04.

Sewer cleanouts (main or lateral) will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include fittings; riser pipe, frame, cover, and box; excavating; backfilling; compacting; disposing of surplus and unsuitable material; and restoring property.

Reconstruct existing sanitary manhole will be measured in meters, vertical measure, from the point of the removed section to the top of masonry on which the frame and cover is placed and will be paid for at the contract unit price per meter. This price shall include removal, salvaging and resetting frame and cover, reconstruction of manhole, new materials, excavation, backfilling, compaction, disposal of surplus of unsuitable material, and restoring property.

Fire hydrants will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include excavating, dewatering, backfilling, compacting, connections, concrete blocking, pipe straps, crushed stone drain, disposing of surplus and unsuitable material, restoring property, and testing.

Water meters and boxes; water meter boxes and yokes; valves and boxes or manholes; and tapping sleeves, valves, and boxes or manholes will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include excavating, backfilling, and restoring property.

Bends, plugs or caps, reducers, and branches (tees, wyes, and crosses) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include restrained joints, excavating, reaction blocking, testing, backfilling, sheeting and shoring, watertight welds, abandoning or removing existing lines as noted on the plans, and restoring property.

Offsetting existing pipe will be measured in meters of pipe parallel to the flow line between tie-in points, complete-in-place, and will be paid for at the

unit price per meter. This price shall include fittings, couplings, restrained joints, excavating, testing, disinfecting, backfilling, compacting, dewatering, disposing of surplus or unsuitable material, sheeting and shoring, bedding material, installing pipe, connecting existing lines as noted on the plans, reaction blocking, watertight welds, abandoning or removing existing lines as noted on the plans, and restoring property.

Leak detectors will be measured in units of each. This price shall include pipe, return bends, bird screens, clamps, excavating, backfilling, and restoring property.

These prices shall include containing or pumping sewage during adjusting or connecting existing sewers and providing and maintaining adequate and safe passage over excavations to accommodate pedestrians or vehicles as directed by the Engineer.

Payment will be made under:

Pay Item	Pay Unit
Water main (Size and type)	Meter
Water service line (Size)	Meter
Encasement pipe (Size and type)	Meter
Casing pipe and concrete (Size)	Meter
Leak detector (Standard)	Each
Bend (Size)	Each
Reducer (Size)	Each
Plug or cap (Size)	Each
Branch (Size)	Each
Offset existing pipe (Size)	Meter
Valve and (Box or manhole) (Size and type)	Each
Tapping sleeve, valve, and (Box or manhole)	Each
Fire hydrant (Standard and type)	Each
Water meter and box (Size)	Each
Water meter box and yoke (Size)	Each
Jacked encasement pipe (Size and type)	Meter
Sanitary sewer pipe (Size and type)	Meter
Sanitary service lateral connection (Size)	Meter
Sanitary sewer force main (Size)	Meter
Bend-force main (Size)	Each
Reducer-force main (Size)	Each
Plug or cap-force main (Size)	Each
Branch-force main (Size)	Each
Offset existing pipe-force main (Size)	Meter
Sanitary sewer manhole (Standard)	Meter
Manhole frame and cover (Standard)	Each

Sanitary drop connection	Meter
Valve and (Box or manhole) (Size and type)-force main	Each
Tapping sleeve, valve, and (Box or manhole) (Size)-force main	Each
Concrete encasement (Standard)	Meter or cubic meter
Reconstruct existing sanitary manhole	Meter
Watertight manhole frame and cover (Standard)	Each

Division VI

ROADSIDE DEVELOPMENT

SECTION 601—SELECTIVE TREE REMOVAL, TRIMMING, AND CLEANUP

601.01—Description.

This work shall consist of selective cutting and disposing of trees, shrubs, and vegetation to improve sight distance, create open vistas, or improve the appearance and condition of trees. This shall be accomplished by removing and disposing of rubbish and fallen and undesirable trees and shrubs, selective pruning, and spraying stumps with an approved herbicide to prevent sprouting.

601.02—Materials.

Herbicide shall conform to the requirements of Section 244.02(a).

601.03—Procedures.

Trees and stumps shall be cut in such a manner that remaining stumps are not higher than 100 millimeters above the ground. Loose roots more than 25 millimeters in diameter and more than 300 millimeters in length shall be removed. Only those living trees and shrubs selected by the Engineer shall be removed. Trees to be removed shall be felled in a manner that will not damage the trees and shrubs to be preserved.

Debris shall be disposed of by burning or chipping or in accordance with the requirements of Section 106.04. Burning shall be performed in accordance with the requirements of Section 107.14. Fires shall be located and supervised so that they will not spread or damage vegetation. A mechanical chipper may be used, and the resulting chips spread thinly and uniformly within the immediate area or disposed of as directed by the Engineer.

(a) **Treating Stumps:** Stumps of living trees and shrubs shall be coated with a herbicide solution within 48 hours after they are cut. The exposed surface of stumps and exposed live roots shall be saturated with herbicide to the point of runoff.

(b) **Trimming:** Branches and limbs that affect sight distance or the open vista and dead or diseased branches and limbs more than 50 millimeters in diameter that will hinder the healthy normal growth of trees shall be removed as designated by the Engineer. Cuts shall be made flush at the collar of the supporting trunk or limb.

The Contractor's operations and equipment used to perform selective trimming shall not damage trees and shrubs that are to remain.

Climbing spurs or spikes shall not be used. Damage to the bark, limbs, and roots of trees and shrubs that are to remain shall be repaired in a manner acceptable to the Engineer. Such repairs and the replacement, in kind, of those that cannot be satisfactorily repaired shall be at the Contractor's expense.

601.04—Measurement and Payment.

Selective tree removal, trimming, and cleanup will be measured in hectares of surface area computed to the nearest 0.1 hectare and will be paid for at the contract unit price per hectare.

Payment will be made under:

Pay Item	Pay Unit
Selective tree removal, trimming, and cleanup	Hectare

SECTION 602—TOPSOIL

602.01—Description.

This work shall consist of applying topsoil in accordance with the requirements of these specifications and in reasonably close conformity to the depths and limits shown on the plans or as established by the Engineer.

602.02—Materials.

(a) **Class A topsoil** shall conform to the requirements of Section 244.02(b)1.

(b) **Class B topsoil** shall conform to the requirements of Section 244.02(b)2.

602.03—Procedures.

(a) **Preparing Areas To Receive Topsoil:** Unless otherwise directed by the Engineer, areas designated to receive topsoil shall be graded, shaped, and then scarified or tilled by disking, harrowing, or other approved methods to a depth of approximately 50 millimeters. Topsoil shall be applied only when the subsoil is in a loose, friable condition.

Subsoil on slopes that have been horizontally grooved in accordance with the plans shall not be loosened.

(b) **Applying Topsoil:** The loose depth of topsoil shall be sufficient to allow the area to conform to the elevations shown on the plans after topsoil settles.

After topsoil has been applied, large clods, hard lumps, and stones more than 75 millimeters in diameter; brush; roots; stumps; litter; and foreign material shall be removed from the area. When the operation is complete, the area shall be in a condition to receive seed, sod, or plants without further soil preparation. Areas shall be seeded within 15 days after topsoil is applied.

602.04—Measurement and Payment.

Topsoil will be measured in hectares of surface area computed to the nearest 0.1 hectare and will be paid for at the contract unit price per hectare. This price shall include preparing areas to receive topsoil; furnishing, loading, transporting, and applying topsoil; finishing areas; and restoring damaged areas prior to final acceptance.

Payment will be made under:

Pay Item	Pay Unit
Topsoil (Class and depth)	Hectare

SECTION 603—SEEDING

603.01—Description.

This work shall consist of furnishing and applying fertilizer, lime, mulch, and seed in the quantities specified for areas designated on the plans or selected by the Engineer.

603.02—Materials.

(a) **Seed** shall conform to the requirements of Section 244.02(c).

(b) **Fertilizer** shall conform to the requirements of Section 244.02(d).

(c) **Lime** shall conform to the requirements of Section 244.02(e).

(d) **Mulch** shall conform to the requirements of Section 244.02(g).

603.03—Procedures.

Unless otherwise specified, seeding operations shall be performed at the times specified in Sections 303.03(b) and 602.03(b). Seeding operations shall not be performed when the ground is frozen or when soil or weather conditions would prevent proper soil preparation and subsequent operations. When hydroseeding is performed, nozzles or sprays shall not be directed toward the ground in a manner that will cause erosion or runoff. The Contractor shall notify the Engineer at least 48 hours prior to beginning seeding operations.

(a) **Applying Lime:** Lime shall be uniformly applied to areas to be seeded at the rate of 4.5 metric tons per hectare. Any approved method may be used.

(b) **Preparing Soil:** After lime is applied, areas to be seeded shall be prepared in accordance with the following: Slopes 3:1 or flatter shall be loosened to a depth of approximately 75 millimeters by disking, harrowing, or other approved methods. Loosening of soil on excavated slopes steeper than 3:1 will not be required except to eliminate hard or crusted surfaces. Shoulders and embankment slopes steeper than 3:1 shall be loosened to a depth of approximately 25 millimeters. Clods, loose stones, and other foreign material larger than 75 millimeters in any dimension shall be removed and disposed of in accordance with the requirements of Section 106.04 or as approved by the Engineer. Gullies, washes, and disturbed areas that develop subsequent to final dressing shall be repaired before they are seeded.

Topsoil, when specified, shall be applied in accordance with the requirements of Section 602.

(c) **Applying Fertilizer:** When dry fertilizer is used, it shall be applied uniformly to the seeding areas at the time of seeding at the rate of 675 kilograms of 15-30-15 fertilizer, or an equivalent quantity of 1-2-1 fertilizer, per hectare.

When applied in liquid form or mixed with water, fertilizer shall provide the same value of nutrients per hectare as specified for dry fertilizer. Fertilizer applied in liquid form shall be agitated during application.

(d) **Applying Seed:** Regular seeding shall consist of uniformly applying seed, fertilizer, and mulch on prepared areas.

Overseeding shall consist of applying seed and fertilizer on areas prepared as directed by the Engineer.

For hydroseeding, seed shall be put in the mixture slowly to result in a uniform mixture before application. Hydroseeding mixtures shall be constantly agitated from the time of mixing until application on the seed bed and used within 8 hours from the beginning of mixing.

If special seed is required in addition to the regular mixture, it will be furnished by the Department and shall be applied with the regular mixture at the Contractor's expense.

Leguminous seeds shall be inoculated or treated with approved cultures as specified by the manufacturer or directed by the Engineer before they are applied or mixed with other seeds to be applied. Seed shall be applied within 24 hours after treatment. When the hydroseeding method is used, leguminous seeds shall be treated with 5 times the amount of inoculant recommended by the manufacturer.

(e) **Applying Mulch:** Mulch shall be applied within 48 hours after completion of the seeding operation. When straw or hay mulch is used, it shall be applied on seeded areas at the rate of approximately 4.5 metric tons per hectare. When wood cellulose fiber mulch is used, it shall be uniformly applied at the rate of approximately 1,680 kilograms (net dry mass) per hectare. Mulch will not be required on overseeded areas.

Straw and hay mulch shall be applied to a uniform thickness in such a manner that not more than 10 percent of the soil surface will be exposed. Wet straw or wet hay shall not be used. Straw or hay mulch shall be anchored to the seeded surface by spraying with wood cellulose fiber mulch at the rate of 840 kilograms per hectare; spraying with an emulsified asphalt at the rate of at least 415 liters per metric ton of mulch in a manner that will protect adjacent property and pedestrian traffic areas; disking or punching the mulch partially into the soil; using approved netting; or using other materials or methods approved by the Engineer. The Contractor may use more than one method on the same project.

603.04—Measurement and Payment.

Lime will be measured in metric tons and will be paid for at the contract unit price per metric ton.

Fertilizer will be measured in metric tons and will be paid for at the contract unit price per metric ton. When a grade different than that specified in the

Contract is used, the metric tonnage quantity will be adjusted to the grade specified.

Seed will be measured in kilograms of seed used and will be paid for at the contract unit price per kilogram. When opened bags of seed are transferred from project to project, certified scales shall be used for determining the mass of the seed.

Prices for seed, fertilizer, and lime shall include preparing seed beds; furnishing and applying seed; furnishing and applying mulch; and maintaining seeded areas until final acceptance.

Overseeding will be paid for at the contract unit price per kilogram of seed. This price shall include preparing seed beds and furnishing and applying seed and additional fertilizer.

Mulch will not be measured for separate payment. The cost thereof shall be included in the price for seed.

Payment will be made under:

Pay Item	Pay Unit
(____) seed	Kilogram
(____) overseeding	Kilogram of seed
Fertilizer (Ratio)	Metric ton
Lime	Metric ton

SECTION 604—SODDING

604.01—Description.

This work shall consist of preparing sod beds; furnishing and placing sod; and furnishing and applying lime, fertilizer, topsoil, and water at locations designated on the plans or by the Engineer.

604.02—Materials.

(a) **Sod** shall conform to the requirements of Section 244.02(h).

(b) **Fertilizer** shall conform to the requirements of Section 244.02(d).

(c) **Lime** shall conform to the requirements of Section 244.02(e).

604.03—Procedures.

(a) **Preparing Sod Beds:** Soil on which sod is to be placed shall be shaped to an even surface and graded to such an elevation that sod and adjacent surfaces will have a smooth contour.

Lime shall be uniformly applied to areas designated to receive sod at the rate of approximately 4.5 metric tons per hectare.

Fertilizer shall be uniformly applied to areas designated to receive sod at the rate of 80 kilograms of 15-30-15 fertilizer, or an equivalent quantity of 1-2-1 fertilizer, and 50 kilograms of ureaformaldehyde per 1,000 square meters. Following application of lime and fertilizer, the soil shall be thoroughly cultivated to a depth of 50 to 75 millimeters and sprinkled with sufficient water to moisten the cultivated soil.

(b) **Placing Sod:** Sod shall not be placed between June 1 and September 1 or at any time the ambient temperature is below 0 °C. Frozen sod shall not be placed, and sod shall not be placed on frozen soil. Sod shall be placed by hand, and joints shall tightly abut without overlapping. Open joints and gaps shall be plugged with sod that has been cut to the size and shape of the opening.

Sod shall be placed on sloping areas beginning at the bottom of the slope. Sod shall be placed in horizontal strips with the long edges of rectangular pads parallel to the contour. When practicable, horizontal joints shall be reasonably straight and vertical joints staggered. In areas where sod pads may be displaced by foot traffic during sodding operations, ladders or treaded planks shall be used.

Sod placed on slopes steeper than 2:1 shall be anchored in place with wood stakes driven flush with the top of the sod. Stakes shall be at least 200 millimeters in length with a cross-sectional area of approximately 645 square millimeters. The number and spacing of stakes shall be adequate to hold sod securely in place. Special attention shall be given to anchoring sod placed in drainage ditches, channels, and swales.

After sod has been placed, joints and gaps that were too small to be effectively plugged with sod shall be filled with loamy topsoil.

Sodded areas shall be watered thoroughly and rolled or tamped to press the root system of the sod into full contact with underlying soil.

Sodded areas shall be kept watered to maintain the life and growth of the sod until final acceptance.

604.04—Measurement and Payment.

Sod will be measured in square meters of surface area, complete-in-place, and will be paid for at the contract unit price per square meter of surface area. This price shall include preparing sod beds; furnishing and applying lime, fertilizer, sod, and water; and maintaining sodded areas until final acceptance.

Payment will be made under:

Pay Item	Pay Unit
Sod	Square meter

SECTION 605—PLANTING

605.01—Description.

This work shall consist of furnishing and planting trees, shrubs, vines, and other plants of the kinds, sizes, and quantities specified on the plans or by the Engineer and maintaining and replacing plants as specified herein.

605.02—Materials.

(a) **Plants** shall conform to the requirements of Section 244.02(i).

(b) **Planting materials** shall conform to the requirements of Section 244.02(j).

605.03—Procedures.

The Contractor shall notify the Department at least 48 hours prior to beginning work.

(a) **Sources of Supply:** Plants shall be obtained from approved sources. The Department may withdraw its approval of sources that do not consistently furnish acceptable plants.

(b) **Inspecting and Identifying Plants:** Plants will be inspected and identified in accordance with the *Standardized Plant Names* prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature. The Engineer may inspect and reject plants at any time and place. Plants will be inspected immediately

prior to being planted. If they are planted prior to inspection and found to be unsatisfactory, they shall be replaced with approved plants at the Contractor's expense.

(c) **Substitutions:** No change in the quantity, size, kind, or quality of plants from those specified will be permitted without the approval of the Engineer. When requesting permission to substitute, the Contractor shall submit written evidence that the specified plants are not available and shall suggest substitute plants that conform to the requirements of the Contract. The Contractor shall indicate the reduced cost, if any, that will accrue to the Department as a result of the substitution. The Engineer may delete plants from the Contract in lieu of approving substitutions.

(d) **Layout:** Plant locations and outlines of areas to receive plants shall be staked or marked in ample time to allow inspection and approval by the Engineer before digging is started. Unforeseen conditions such as the location of traffic signs and drainage items may necessitate adjustments in plant locations, and such adjustments will be permitted when approved by the Engineer.

(e) **Delivery:** The Contractor shall notify the Engineer at least 48 hours in advance of the anticipated delivery date for plants. A legible copy of the invoice showing the kinds and sizes of plants in each shipment shall be furnished the Engineer. A copy of the current Certificate of Nursery Inspection shall accompany each shipment of plants.

(f) **Labeling:** Representative samples of each shipment of plants shall be legibly labeled as to the genus, species, size, and quantity of the plants. When plants are in bales, bundles, boxes, or other containers, a legible label indicating the genus, species, size, and quantity of the plants shall be attached to each container.

(g) **Transporting and Protecting:** Plants transported to the project in open vehicles shall be covered with suitable covers securely fastened to the body of the vehicle. Closed vehicles shall be adequately ventilated to prevent overheating plants. Plants shall be kept moist, fresh, and protected at all times.

(h) **Storing:** When plants are to be stored, they shall be stored at a location approved by the Engineer. Plants stored for more than 30 days shall not be used unless they are approved by the Engineer. Unless other methods of storage are approved by the Engineer, bare-root plants that are not planted within 24 hours after delivery shall be heeled-in in a moist trench dug in the ground. Bundles shall be opened, and plants shall be separated and placed singly in the trench with the roots spread in a natural position. Roots of each layer of plants shall

be immediately covered in a manner satisfactory to the Engineer with moist, pulverized soil; moist sawdust; or other approved material. Root-covering materials shall be kept moist at all times. Shade shall be provided as directed by the Engineer. At the discretion of the Engineer, balled material, container-grown material, and plants in plantable pots that are not planted within 48 hours of delivery shall have their root zone protected by wet sawdust or other approved material. Rejected plants shall be removed from the storage area within 24 hours of rejection or, with the approval of the Engineer, may be marked with yellow paint or otherwise made readily identifiable. If rejected plants have not been removed or acceptably marked within 24 hours, the use of plants from the storage area will not be allowed until rejected plants have been removed or identified.

(i) **Planting:**

1. **Underground conditions:** If underground obstructions or any other unforeseen subsurface conditions that would be detrimental to plant growth are encountered, the Engineer may require that plant pits be enlarged or relocated or that the plants be deleted from the Contract.

2. **Planting trees or shrubs on slopes steeper than 3:1:** Drainage requirements for trees or shrubs on slopes steeper than 3:1 will be determined by percolation tests, with no more than 3 tests per slope, as designated by the Engineer. Slope for this test is determined to be from cut to fill points as shown on the plans.

3. **Preparing planting pits:** Sides of pits that become plastered or glazed shall be scarified. Surplus excavation and unsuitable material shall be disposed of in accordance with the requirements of Section 106.04 or as otherwise approved by the Engineer.

4. **Preparing plant beds:** The entire area of the plant bed shall be cultivated to a depth of at least 100 millimeters by a rotary cultivator before plant pits are excavated. Grass, sod, and weeds shall be removed from the bed. Rocks, clods, roots, and other objectionable material remaining on the surface shall be removed and disposed of in accordance with the requirements of Section 106.04 or as approved by the Engineer. Unless authorized by the Engineer, soil excavated from plant pits shall not be used in the bed. Individual planting pits shall not be dug until after the bed is prepared to the satisfaction of the Engineer.

   Upon completion of planting, the bed shall be hand raked to an even surface and neatly edged. Mulch shall be applied to the entire cultivated area.

5. **Installing plants and backfilling:** Plants shall be installed in pits on a soil mixture conforming to the requirements of Section 244.02(j)4. that has been placed and tamped to the proper depth. Bare roots of plants shall be spread out in a natural position. Broken or bruised roots shall be pruned. The soil mixture shall then be filled in around roots and tamped. Tamping around root balls shall be performed using a mattock handle or similar round-ended instrument. Foot tamping will be permitted in the bottom of pits before plants are installed, around root balls when there is ample room to accommodate the foot without damage to the ball, and in the planting of bare-root plants after roots have been covered with the soil mixture.

   Backfill in pits shall be saturated with water. The amount of water applied and method of application shall be to the satisfaction of the Engineer. Failure to water properly at the time each plant is installed will be cause for rejection of the plant. Frozen backfill shall not be used.

   After positioning plants in the planting pit and prior to backfilling, root ball wrapping materials, except metal root ball cages, shall be cut and dropped to the bottom of the pit. Root ball wrapping materials shall not be removed from under the root ball. Metal root ball cages shall be cut and removed to approximately 150 millimeters below finished grade. Wrapping materials within root ball cages shall be cut or unwrapped to the same elevation as the cage.

   Potted plants shall not be removed from their container until immediately before planting. Containers shall be removed by approved methods that will not damage roots or loosen soil balls.

   When planted, watered, and fully settled, plants shall be vertical and shall stand at a height flush with or slightly below the height at which they were growing.

6. **Handling plants during planting:** Roots of bare-root plants shall be kept covered with moist burlap or other approved material prior to planting. Forest tree seedlings and forest tree transplants shall be carried in a container filled with sufficient mud to puddle roots. When seedling roots have been coated with a protective material, the seedlings shall be protected in accordance with the U.S. Forest Service's recommendations relative to treatment of seedling roots while seedlings are being planted. Plants will be rejected if their roots are exposed to drying conditions at any time.

(j) **Forming Water Rings and Saucers:** Immediately after installation of each plant, a saucer shall be formed around the plant pit as shown on the plans. Soil used to form the saucer shall be compacted by tamping to prevent runoff of water from the pit. Saucers will not be required for plant beds, forest tree seedlings, or forest tree transplants.

(k) **Applying Mulch:** Mulch shall be applied uniformly over the entire area of the plant pit or plant bed within 48 hours after completion of planting. Mulch shall be anchored in a manner satisfactory to the Engineer. Mulch will not be required for forest tree seedlings or forest tree transplants.

(l) **Staking and Guying:** Each tree shall be staked or guyed immediately following planting.

(m) **Wrapping:** Deciduous trees shall be wrapped within 48 hours after planting but not before the condition of their trunk has been approved by the Engineer.

(n) **Pruning:** Plants that have been freshly pruned before delivery will be rejected. Plants shall be pruned either immediately before or within 48 hours after they are planted. Pruning of trees and shrubs shall consist of thinning out approximately 1/3 of the growth. Care shall be taken to preserve the natural character of the plant. Pruning shall be performed with tools and equipment specifically designed for the pruning to be performed.

(o) **Pit Drains:** Pit drains shall be installed as shown on the plans.

605.04—Care of Plants.

Plant care shall begin immediately after each plant is satisfactorily installed and shall continue until final acceptance. Care shall include but not be limited to replacing displaced mulch within 7 days, repairing and reshaping water rings or saucers, maintaining stakes and guys as originally installed, watering when needed or directed, and performing any other work required to keep plants in a healthy condition. Dead, defective, or rejected plants shall be immediately removed and replaced at the Contractor's expense.

605.05—Establishment Period.

(a) **Beginning of Establishment Period:** The establishment period will begin on the date that an inspection by the Engineer confirms that plants have been installed in accordance with the requirements of these specifications and that dead or defective plants have been replaced to the satisfaction of the Engineer.

(b) **Establishment Period:** During the establishment period, living plants shall be watered as frequently as is necessary to maintain an adequate supply of moisture within the root zone at all times. Water shall not be applied at a force that will displace mulch. The Engineer may require the use of watering needles or other approved methods to prevent displacement of mulch and runoff of water. The Engineer will make periodic inspections to ascertain the moisture content of the soil. When notified by the Engineer that watering is required, the Contractor shall begin watering within 48 hours with sufficient labor and equipment and shall continue to water daily where and as directed, without delays or interruptions, to ensure that the root zone does not become dry at any time. The quantity of water supplied shall not be in excess of that normally required to ensure optimum growing conditions. The Engineer may require or suspend watering at any time.

Work, except watering, shall begin within 10 days after the Engineer notifies the Contractor that the establishment period has begun.

Plants shall be pruned, and mulch shall be replaced as required.

Stakes, guys, tree wrap, and eroded plant saucers shall be repaired or replaced and removed when no longer required.

Plant beds and mulched areas around plants shall be kept free from grass and weeds, including root growth.

Grass and other vegetation shall be cut between individual plant pits that are not in beds to a height of approximately 100 millimeters. Mowing shall be performed once in June and once in September.

Herbicides may be used when approved by the Engineer.

Additional work, including pruning and seasonal spraying with approved insecticides and fungicides, shall be performed to ensure plant survival as approved or directed by the Engineer.

Dead plants shall be removed immediately at the Contractor's expense.

(c) **Termination of Establishment Period:** The establishment period shall end during the ensuing planting season on the date that an inspection by the Engineer shows that the Contractor has complied with the requirements of (b) herein.

Dead, missing, or defective plants shall be replaced as directed by the Engineer, but not prior to November 1. The Engineer shall be notified when replacement is started.

605.06—Guarantee.

The Contractor's performance bond, furnished in accordance with the requirements of Section 103.05, shall provide for necessary maintenance during the establishment period and replacements in kind, or with a substitute acceptable to the Engineer, for plants that are not in a healthy growing condition or that have died back to the crown or beyond the normal pruning limit.

605.07—Measurement and Payment.

Plants will be measured by an actual count of living plants in a healthy growing condition and will be paid for at the contract unit price per each. Plants that the Engineer deleted from the Contract will not be measured for payment. This price shall include furnishing and delivering plants and planting material; preparing planting pits and beds; forming saucers; planting; watering (except during establishment period); applying fertilizer; backfilling with approved soil mixture; staking; guying; wrapping; pruning; applying mulch (except to areas designated on the plans as plant beds); replacing plants; cutting or mowing; repairing, replacing, and removing stakes when no longer needed; guys and tree wrap; and maintaining plants in a healthy condition until final acceptance.

Trees or shrubs planted on a slope steeper than 3:1 with pit modification will be paid for at 125% of the price bid. Such price shall also include cost of pit modification, stone, and geotextile filter fabric. Percolation tests shall be included in the price bid for plants.

Pit drains will be measured and paid for in units of each, complete-in-place, which price shall include pipe grate, pipe, geotextile fabric, and aggregate.

Replacements for plants lost during the establishment period because of theft, damage, or destruction caused by persons or equipment belonging to persons or organizations other than those engaged in performing the work or during delivery of plants will be paid for at the rate of 1/2 the contract unit price per each. This price shall include all costs associated with replacement.

Mulching will be measured in units of 10 square meters of surface area. Mulch for plant beds will be paid for at the contract unit price per 10 square meters. This price shall include furnishing, delivering, and applying mulch. No separate payment will be made for applying mulch around plants that are not in cultivated plant beds. The cost thereof shall be included in the price for the plant.

Watering during the establishment period will be measured in units of 3,785 liters and will be paid for at the contract unit price per 3,785 liters. This price shall include furnishing, delivering, and applying water and performing

all other work in connection therewith and incidental thereto. No payment will be made for watering at the time of original planting or when replacements are planted.

Payment will be made under:

Pay Item	Pay Unit
(Name of) Plant (Size)	Each
Mulching	Unit (10 square meters)
Watering	Unit (3,785 liters)

SECTION 606—SOIL RETENTION COVERINGS

606.01—Description.

This work shall consist of furnishing and placing protective coverings for soil retention, including seed, fertilizer, lime, topsoil, and water, in accordance with the requirements of these specifications and in reasonably close conformity to the dimensions, lines, and grades shown on the plans or as established by the Engineer.

606.02—Materials.

Materials shall conform to the requirements of Section 244.02(k).

606.03—Procedures.

(a) **Preparing Areas:** Fifty millimeters in depth of topsoil shall be applied to the area to be covered. Drainage channels shall be shaped in accordance with the cross section shown on the plans and shall be rolled or tamped to compact soil in place before final shaping.

During shaping operations, a seed bed approximately 20 millimeters in depth shall be provided.

Stones, roots, and other objects that will prevent protective covering from making close contact with the seed bed shall be removed before covering is installed.

(b) **Applying Seed:** Seed shall be applied in accordance with the requirements of Section 603 except that mulch will not be required.

Seed, fertilizer, and lime shall be applied prior to installation of protective coverings.

Seeded areas adjacent to the channel or ditch that are disturbed during installation of covering shall be uniformly reshaped, reseeded, and mulched at the Contractor's expense.

(c) **Installing Soil Retention Coverings:** Coverings shall be installed in accordance with the standard drawings and manufacturer's recommendations.

(d) **Watering:** After coverings are installed, seeded areas shall be watered sufficiently to saturate the seed bed. Water shall be applied in a spray, and no additional watering will be required.

606.04—Measurement and Payment.

Protective coverings and soil stabilization mats will be measured in square meters of area covered, complete-in-place, in accordance with the nominal plan dimensions, and will be paid for at the contract unit price per square meter. Overlaps, overwidths, and cut slots will not be measured for separate payment. This price shall include furnishing, installing, and stapling soil retention coverings; smoothing and shaping ditch channels and waterways; preparing seed beds; and furnishing and applying topsoil, lime, seed, fertilizer, and water.

Payment will be made under:

Pay Item	Pay Unit
Protective covering (Standard)	Square meter
Soil stabilization mat (Standard and type)	Square meter

SECTION 607—HERBICIDE SPRAYING

607.01—Description.

This work shall consist of applying an approved herbicide for the control of weeds in turfed areas as indicated on the plans or as designated by the Engineer.

607.02—Materials.

Herbicide shall conform to the requirements of Section 244.02(a).

607.03—Procedures.

Herbicide shall be applied in accordance with the manufacturer's recommendations. Herbicide shall not be applied when the ambient temperature is above 30 °C or below 15 °C. The spray pressure shall be at least 140 kilopascals but not more than 200 kilopascals. Spraying shall not be performed when the vegetation is wet, when it appears that rain is imminent within 6 hours, or when the wind is blowing enough to scatter paper or trash.

607.04—Measurement and Payment.

Herbicide spraying will be measured in units of 3,785 liters of mixture and will be paid for at the contract unit price per 3,785 liters. This price shall include furnishing and applying herbicide.

Payment will be made under:

Pay Item	Pay Unit
Herbicide spraying	Unit (3,785 liters)

SECTION 608—MOWING

608.01—Description.

This work shall consist of mowing designated areas to a height of not less than 100 millimeters when and as directed by the Engineer until final acceptance.

608.02—Equipment.

Equipment used for mowing operations shall be mechanical with a cutting width of at least 1.5 meters.

608.03—Measurement and Payment.

Mowing, when a pay item, will be measured in hours of operation and will be paid for at the contract unit price per hour. This price shall include equipment, operators, fuel, and lubricants.

Payment will be made under:

Pay Item	Pay Unit
Mowing	Hour

SECTION 609—TREE WELLS AND TREE WALLS

609.01—Description.

This work shall consist of constructing wells and walls to protect the root system of trees, shrubs, or other woody plants at the locations shown on the plans or as designated by the Engineer.

609.02—Procedures.

Excavation incidental to and necessary for constructing tree wells and tree walls shall be conducted in a manner that will not damage the root system. Ends and damaged sections of roots shall be cleanly cut. Roots with a diameter of more than 75 millimeters shall not be cut.

Before any earth fill that will exceed 300 millimeters in thickness is spread over the feeding root system of trees or shrubs to be protected by tree wells, an aeration layer of coarse gravel or stone ranging from 12 to 125 millimeters in size shall be spread over the entire area for a depth of at least 150 millimeters or at the rate of 75 millimeters for every 300 millimeters of earth fill where such fills will be more than 600 millimeters in depth. The layer of aggregate shall be covered with sufficient fine screenings to choke the top of the porous fill. Aggregate shall not be placed inside the tree well.

609.03—Measurement and Payment.

Tree wells and tree walls will be measured in cubic meters of masonry, complete-in-place, and will be paid for at the contract unit price per cubic meter of masonry. This price shall include excavation, drain pipe, and backfill, including aggregate.

Payment will be made under:

Pay Item	Pay Unit
Tree well (Standard)	Cubic meter
Tree wall (Standard)	Cubic meter

SECTION 610—GABIONS

610.01—Description.

This work shall consist of furnishing and installing gabions in accordance with the requirements of these specifications and in reasonably close conformity to the lines, dimensions, and grades shown on the plans or as established by the Engineer.

610.02—Materials.

(a) **Gabions** shall have a uniform horizontal width of at least 900 millimeters. Their dimensions shall be within ±3 percent of the manufacturer's stated sizes.

(b) **Wire mesh** shall conform to the requirements of Section 223.

(c) **Selvedge (or perimeter) wire** shall be at least 3.77 millimeters in diameter and shall conform to the requirements of Section 223 for wire mesh.

(d) **Tie and connection wire** shall conform to the requirements for the wire used in the mesh except that it shall not be less than 3.06 millimeters.

(e) **Gabion stone** shall conform to the requirements of Section 204.

610.03—Procedures.

Gabions shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets. Gabions shall be of single-unit construction whereby the base, lid, ends, and sides are woven into a single unit or whereby one edge of these units is connected to the base section of the gabion. The strength and flexibility at the point of connection shall be at least equal to those of the mesh.

If the length of the gabion exceeds its horizontal width, the gabion shall be equally divided into cells by diaphragms of the same mesh and gage as the body of the gabion. The length of each cell shall not exceed its width. The gabion shall be furnished with the necessary diaphragms secured in the proper position on the base so that no additional tying at the junction will be necessary.

Perimeter edges of the mesh forming the gabion shall be securely clip bound or selvedged in such a manner that the joints formed by tying the selvedges will have at least the same strength as the body of the mesh.

Tie and connection wire shall be supplied in sufficient quantity to fasten securely all edges of the gabion and diaphragms. At least two cross-connecting wires shall be in each cell whose height is 1/3 or 1/2 the width of the gabion. At least four cross-connecting wires shall be in each cell whose height equals the width of the gabion. The wire shall be secured through two open loops of the cage.

Excavating and backfilling for gabions shall be performed in accordance with the requirements of Section 303. Gabions shall be placed on a smooth foundation, and the final line and grade shall be approved by the Engineer.

Each gabion unit shall be assembled by binding the vertical edges with wire ties at approximately 150-millimeter intervals or by stitching a continuous piece of connecting wire around the vertical edges with a coil approximately every 100 millimeters. Wire ties or connecting wire shall be used to join units in the same manner as described for assembling. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure.

A standard fence stretcher, chain fall, or iron rod may be used to stretch wire baskets and hold the alignment.

Gabions shall be filled with stone in a manner that will ensure alignment, ensure a minimum of voids, and avoid bulges. Rock and connection wires shall be alternately placed until the gabion is filled. After the gabion is filled, the lid shall be bent over until it meets the sides and edges of the gabion. The lid shall be secured to the sides, ends, and diaphragms with wire ties or connecting wire in the manner described for assembling.

610.04—Measurement and Payment.

Gabions will be measured in cubic meters, complete-in-place, and will be paid for at the contract unit price per cubic meter. This price shall include furnishing and installing gabions; excavating; backfilling with suitable material; compacting; and disposing of surplus or unsuitable material.

Minor structure excavation for gabions, when specified on the plans, will be measured and paid for in accordance with the requirements of Section 303.

Payment will be made under:

Pay Item	Pay Unit
Gabion	Cubic meter

Division VII

TRAFFIC CONTROL DEVICES

SECTION 700—GENERAL

700.01—Description.

These specifications cover general construction items, methods, and procedures common to traffic control devices.

700.02—Materials.

(a) **Concrete** shall be Class 20 conforming to the requirements of Section 217.

(b) **Reinforcing steel** shall conform to the requirements of Section 223.

(c) **Paint** shall conform to the requirements of Section 231 and shall be applied in accordance with the requirements of Section 411 except on nonferrous materials where it shall be applied in accordance with the requirements of the manufacturer's recommendations.

(d) **Galvanizing** shall conform to the requirements of Section 233.

(e) **Electrical items** shall conform to the requirements of Section 238.

(f) **Wood for posts and poles** shall conform to the requirements of Section 236 and shall be treated in accordance with the requirements of Section 236. Wood items shall be cut prior to treatment.

(g) **Steel** for fabricated items shall conform to the requirements of Section 226 and shall be fabricated, welded, and inspected in accordance with the requirements of Section 407.

(h) **Aluminum** for fabricated items shall conform to the requirements of Section 229 and shall be fabricated, welded, and inspected in accordance with the requirements of Section 407.

(i) **Poles, posts, and overhead and bridge-mounted sign structures** shall conform to the following: When painting is not required, steel poles and posts shall be hot-dip galvanized after fabrication. When painting is required, steel poles and posts shall be given one shop coat of primer and two field coats of paint.

Overhead and bridge-mounted sign structures shall be hot-dip galvanized after fabrication. When painting is required, the galvanization finish of overhead and bridge-mounted sign structures shall be field treated for paint retention and two coats of paint applied.

Mast arms and lighting, signal, and pedestal poles shall be of a one-piece or sectional single unit, tubular form, and shall be round or multisided. Multisided poles shall have at least eight sides. Pole shafts and arms shall have a removable cap fastened by at least three screws.

Mast arms shall not deflect below the horizontal plane or exceed a rise of 3 percent of the arm length after loads are applied. Mast arm poles shall include an arm attachment flange plate continuously welded to the gusset and side plates. The gusset and side plates shall be continuously welded to the pole and each other. The flange shall be fabricated with four studs permanently attached for receiving nuts (attaching arm). The flange plate and pole shall have a 100-millimeter wiring hole with a grommet centered in the pattern.

Strain poles shall not exceed a dead load deflection of 3 percent of the distance between the base of pole and point of dead load attachment. The minimum bottom diameter of strain poles shall be 280 millimeters.

Lighting, signal, and pedestal poles; sign posts; and overhead and bridge-mounted sign structures shall conform to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.* To prevent serious aerodynamic vibrations in cantilevered sign structures with variable/changeable message sign(s) attached, Section 1.9.6 of this AASHTO specification is modified to require the critical wind speed at resonance (V_c) to be greater than the design wind speed.

1. **Conventional and offset lighting poles** shall be steel or aluminum.

2. **Overhead and bridge-mounted sign structures, signal poles, and high-mast lighting poles** shall be steel.

3. **Pedestal poles** with a nominal diameter of more than 50 millimeters shall be steel or aluminum. Pedestal poles 50 millimeters and less in nominal diameter shall conform to the requirements of Section 238 for metal conduit.

4. **Sign posts** shall be wood or steel.

(j) **Anchor bolts** shall be steel conforming to the requirements of Section 226.02(d)2. Except when stainless steel is used, the portion of anchor bolts beginning 100 millimeters below the top of the foundation and extending above the foundation shall be galvanized.

(k) **Breakaway support systems** shall conform to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.*

1. **Breakaway couplers and skirt covers** shall be aluminum. Threaded studs, nuts, and washers shall be stainless steel or galvanized steel.

2. **Frangible bases** shall be aluminum.

3. **Slip bases** shall be galvanized steel or other approved noncorrosive metal.

(l) **Miscellaneous hardware** shall be brass, bronze, stainless steel, or galvanized steel.

700.03—Working Drawings.

The Contractor shall submit to the Department working drawings, including design calculations and catalog cuts, in accordance with the requirements of Section 105 except that seven copies of each shall be submitted. In lieu of working drawings and catalog cuts, the Contractor may submit a letter indicating the brands, types, and models of equipment along with the approval numbers and contract item numbers. The Contractor shall include the words "Testing Required" with the approval numbers when materials testing is required for the equipment. The approval numbers shall be taken from the Department's preapproved traffic control device list. Any equipment on the list for which approval has been rescinded will not be allowed for use if the rescinded date is earlier than the receipt of bids for the project. Inclusion of equipment on this list does not ensure acceptance if contract requirements prohibit use of the equipment. The Contractor shall ensure that the equipment as furnished conforms to the requirements of the Department.

700.04—Procedures.

(a) **Ground Rods:** Ground rods shall be installed in accordance with the requirements of NEC or by other methods approved by the Engineer. Ground rods shall include a No. 6 bare copper conductor and ground rod clamps. Ground rods shall not have a resistance to ground of more than 25 ohms.

(b) **Excavation for Foundations:** Excavation shall be performed in accordance with the requirements of Section 401.

(c) **Concrete Foundations:** Foundations shall be constructed and cured in accordance with the requirements of Section 404 and shall rest on

material that will adequately support the design load. Exposed areas of concrete foundations shall be given a Class 7 finish in accordance with the requirements of Section 404. Items shall not be erected on concrete foundations until concrete has cured for at least 28 days or has obtained a compressive strength of at least 20 megapascals.

Foundations for overhead sign structures shall be spread footings, unless inadequate soil conditions require timber piles. Drilled foundations may be permitted except for single pole structures (overhead span structures with signal poles at ends, cantilever or butterfly).

Foundation designs for signal poles and overhead sign structures shall be furnished by the Contractor. Foundations shall be designed to conform to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.*

(d) **Electrical Service:** Electrical service shall be installed in accordance with the requirements of NEC and the local power company. Meter bases and current transformer cabinets will be furnished by the local power company. The Contractor shall make arrangements with the local power company for pickup of this equipment. The Department will request and pay for electrical service and temporary electrical service for items temporarily relocated or adjusted for the purpose of traffic control shown on the plans or directed by the Engineer. If the Contractor desires temporary service for his convenience, he shall arrange and pay for the service.

(e) **Poles, Posts, and Sign Structures:** The location of each pole, post, and sign structure shall be established by the Contractor with a stake bearing the number or identification designated on the plans. The Engineer, accompanied by the Contractor, will inspect the locations and advise the Contractor of any necessary adjustments. Poles, posts, and sign structures shall be made plumb after installation of loads by the use of nuts and flat washers above and below the base plate on each anchor bolt or by other approved methods.

If a pole, overhead sign structure, or span wire is to be located within 3 meters of an electric power line as measured in any direction, the Contractor shall immediately inform the Engineer. The Contractor shall not install the equipment until the Engineer has reviewed and advised the Contractor of any relocation or to proceed with the work.

A noncorrosive metal identification tag shall be permanently attached to each signal, pedestal and lighting pole, overhead sign structure, and I-beam steel sign post, except U-channel sign posts, approximately 1 meter above the foundation.

The tag shall be 50 by 100 millimeters and shall be attached by noncorrosive screws or rivets.

The tag shall be imprinted with "VDOT" except when the structures are located within an incorporated town or city on a primary or secondary roadway, where it shall be imprinted with the municipality's name. The tag shall also be imprinted with the following:

1. **signal poles:** gage and length of pole and mast arm(s)

2. **pedestal poles:** gage and length of pole

3. **lighting poles:** gage and length of pole and luminaire arm(s); electrical phase circuit designation except on high mast

4. **overhead sign structures:** gage and length of pole and span

5. **steel sign posts:** length, size, and mass per meter of post

When transformer bases are used, bolt covers shall be installed on pole anchor bolts. Bolt covers shall be designed to allow ventilation of the nut and anchor bolt.

Poles shall be provided with hand holes that face away from traffic. Hand holes shall be at least 75 by 125 millimeters and provided with a gasket and cover. The cover shall be attached to the pole with noncorrosive cap screws, and attachment holes shall be drilled and tapped.

When required by the plans, the Contractor shall supply a terminal strip consisting of 24 double-pole terminals. The terminal strip shall be constructed of noncorrosive materials and shall be located on the outside of the pole just above the hand hole. A continuously welded frame and a removable, weatherproof, gasketed cover designed to enclose both the hand hole and terminal strip shall be provided.

(f) **Breakaway Support Systems:** Breakaway support systems shall be installed on lighting poles when required by the plans and on pedestal poles except when used for power service. Breakaway support systems shall be installed in accordance with the requirements of the manufacturer's recommendations.

(g) **Conductor Cables:** Conductor cables in conduit runs more than 30 meters in length shall be installed with the use of an approved lubricant or pulling compound. Cleaning agents and lubricants that have a deleterious effect on cable coverings shall not be used.

Aerial cables that extend more than 6 meters shall be supported by a span wire or reinforced with a copper-clad, galvanized, or stainless steel wire for self-support. Cable rings shall be used to attach conductor cables to the supporting wire; however, lash wire may be used to attach interconnect cable when no other conductor cables are attached to the same span wire. Vinyl tape shall be used as shown on the plans to prevent sag. When aerial cables enter a service entrance head, a 200-millimeter drip loop shall be formed.

Bends in single or multiple conductor cables shall have a bend radius of at least 5 times the outside diameter of the cable.

Conductor cables shall be installed with the slack length coiled in junction boxes. The coiled length shall be sufficient to allow cables to extend at least 600 millimeters above junction boxes.

Solderless terminals shall not be used for connecting conductor cables having solid conductors to terminal posts.

Splices in lighting conductor cables will be permitted only at accessible locations. Splices in service entrance conductor cable will be permitted only for connection to the utility company's service conductor cables. Splices shall be made in accordance with the requirements of NEC. Splices will not be permitted in signal and interconnect conductor cables.

Breakaway connectors shall be installed on luminaire conductors and on signal conductors for signal head assemblies on pedestal poles. Breakaway connectors shall be fused for the hot conductors and nonfused for the grounded conductor. Breakaway connectors shall be located in the hand hole of the pole.

Signal and interconnect cable terminal strips shall be sealed with a moisture block compound to prevent moisture from entering the open cable end. The compound shall be soft, pliable, and easily removable and shall be used in accordance with the requirements of the manufacturer's recommendations.

Termination of interconnect cable will be allowed only in a master controller cabinet, local controller cabinet, or terminal enclosure. The cable shield shall be grounded at each termination point. Whenever the cable is entered for connection to equipment, each wire of the cable shall be connected to a terminal post position.

The Contractor shall conduct a Megger test on the installed interconnect cable and shield, for which a reading of 100M ohms shall be required. Testing for 300-volt cable shall be performed at 200 volts, and testing for 600-volt cable shall be performed at 500

volts. Cables shall be disconnected from controller cabinet terminals during testing.

Service entrance and lighting conductor cables shall be marked in accordance with the requirements of Article 310-11 of NEC. Markings shall be continuous and permanent. Signal and interconnect conductor cables shall be marked in accordance with the requirements of the applicable IMSA specification.

Prior to energizing an electrical system, the Contractor shall demonstrate to the Engineer that the system is clear and free from short circuits, open circuits, and unintentional grounds. Faulty circuits shall be repaired or replaced by the Contractor at his expense.

1. **Lighting conductor cables** shall be identified at accessible locations by integral-impregnated color coding, durable color-coded plastic tape, or other approved means. Color coding shall be as follows:

Circuit Designation	**Color Code**
Phase A or Line A	Black or unmarked
Phase B or Line B	Red or orange[1]
Phase C	Blue
Neutral	White or gray
Grounding	Green or bare

[1] For 3-phase, 4-wire delta systems, Phase B shall be the high leg and shall be orange.

2. **Signal and interconnect cable** shall be identified by integral-impregnated color coding. Color-coding for signal cable shall be as follows:

Cable Jacket Color	**14/12 Cable**	**14/7 Cable**	**14/4 Cable**	**14/3 Cable**
Red	Red	Red	Red	Don't Walk
Orange	Amber	Amber	——	———
Green	Green	Green	Green	———
Red w/ black tracer	Red	———	———	———
Orange w/ black tracer	Amber	———	———	———
Green w/ black tracer	Green	———	———	———

Blue	Green	Green	———	———
White w/ black tracer	Amber	Amber	———	———
Black	Red	Red	Amber	Walk
Black w/ white tracer	Spare	———	———	———
Blue w/ black tracer	Spare	———	———	———
White	AC ground	AC ground	AC ground	AC ground

Signal and interconnect conductor cable jackets shall be permanently identified in the controller cabinet and junction boxes. Signal conductor cable jackets shall also be identified in the hand hole of poles if the cables are attached to terminal strips in the hand hole. Identifications shall be indicated on nonferrous metal tags or nylon tags attached to the cable with nylon cable ties. The identification shall be stamped or engraved on the metal tags and lettered with permanent ink on the nylon tags. Identifications shall be legible and shall conform to the following:

a. **signal cable:** phase and location of signal head; e.g., 1 NB left-turn head; 1 NB inside left-turn head; 2 SB through-lane heads; 1 left-turn head and 6 through-lane heads; 2 Ped head NW Quad

b. **interconnect cable:** description and direction from location (if cable is a spare). The word "spare" shall be included after "inter." The direction from location is required only in the controller cabinet, e.g., Inter. NB; Inter. Spare NB; Inter. WB; Inter.

(h) **Conduit Systems:** PVC, fiberglass, and metal conduit runs shall have the minimum number of couplings permitted by the use of standard conduit lengths. Ends of conduit sections that must be field cut shall be reamed smooth. PE conduit shall be installed in continuous unspliced runs between enclosures. Field-threaded portions of metal conduit shall be galvanized. Except for expansion couplings, conduit sections shall be connected with couplings so that ends will abut squarely inside couplings.

Joint sealing solvent shall be used as recommended by the conduit manufacturer. Where necessary, ends of each length of nonmetallic conduit shall be tapered by machining to provide joints that are tight after assembly.

Conduits shall be continuous and watertight between outlets. Deformed conduit shall not be used. Conduits shall be free from

kinks or defects that would cause damage to conductor cables when pulled. Conduits shall be installed so that moisture will drain properly to electrical junction boxes or drainage tees with drip spouts.

After installation, each conduit shall be tested in the presence of the Engineer for obstructions. A suitable rigid or flexible mandrel having a diameter at least 80 percent of the inside diameter of the conduit shall be pulled through each conduit run. Obstructions shall be removed, and the conduit repaired at the Contractor's expense.

After testing, individual conduit runs more than 45 meters in length that are to remain empty shall be equipped with a nylon or polypropylene pull rope having a tensile strength of at least 4,500 newtons. Three hundred millimeters of rope shall be doubled back into the conduit at each end.

Open ends of unused conduit shall be closed with watertight plugs, caps, or other seal fittings to seal them against moisture.

Wherever conduit crosses a structural expansion joint, conduit shall be provided with an expansion fitting. The fitting shall permit longitudinal movement of the amount specified on the plans.

Metal conduit systems shall be bonded. When a nonmetallic conduit system is used, the Contractor shall furnish and install a grounding conductor wire to maintain a bonded system in accordance with the requirements of NEC.

1. **Exposed conduit systems** shall be fabricated of heavy-wall PVC, fiberglass, or metal, with not more than four bends between any two outlets. The angular sum shall be not more than 360 degrees. When heavy-wall PVC or fiberglass conduit is accessible to public contact, it shall be covered with a protective shield, conforming to the requirements of Section 238, for a distance of at least 2.5 meters above the adjacent finished grade. Splice boxes or pull boxes shall be of a size that will allow proper termination of conduit and connection of conductor cables as required by NEC. Conduit shall be terminated by means of approved fittings or bushings.

2. **Buried conduit systems** shall be installed in straight lines between outlets. When obstructions are encountered during installation and conduit cannot be economically located elsewhere, the obstruction shall be bypassed by offsetting the conduit line in accordance with the requirements of the standard drawings. Required conduit bends shall be installed with a bend radius of at least 1.5 meters. Conduit bends in structures and foundations shall be installed in accordance with the requirements

of NEC. The use of a pipe tee or vice for bending conduit will not be permitted.

When conduit is to be installed under an existing roadway and open cutting is not permitted, conduit shall be installed in a pipe sleeve that has been jacked or bored in accordance with the requirements of Section 302.

Open cut areas shall be backfilled in accordance with the requirements of Section 302.

(i) **Junction Box Covers:** If a special tool or wrench is needed to remove a cover, the Contractor shall furnish the Engineer five such tools.

(j) **Hydraulic Cement Concrete Sidewalk:** When disturbed by the installation of equipment, sidewalk shall be replaced in accordance with the requirements of Section 504 along existing joint lines.

700.05—Measurement and Payment.

Concrete foundations will be measured in units of each and will be paid for at the contract unit price per each. This price shall include foundation designs, concrete, reinforcing steel, anchor bolts, bolt circle templates, stub poles, grounding equipment, conduits, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

Electrical service will be measured in units of each and will be paid for at the contract unit price per each. This price shall include service poles, safety switches or breaker boxes, service entrance conductor cables from the utility company's service box conductors to the safety switch and circuit breaker box, conduit and fittings on poles and steel supports, conduit straps or clamps, meter bases, grounding equipment, service entrance heads, thimbleye bolts, steel supports, wireway, excavating, concrete, and pickup and installation of meter base and current transformer cabinet.

Luminaire arms will be measured in units of each and will be paid for at the contract unit price per each. This price shall include slipfitters, fittings, and mounting hardware.

Lighting poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pole shafts, luminaire arms, grounding lugs, hand holes and covers, caps, identification tags, anchor bases, bolt covers, bracket arms, and breakaway support systems.

Signal poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pole shafts, mast arms,

grounding lugs, hand holes and covers, caps, fittings, anchor bases, bolt covers, and identification tags.

Overhead and bridge-mounted sign structures will be measured in units of each and will be paid for at the contract unit price per each. This price shall include structural units and supports, foundation designs, hand holes and covers, grounding equipment, conduit, fittings, concrete foundations, reinforcing steel, walkways and handrails, electrical systems, identification tags, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

Sign posts will be measured in meters and will be paid for at the contract unit price per meter. This price shall include clamps, identification tags, and breakaway base assemblies.

Pedestal poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include caps, breakaway support systems, hand holes and covers, grounding lugs, identification tags, and anchor bases and bolt covers.

Wood poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include thimbleye bolts, guy wires with guards and anchors, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

Conductor cables will be measured in meters and will be paid for at the contract unit price per meter. This price shall include conductors, breakaway connectors, markings and identifications, splice kits, electrical tape, testing, and connections.

Conduit will be measured in meters and will be paid for at the contract unit price per meter. This price shall include conduit bodies, fittings, bonding systems, pull ropes, plastic spacers, pull or splice boxes with an area of 8 cubic decimeters or less, supports, and protective metal shields.

Trench excavation will be measured in meters and will be paid for at the contract unit price per meter. This price shall include trenching, encasing, backfilling, locator tape, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

Junction boxes will be measured in units of each and will be paid for at the contract unit price per each. This price shall include concrete collars, frames and covers, tools to remove the cover, ground rods, ground conductors, grounding lugs, knockouts, cable racks, aggregate, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

These prices shall include providing the required finish.

Payment will be made under:

Pay Item	Pay Unit
Concrete foundation (Standard, type, and size)	Each
Electrical service (Standard and type)	Each
Luminaire arm (Length)	Each
Lighting pole (Standard, luminaire mounting height, and length of uminaire arm)	Each
Signal pole (Standard, length, number, and length of arms)	Each
Overhead sign structure (Location)	Each
Bridge-mounted sign structure (Location)	Each
Sign post (Type and size)	Meter
Pedestal pole (Standard and length)	Each
Wood pole (Class and length)	Each
Conductor cable (Size/number)	Meter
Conduit (Type and size)	Meter
Trench excavation (Standard)	Meter
Junction box (Standard)	Each

SECTION 701—TRAFFIC SIGNS

701.01—Description.

This work shall consist of furnishing, fabricating, and erecting signs as specified on the plans.

701.02—Materials.

Reflective sheeting shall conform to the requirements of Section 247.

701.03—Procedures.

(a) **Fabrication:**

1. **Aluminum welds:** Aluminum shall be welded in accordance with the requirements of Section 407.

2. **Sign panels:** Panels shall be fabricated of aluminum 2.54 millimeters in thickness and shall be smooth, flat, and free of metal burrs and splinters.

3. **Applying reflective background sheeting:** Sheeting shall be applied in accordance with the requirements of the manufacturer's recommendations.

   A single piece of applied sheeting shall be at least 1.2 meters by 1.2 meters on sign panels 1.5 square meters or more in area, except for sign panels fabricated with fluorescent prismatic lens orange sheeting. Sign panels 1.5 square meters or more in area and fabricated with fluorescent prismatic lens orange sheeting shall consist of sheeting at least 1.2 by 0.6 meters, except that one piece of sheeting may be less than 0.2 meter wide to obtain the exact dimension required. Joints, splices, or laps will not be permitted on sign panels less than 1.5 square meters in area except for the following:

   — One factory splice from the roll will be permitted.

   — One joint will be permitted on fluorescent prismatic lens orange signs when one dimension of the panel is greater than 0.9 meter and less than 1.2 meters.

   When more than one width of sheeting, except fluorescent prismatic lens orange, is applied to a sign panel, sheeting edges shall form a vertical butt joint or may overlap not more than 10 millimeters. Where horizontal joints are used, except for fluorescent prismatic lens orange sheeting, the bottom edge of the top sheeting shall lie over the top edge of the next lower sheeting in a shingle lap of not more than 10 millimeters. Multiple pieces of fluorescent prismatic lens sheeting shall be installed with a 1-millimeter to 2-millimeter gap between the edges. Sheeting shall be carefully matched to maintain a uniform shading and prevent contrast between widths of sheeting.

   The finished sign shall be free from cracks, gaps, streaks, wrinkles, blisters, discoloration, buckles, and warps and shall have a smooth surface of uniform color.

4. **Letters, numerals, arrows, symbols, borders, and other features of the sign message:** Features of the sign message shall conform to the requirements of the *MUTCD.* Units of the sign message shall be formed to provide a continuous stroke width with smooth edges; present a flat surface free from warps, blisters, wrinkles, burrs, and splinters; and conform to the following:

a. **Type L1, screen process, applied:** Features shall be produced by a direct or reverse screening process approved by the Engineer. Sign messages and borders that are darker than the sign field shall be applied to the reflective sheeting by a direct process. Sign messages and borders that are lighter than the sign field shall be produced by the reverse process in which the message and border are outlined by a color that is darker than the paint or the sheeting on the sign field. Transparent colors, inks, and paints used in the screening process shall be of the type and quality recommended by the sheeting manufacturer.

Screening shall produce a uniform color and tone. Edges of the legend and borders shall not have blemishes.

Signs shall be air dried or baked in accordance with the requirements of the manufacturer's recommendations to provide a smooth, hard finish.

b. **Type L2, plastic film sheeting, applied:** Features of the sign message shall be cut from plastic film sheeting of the color specified on the plans. Sheeting shall be an elastomeric pigmented film suitably compounded and processed, coated on one side with an adhesive, and covered with a paper liner that shall be removable from the adhesive without being moistened. Adhesive shall be activated by heat or a solvent recommended by the sheeting manufacturer and shall be suitable for use with a hand roller, squeeze roller, or vacuum applicator that will form a durable bond to wood, metal, plastic, porcelain enamel, paint lacquer, and reflective sheeting. Sheeting shall be at least 0.051 millimeter and not more than 0.089 millimeter in thickness and sufficiently opaque so that its color will be unaffected by the color of the sign field.

c. **Type L3, cutout, reflective sheeting, pressure applied:** Features of the sign message shall be cut from approved reflective sheeting of the color specified on the plans. Sheeting shall have heat-activated or pressure-sensitive adhesive and be applied to the background sheeting in accordance with the requirements of the manufacturer's recommendations.

5. **Joining sign base panels:** Horizontal joints will not be permitted. Where multiple vertical panels adjoin, the face and edges shall be milled or finished to a tolerance of ±1 millimeter from a straight plane such that no gap more than 2 millimeters is allowed between panels.

6. **Applying the sign message:** Features shall be straight, properly spaced, smooth, and free from irregular edges.

7. **Sign finishing:** The complete outer edge, splices, messages, and borders of signs shall be sealed after application to the sign panel. Sealant material and its application shall be in accordance with the requirements of the sheeting manufacturer's recommendations.

8. **Rejected sign messages:** Sign messages rejected by the Engineer shall be immediately obliterated by the Contractor.

(b) **Transporting and Storing Signs From the Fabricator:** Signs shall be transported in accordance with the requirements of either of the following methods:

1. Signs shall be transported in cardboard cartons with a slipsheet covering the sheeting. The slipsheet shall be paper with a plastic coating on one side with the plastic placed toward the sign sheeting in accordance with the requirements of the sheeting manufacturer's recommendations. Not more than 10 signs may be placed in one carton. Signs shall alternate face to face, back to back, throughout the carton. A microfoam pad at least 2 millimeters in thickness shall be placed between signs placed face to face. Cartons shall be placed vertically within a container designed to elevate boxes above ground level and provide lateral structural support. Cartons shall not be exposed to moisture during transportation.

2. Signs shall be transported on an open truck or trailer bed with vertical racks for attachment of signs. Racks shall be designed to provide lateral structural support and allow the free flow of air around the sign face. Large signs may be transported on an open truck or trailer bed in shipping containers consisting of framing around edges of signs. Framing shall be nontreated lumber that will provide support for the sign without allowing pressure on the sign sheeting. Each container may house two signs positioned with the sign sheeting facing toward the inside. Signs shall be held in place in containers through the use of metal stiffeners attached to the framing, T-bars and Z-bars, and horizontal stiffeners. Shipping containers shall be secured in the vertical position for transportation.

Signs transported in cardboard cartons shall be stored in original shipping containers in a dry, enclosed location providing protection from extreme heat and humidity. Signs transported on racks or in wooden containers shall be stored on vertical racks designed to elevate signs above ground level, provide lateral structural support, and allow

the free flow of air around the sign face. Signs shall not be stored where they are subjected to water runoff.

Signs may be removed from storage and installed on their structural supports before the structure is erected. The structure along with the sign shall be erected within 24 hours after removal of the sign from storage. During this time period, the sign and its structural support shall be stored at a sufficient angle to facilitate water runoff from the sign while preventing the sign from coming in contact with the ground.

Signs shall not be banded together, covered with tarps, stored flat, or subjected to pressure on the sign sheeting.

Signs transported or stored in cardboard cartons that have been exposed to moisture to the extent that moisture has entered the cartons will be rejected. The Contractor shall immediately obliterate the sign message and remove rejected signs from the project.

(c) **Transporting and Storing Relocated Signs:** Relocated signs shall be transported and stored in a manner that will not allow pressure to be placed on the sign sheeting. Relocated signs shall be stored in their vertical position above ground level. Relocated signs that have been removed from their structure shall be stored in accordance with the requirements of (b) herein.

(d) **Erection:** Vertical clearance for overhead and bridge mounted sign structures shall be no less than 5.8 meters and no more than 6.4 meters from the bottom of the lowest mounted sign panel to the crown of the roadway, unless otherwise specified on the plans. Walkway or luminaire assemblies shall have a vertical clearance of no less than 5.3 meters from the bottom of the assembly to the crown of the roadway. Sign panels shall be installed during a sequence of construction as required to provide necessary traffic control. When possible, sign panels shall be installed at a time when covering of the sign message will not be needed. When this is not possible, a porous cloth cover rendering the sign message nonvisible shall be placed over the sign sheeting, folded over the sign edges, and secured to the back of the sign panel. Sign panels shall be securely fastened to posts or supports and erected plumb. Stud breakage of 10 percent or less of the total number of studs may be repaired with rivets. If breakage exceeds 10 percent, the sign panel will be rejected.

Ground-mounted signs shall be horizontally angled at 93 degrees between the face of the sign and the center line of the roadway.

Vertical and horizontal spacing between signs shall be 25 millimeters.

A neoprene gasket 2 millimeters in thickness shall be used between the seat of the galvanized steel post clamps and the framing unit.

Illumination of signs shall be in accordance with the requirements of Section 705.

Damage to reflective sheeting may be repaired and edge sealed in accordance with the requirements of the manufacturer's recommendations and the following: Sign patch material shall be of the same type and color as the surrounding sheeting and shall have at least the same life expectancy. Patching will not be permitted on any letter, numeral, arrow, symbol, or border. Where the number, size, or spacing of patches is more than the following, the sign will be rejected and shall be replaced at the Contractor's expense:

Sign Face Area (m^2)	Max. No. of Patches	Max. Size of Patches (mm^2)	Min. Spacing Between Patches (mm)
2.49 or smaller	No patching allowed		
2.5 to 4.99	1	650	0
5.0 to 9.99	2	650	150
10 to 19.99	3	1,300	150
20 or larger	4	2.000	300

Superficial damage to sign panels may be repaired using proper methods to obtain a smooth and flat panel. Sign panels that have more than superficial damage will be rejected and shall be replaced at the Contractor's expense.

701.04—Measurement and Payment.

Sign panels will be measured in square meters and will be paid for at the contract unit price per square meter. This price shall include background sheeting, sign messages, and framing units.

Payment will be made under:

Pay Item	Pay Unit
Sign panel	Square meter

SECTION 702—DELINEATORS

702.01—Description.

This work shall consist of furnishing and installing road edge, barrier, or guardrail delineators of the type specified in accordance with these specifications and in reasonably close conformity with the lines and dimensions shown on the plans or as established by the Engineer.

702.02—Materials.

(a) **Fabrication** of aluminum panels with reflective sheeting shall conform to Section 701.

(b) **Reflective sheeting** shall conform to Section 247 and shall be the same color as the adjacent pavement marking.

(c) **Plastic lens retroreflectors** shall conform to Section 235 and shall be the same color as the adjacent pavement marking.

(d) **Plastic panels** shall conform to Section 235.

(e) **Aluminum panels** shall conform to Section 235.

(f) **Adhesive** for attaching delineators to guardrail and barrier shall be as recommended by the manufacturer.

702.03—General Requirements.

(a) **Road edge delineators:**

1. **Interstate road edge delineators** shall consist of two types.

   Type I shall be an aluminum panel with reflective sheeting.

   Type II shall be plastic lens retroreflector.

2. **Standard and special road edge delineators** shall be an aluminum panel with reflective sheeting.

(b) **Barrier and guardrail delineators** shall have no less than 45 square centimeters of retroreflective sheeting and shall have no more than 125 millimeters of vertical projection when installed. The delineator shall be fabricated from a flexible plastic panel.

702.04—Procedures.

(a) **Road edge delineators** shall be placed as shown on the Standard Drawings.

(b) **Barrier and guardrail delineators** shall be applied to clean dry surfaces in accordance with manufacturer's recommendations. Loose material and dirt shall be removed from concrete by wire brushing and from steel by appropriate methods. When recommended by the manufacturer, a primer shall be utilized.

Delineators shall be installed on barriers and guardrails that are within 4.5 meters of the edge of pavement.

Barrier delineators shall be installed with an adhesive on the top surface of the barrier wall, except barriers with glare screens or handrail attached and barriers located in construction work zones shall have the delineators installed with adhesive to the sides of the barrier at a height of approximately 625 millimeters above the roadway. Delineators installed on the sides of barrier shall be installed so the reflective surface lies in a vertical plane facing oncoming traffic.

Guardrail delineators shall be installed on the web of the guardrail posts. Where guardrail blockouts are installed, delineators shall be installed on the web of the blockouts. Where weak post guardrail and cable guardrail systems are installed, delineators shall be manufactured to fit on the web of the guardrail posts; no field cutting or adjustments will be allowed. If a bolting system is utilized to attach the delineators to the posts, the bolting system shall be such that no drilling of the guardrail posts or blockouts is necessary. Where wooden support posts or blockouts are utilized, delineators shall be attached with screws or by an adhesive system as recommended by the manufacturer. Screws shall be stainless steel or galvanized.

Spacing for delineators on barrier or guardrail shall be on 24-meter centers unless otherwise indicated. Delineators mounted on guardrail and barriers located in curves on interchange ramps shall be spaced in accordance with the spacing for interstate road edge delineators as shown on the Standard Drawings except the maximum spacing shall be 24 meters.

Where the center to center spacing for delineators on guardrail cannot be obtained due to post spacing, the delineators shall be installed to provide spacing that is not greater than the spacing indicated above.

702.05—Measurement and Payment.

Road edge delineators will be measured in units of each and will be paid for at the contract unit price. This price shall include sign post, fasteners, retroreflective elements, and excavation and backfill.

Barrier and guardrail delineators are considered incidental to barrier and guardrail construction and will not be measured for separate payment unless specified in the Contract. When specified in the Contract for installation on existing barriers and guardrail, delineators will be measured in units of each and paid for at the contract unit price per each. This price shall include surface preparation, adhesive, fasteners, and retroreflectors.

Payment will be made under:

Pay Item	Pay Unit
Road edge delineator (Standard and type)	Each
Barrier delineator	Each
Guardrail delineator	Each

SECTION 703—TRAFFIC SIGNALS

703.01—Description.

This work shall consist of furnishing and installing traffic signal equipment in accordance with these specifications and as shown on the plans or as directed by the Engineer. The terminology used herein and on the plans shall be as generically interpreted by manufacturers in the field except that certain terminology shall be interpreted as follows:

Auxiliary equipment: separate devices used to add supplementary features to a controller, such as conflict monitors, load switches, and flashers

Manufacturer: the company that assumes the responsibility for producing and assembling the equipment and that is responsible for guaranties and warranties for the equipment

System: the coordination of traffic signals through a time relationship or by interconnection of controllers with a master controller or computer to permit coordinated movement along a street(s)

System manufacturer: the company or system supplier that assumes the responsibility for procuring and assembling the equipment and that is responsible for guaranties and warranties for the equipment

703.02—Equipment.

Traffic signal controllers, master controllers, auxiliary equipment, and flashers for operating flashing beacons furnished by the Contractor shall be certified by the manufacturer as conforming to the requirements of NEMA TS-1 and any exceptions and additions stated herein unless otherwise specified. The manufacturer shall also provide certification from an independent testing laboratory that the model of controller, auxiliary equipment, and flasher furnished conforms to NEMA environmental standards and test procedures. Controllers and auxiliary equipment shall be the manufacturer's standard design. Controllers shall be furnished completely housed in a waterproof cabinet. Controllers and auxiliary equipment shall operate from a 120-volt, 60-Hz, single-phase, AC power supply. The manufacturer's name, model number, serial number, and part identification number shall be permanently attached to the cover of the equipment. The Contractor shall furnish the manufacturer's instructions for installing and maintaining the equipment.

The Contractor shall provide at least 15 hours of training for Department personnel in the operation, timing, maintenance, and repair of the signal equipment supplied by the Contractor. Training shall consist of at least 50 percent hands-on training. Training shall be held at a location specified by the Department and conducted by a qualified instructor representing the equipment manufacturer. Training material shall contain "hand-outs" for each attendee that shall serve not only for subject guidance, but as quick reference material for future use by the students. The Contractor shall also provide training on VHS tapes.

The Contractor shall secure assistance from the manufacturer as necessary to produce, implement, and fine-tune the controller, coordination, and preemption timings required to provide for an orderly movement of traffic as approved by the Engineer. Coordination timings shall include plans for morning and afternoon peak hours and off-peak conditions. The Department will furnish traffic counts for the Contractor's use in producing the timings within 30 days of the Contractor's request to the Engineer. The Contractor shall furnish to the Department three copies of the timing data and documentations used in calculating the timings. This data shall be submitted for approval 60 days prior to timing implementation. When specified on the plans, the Department will supply the final timing plan for implementation and fine-tuning by the Contractor. The Contractor shall request the final timing plan at least 90 days in advance of implementation.

(a) **Traffic Signal Controllers:** Controllers shall be eight phase, traffic actuated, solid state, and digital. Controllers shall be capable of operation in a closed loop traffic control system by the addition of a communication module/board and closed loop system software. No additional changes to the controllers shall be required. Controllers shall be completely modular consisting of a main frame and plug-in modules/boards that can be secured in place but easily removed for inspection and servicing.

Controllers shall also include the following programmable features:

Volume density functions.

Pedestrian functions.

Four signal overlaps with extension timing capability to allow the overlap green to extend beyond the parent green by a user programmable time. Amber and all red clearances shall be programmable for the overlaps when extension timing is utilized.

Phasing:

Concurrent phasing.

Sequential phasing in ascending numerical order.

Concurrent phasing on one side of the barrier (compatibility line) and sequential phasing on the other side.

Reversal of phases in the same ring on the same side of the barrier.

Soft Recall:

Places a demand on a phase(s) when no other calls exist.

Conditional Service:

Allows an odd phase to be reserviced after the even phase but prior to crossing the barrier provided the following conditions are met:

Even phase in the same ring has gapped out and is resting.

A call exists across the barrier.

Even phase in the opposite ring is still extending with enough time left in its max timer. Time shall be equal to or greater than the

minimum green of the phase about to be served plus the even phase, same ring's clearance times.

Last Car Passage:

Allows for timing a full passage time when a phase gaps out.

Security Code:

When enabled, a user-specified security code is required to be entered before data may be changed. Security access shall be automatically rescinded 10 minutes after the last user keystroke or 10 minutes after access if there are no user keystrokes. Viewing of data shall not require the entering of the security code. In closed loop systems, central equipment shall have free access to data within the local controllers via the master controller regardless of security codes imposed at the local controllers.

Controllers shall have an auxiliary connector mounted on the front panel that will allow the following functions to be accomplished in accordance with the Electronic Industries Association's RS-232C interface standard. Accomplishment of these functions shall be capable while the controllers are in normal operation without any adverse effects.

Data Transfer:

All user-entered data shall be transferable to other controllers of the same manufacturer and model through the use of a data transfer cable connected to the auxiliary connector on the controllers. Messages shall be displayed on the LCD when transfer is completed and when there is an error in transmission. The Contractor shall furnish two data transfer cables to the Department unless otherwise indicated on the plans.

Downloading and Uploading of Data:

Controller manufacturer–developed menu-driven computer software shall provide for the downloading and uploading of user-entered data between the controllers and an IBM or IBM-compatible computer with a 20MB minimum hard drive and operation of the following functions:

Creation, review, and modification of user-entered data.

Creation, review, and modification of intersection configurations including but not limited to graphic display

of intersection geometrics, laneage, street names, phases, and overlaps. Standard intersection geometric graphics consisting of at least a four-leg approach, tee, offset tees, and diamond interchanges that are user selectable for use in creating intersection configurations shall be included in the software.

Transfer of user-entered data except real time and date from one intersection's data base to another intersection's data base.

Comparison of an intersection's data base and reports stored on disk to that uploaded from the intersection's controller. Differences shall be indicated.

Storage and retrieval of an intersection's data base and configurations to and from diskettes.

Printout of an intersection's data base through a printer.

Display of controller status while connected to the controller.

The number of intersections whose data base and configurations can be stored, retrieved, and downloaded from and to a diskette shall be limited only by available space on the diskette. Each intersection file shall be uniquely identified and accessible by an alphanumeric name. Cross referencing of the alphanumeric name to the intersection name shall be provided if different.

Connection of the controller to the computer shall be accomplished through the use of a cable with a DB-9 female connector on one end for connection to the computer and the appropriate connector on the other end for connection to the controller auxiliary connector.

The Contractor shall furnish the manufacturer's certification that software on 3.9-millimeter (720K) diskettes and connecting cables are available that will provide for operation of the above functions.

Printing:

All user entered-data and reports shall be capable of being downloaded to a serial printer in a usable format. Data to be printed shall be selectable by the user from at least the following submenus:

Controller
Coordination
Time base coordination
Preemption

Terminologies other than those listed above may be used provided they are readily identifiable to the user. Connection of the controller to the printer shall be accomplished through the use of a cable with a DB-25 male connector on one end for connection to the printer and the appropriate connector on the other end for connection to the controller auxiliary connector. The Contractor shall furnish two cables to the Department unless otherwise indicated on the plans. Messages shall be displayed on the LCD indicating when printing is completed and when there is an error in transmission.

Controllers shall have internal traffic adjusted system coordination (hardwire), non-interconnected system coordination (time base), and preemption. Coordination commands shall be accepted and responded to by the controllers regardless of the phasing utilized. Controllers shall have coordination outputs to allow its use as a master controller transmitting coordination commands based upon time of day.

Coordination:

Coordination shall provide for at least four cycle lengths, three offsets per cycle plan, three splits per cycle plan, three permissive periods per split plan, eight force-offs per split plan, and remote flash operation. A shortway smoothing routine shall be provided to smooth coordination plan cycle and offset changes.

Traffic adjusted system coordination shall be designed to operate with an impulse through an interconnect cable from a master controller.

Non-interconnected system coordination shall be designed for coordination of signals based upon time of day and without the use of interconnect cable.

In addition to the requirements stated under coordination, minimum program functions shall conform to one of the following two types:

Type 1	**Type 2**
150 event times	180 event times

150 time of day functions	48 time of day functions
10 day programs	7 day week program
8 week programs	99 exceptions to the week program
1 year program	Synch reference by time and event
10 unique exceptions to the year program	3 auxiliary outputs
Synch reference by time and event	Max II selection
3 auxiliary outputs	Phase reversal
Max II selection	
Phase reversal	

Definitions:

An event time is an hour, minute, and second of a 24-hour day. A time of day function can occur at any of these times. A time of day function is a selection of a coordination plan condition or the time switching of an output.

A day program is a list of the time of day functions for the day. These events specify which coordination plan conditions are selected and which outputs switch during the day.

A week program specifies which day program shall be used on each day of the week.

A year program specifies which week program shall be used during each week of the year.

An exception to the year program causes a day program different from that in the year program to be used on a specific day.

Internal preemption shall provide at least one railroad preemption plan and four emergency vehicle preemption plans that will interrupt the normal operation of the controller upon actuation and initiate a special sequence of operation as shown on the plans.

Preemption operation shall be programmable to proceed sequentially through the preemption intervals and hold at the end of a specified interval. Intervals in the preemption plan during which normal cyclic operations resume shall be programmable. Priority of preemption plans shall be programmable or shall be fixed based upon the plan number.

Activation of railroad preemption during the timing of an emergency vehicle preemption will cause the emergency vehicle preemption to immediately clear through normal clearance intervals and initiation of the railroad preemption. Railroad preemption shall be displayed for the duration of the preemption call.

Emergency vehicle preemption timings shall be programmable from at least 0 to 99 seconds. The capability of a delay between the time the emergency vehicle preemption plan input is asserted and the implementation of the preemption plan shall be provided. The timing range for this delay shall be at least 0 to 99 seconds. Emergency vehicle preemption inputs shall be capable of operating in lock and non-lock modes. When programmed non-lock, termination of the input prior to implementation of the preemption plan shall not initiate preemption operation.

Controllers shall be programmed for all required functions through a menu driven keyboard and an LCD except the following, which may be programmed with dip switches or a combination of keyboard and dip switches:

Phasing other than NEMA standard dual ring concurrent
Phase reversals
Security code on and off
Startup signal display indication

The LCD shall be capable of displaying at least 4 lines of 20 characters each. The LCD shall have backlighting and automatically adjusted or selectable contrast levels for optimum viewing.

Backlighting shall be automatically extinguished within one hour after the last keyboard operation. A main menu and submenus shall be provided on the LCD that lists categories in the English language from which the user may select. Entering of data outside of allowable timing ranges shall result in the controller rejecting the data. Controllers shall have circuitry for monitoring the cycling of the microprocessor. Upon determination that the microprocessor is not cycling, this circuitry shall automatically cause the intersection to be placed in flashing operation. Active status indications of controller, coordination, and preemption features and timings shall be displayed

on the LCD using alphanumeric characters. In addition to the indications required by NEMA, the following indications shall also be displayed:

Controller Status:

Time and date
Overlaps in service
Interval timings
Stop time applied
Phase omit active
Ped omit active
Recall type
Variable initial timing
Time before reduction timing
Gap time
Last car passage active

Coordination Status:

Command source, e.g. manual, telemetry, time base coordination, interconnect, free or flash
Cycle, split and offset number active
Cycle length
Offset time
Local cycle timing
Master cycle timing
Offset seeking indication
Telemetry and interconnect failure indications
Vehicle permissive period active
Ped permissive period active
Hold active
Auxiliary output circuit number active

Preemption Status:

Preemption number active
Preemption interval
Preemption timing

Controllers shall have an internal 99-year real-time clock referenced to the 60 Hz AC power line. The clock shall be easily set to the nearest second of the year. A crystal oscillator shall be provided to maintain clock accuracy to at least 0.005 percent (50 PPM) when on standby power. The clock time and date shall be maintained for at least 60 days during periods of power loss. If clock standby power is exhausted during a line voltage power failure, time base coordination shall be

prevented from operation. Automatic corrections shall be made for Daylight Saving Time.

All controller–user entered data except time and date shall be maintained during power outages through the use of an Electrically Erasable Programmable Read Only Memory (EEPROM).

Unless otherwise specified, the controllers shall be furnished to initially operate as follows:

Single entry
Start in major street through phase green interval

(b) **Flashers for Operating Flashing Beacons:** Flashers shall be solid-state, double circuit, and shall be furnished complete in a weatherproof cabinet. The cabinet shall be fabricated of welded sheet aluminum at least 3.17 millimeters in thickness.

The cabinet shall have transient protection conforming to the requirements of Section 703.02(d)3.b. for field wiring, a door gasket, and a standard police panel lock with two keys. A radio frequency interference filter rated at 20 amps, terminal block, and 20-amp circuit breaker shall be mounted in the cabinet. The cabinet shall be provided with removable hub plates tapped for 25-millimeter conduit at the top and bottom and shall be equipped with brackets for wood-pole mounting or with adjustable bands for steel-pole mounting as specified on the plans.

(c) **Master Controller:** Master controllers shall be solid-state, digital, traffic-adjusted controllers adaptable to fully actuated local controllers. They shall provide for at least three cycle lengths, three independent offsets per cycle, and free operation and shall be capable of volume density computations. Master controllers shall be from the same manufacturer as the local controllers furnished by the Contractor.

(d) **Cabinets:** Cabinets for traffic signal controllers and master controllers shall be weatherproof and constructed of welded sheet aluminum, 3.17 millimeters minimum thickness. Cabinet mounting attachments shall be durable, corrosion resistant, and of heavy duty construction.

Cabinets shall be at least 1,370 millimeters in height, 1,115 millimeters in width, and 610 millimeters in depth and shall be large enough to provide for ease of maintenance of the controller and auxiliary equipment. The maximum width and depth shall be such that the cabinet will fit entirely on the standard CF-1 foundation. The cabinet

bolt pattern shall be rectangular, with dimensions of 1,030 millimeters in width and 470 millimeters in depth. Anchor bolts shall be 19 millimeters in diameter and at least 400 millimeters in length with a 125-millimeter L bend.

1. **Doors:** Cabinet doors shall provide full access to the cabinet interior and shall have gaskets to ensure weatherproofing. A small recessed police panel with a separate access door shall be provided in the front door of the cabinet. The main door shall be equipped with the Department's standard tumbler lock No. 9R48773 or the municipality's standard tumbler lock and shall be keyed. The police panel shall be provided with a standard police panel lock. Two keys for each lock shall be provided the Engineer. Hinges shall be stainless steel and continuous. The main door shall have a door stop arrangement that will allow it to be firmly positioned at both 90 and 135 degrees, _10 degrees. The locking mechanism for cabinets shall be a three-point draw roller system. Rollers shall be fabricated from nylon with a diameter of at least 20 millimeters. The door opening shall be double flanged on all four sides.

   A panel shall be mounted on the inside of the main door of the master controller cabinet and shall consist of the following four functional switches: auto-manual, manual cycle selector (three cycles), manual offset selector (three offsets), and manual synch.

2. **Police panel:** The police panel shall be furnished with two toggle switches, each labeled for its purpose. One switch will be used to place the signal in flashing operation and shall not affect the power being supplied to the controller and conflict monitor. The cyclic operation of the controller shall not be affected by this switch. Upon placement of the switch from the automatic position to the flash position, the intersection shall immediately be placed in flashing operation. Upon placement of the switch from the flash position to the automatic position, the signals shall immediately be placed in automatic operation in the major street through phase green interval. The second switch shall be used to disconnect power to the controller. The backside of the police panel shall have an aluminum cover over the switches and their wiring connections. When required by the plans, a third toggle switch with a handle control shall be furnished that will allow manual operation of controller phasing.

3. **Interior:** The interior of cabinets shall be of sufficient size to provide adequate ventilation of the equipment housed therein. Cabinets shall contain at least three adjustable shelves or equivalent supports with enough space to hold the controller, 20 single-channel detector amplifiers, and required auxiliary

equipment. Vertical mounting channels for the shelves shall be continuous and shall allow for adjustable shelf placement ranging 125 millimeters from the bottom to 125 millimeters from the top of the cabinet. Wiring panels (terminal blocks) shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. Conductors shall be neatly arranged in the cabinets and bundled in groups with cable ties. Conductors running to panels other than the resistor panel on the left side of the cabinet shall be positioned below the resistor panel with the nearest conductor being at least 75 millimeters from the bottom resistor position. Conductors connected to terminals located on the door shall be bundled and sheathed. The bundled conductors shall not obstruct access to other circuits and terminals in the cabinet. The controller equipment and terminals shall be arranged within the cabinet so that they will not interfere with the entrance, tracing, and connection of conductors. Unless cable is passing through the cabinet uninterrupted, incoming and outgoing conductors shall have each wire connected to terminal post positions.

Cabinets shall be wired in accordance with Section 10 of NEMA TS-1 for NEMA configuration 8 and the changes and additions noted herein. The cabinet shall also be wired to produce controller pin connector functions, including those on auxiliary connectors. Wiring that is connected to the back panel shall be of adequate length to allow the back panel to be placed in position for maintenance.

When exclusive/permissive left-turn phasing is being used, the red output from the load switch for the left-turn phase shall be connected to ground through a 1.5K-ohm resistor. The resistor shall conform to the requirements of MIL-R18546D, Type RE70G1501. Heat sink compound shall be applied to the housing base prior to attachment. Wiring shall be soldered to the resistors and the connections shall then be covered with heat shrink tubing. On unused phases, red outputs shall be wired to AC+. Wiring shall be readily accessible and shall not require the back panel to be lowered for disconnection of the wiring.

Cabinet wiring shall be provided for railroad preemption whereby the selection of the following is easily accomplished through the use of simple hand tools: (1) 115 VAC or ground true outputs, and (2) normally open or normally closed contacts.

The Contractor shall provide five blue and white prints of the controller circuit diagram. The blue and white prints shall be produced from the original drawing and shall be clear and legible. The Contractor shall install two copies of the circuit diagram

inside the cabinet in a readily accessible waterproof enclosure and shall furnish three additional copies to the Engineer. The waterproof enclosure shall be securely attached to the cabinet with studs welded to the cabinet and nuts. The enclosure shall have noncorrosive metal grommets for use with the studs.

A listing indicating terminal numbers with a description of their use shall be attached to the cabinet door and overlayed with a clear, plastic covering. Edges of the plastic shall be sealed with a clear waterproofing compound.

Detector harness cables shall be stranded copper and shall be not sized less than No. 22 AWG rated at 300 volts. Other AC and DC circuit wiring shall be in accordance with NEMA TS-1. Ribbon cable and printed circuit boards will not be allowed for cabinet wiring. Loop detector harnesses shall include wires connected to the two reserved pins in the connector. At the end of the harnesses, these wires shall be folded back and tied to the harnesses with nylon cable ties. Loop input wiring in the loop detector harnesses shall have soldered on spade connectors for attachment to the detector panel terminals. Heat shrink tubing shall be installed over the soldered connections.

Controller cabinets shall be wired to provide output signals for the controller to the loop detector amplifiers so that the delay feature of the associated phase is inhibited during the green interval.

Outgoing traffic signal circuits shall be the same polarity as the line side of the power supply. The common return of signal circuits shall be the same polarity as the ground side of the power supply. The power supply shall be grounded to the ground bus of the controller cabinet. The ground bus, neutral bus, and logic ground bus in the cabinet shall be copper.

When the time-based coordination feature of the controller is used to establish a coordinated system with controllers operating fully actuated, the controller cabinet shall be wired to inhibit mainline through, right turn, and pedestrian detectors when coordination is not in free operation.

Transient protection shall be provided in traffic signal controller and master controller cabinets for the following:

a. **Main AC power input:** Transient protection for the AC power input shall be connected on the load side of the main AC circuit breaker. The transient protection shall (1) withstand a 15,000-ampere surge current with an 8 by 20-

microsecond wave form, 20 times at 3-minute intervals between surges, without damage to the suppressor; (2) limit the surge voltage to a 2,000-volt peak; and (3) limit follow current to an appropriate level to prevent tripping of the main circuit breaker of the cabinet or enclosure.

b. **Interconnect cable and field wiring:** Transient suppression for field wiring shall be installed on the front of the back panel. Transient suppression for interconnect cable and field wiring, except loop detector lead-in cable, shall (1) clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected and (2) withstand a surge current of 1,000 amperes with an 8 by 20 microsecond wave form, six times at 1-second intervals between surges, without damage to the suppressor.

c. **Loop detector lead-in cable:** The panel shall be located on the right side near the front of the cabinet and above the level of the lowest shelf. A preemption test switch with necessary wiring shall be located on this panel. Transient suppression for loop detector lead-in cables shall not affect the operation of inductive vehicle loop detectors and shall (1) protect detector unit loop inputs against differential (between the loop lead) surges and against common mode (between loop leads and ground) surges, (2) clamp the surge voltage to 25 volts or less when subjected to repetitive 300-ampere surges, and (3) withstand repetitive 400-ampere surges with an 8 by 20-microsecond wave form without damage to the suppressor.

4. **Accessory and auxiliary equipment:** As a minimum, traffic signal controller cabinets shall be furnished with the following:

a. removable, noncorrosive metal back panel (13 gage minimum) that shall incorporate a swing-down design to allow it to be placed in at least a 60-degree angle below the vertical position when the top attachment mechanisms are removed. The design shall use noncorrosive metal hinges or pins of adequate number and strength to support the back panel and attached equipment

b. removable, noncorrosive metal detector panel (2.32 millimeters minimum thickness) at least 890 millimeters in length and 165 millimeters in width with two rows of barrier terminal blocks. Each row shall consist of 48 double-pole terminals rated at 4,000 volts r.m.s., 30 amps, and be able to accommodate up to 10-gage solid wire. The panel shall be wired in accordance with the following:

(1) 16 double-pole terminals for vehicle calls (2 per phase)

(2) 4 double-pole terminals for pedestrian calls (1 each for phase 2, 4, 6, and 8)

(3) 3 double-pole terminals for detector +115 VAC

(4) 3 double-pole terminals for detector AC Common

(5) 3 double-pole terminals for ground

(6) 3 double-pole terminals for detector logic ground

(7) 8 double-pole terminals for 115 VAC delay override

(8) 4 double-pole terminals each for phase 1, 3, 5, and 7 for vehicular detector field wiring

(9) 10 double-pole terminals each for phase 2, 4, 6, and 8 for vehicular detector field wiring

c. removable, noncorrosive metal auxiliary panel(s) (2.32 millimeters minimum thickness) with terminals wired for auxiliary connector(s) functions

d. removable, noncorrosive metal detector test panel (2.32 millimeters minimum thickness), readily accessible when the main cabinet door is opened, providing vehicle inputs through a momentary switch to each of the 8 phases and pedestrian inputs to phases 2, 4, 6, and 8

e. ground fault convenience receptacle

f. removable, noncorrosive metal power panel (2.32 millimeters minimum) located on the right side near the front of the cabinet. A clear Plexiglass shield with openings for manual operation of breakers shall be installed over the panel with standoffs and thumbscrews.

g. 2 circuit breakers. One circuit breaker, which shall be isolated from the power supply for the signal and control equipment, shall be rated at least 20 amps and shall operate the vent fan, ground fault convenience receptacle, and lamp. The other circuit breaker shall be rated at least 40 amps and shall operate all other equipment, including the signal load. Separate terminal strips shall be provided for each circuit breaker and an unfused terminal for the neutral side of the power supply line.

h. screened and louvered vent designed to prevent rain entry, with a 350 by 500 by 25 millimeter standard furnace vent filter. The filter tray shall be sized to house and secure the filter in place. The screen shall be constructed from at least 0.79-millimeter aluminum with 3-millimeter-diameter openings positioned on 5-millimeter staggered centers. The screen shall be placed on the inlet side of the filter and held in place by the filter or silicone adhesive.

i. screened air exhaust opening under the top overhang

j. thermostatically controlled vent fan with a screened guard in the top section of the cabinet with a capability of exhausting at least 2.8 cubic meters per minute. The thermostat shall be adjustable from 25 °C to 55 °C. Degree markings shall be indicated on the thermostat in 5-degree increments.

k. radio frequency interference filter rated at 50 amps

l. transient protection devices

m. dual-circuit flasher, 15 amp rating over the temperature range of -34 °C to +74 °C conforming to NEMA standards with an LED indicator for each circuit

n. fluorescent lamp, ordering code #F20T12/D, and an on/off door switch located in the cabinet so that it will provide for the unobstructed illumination of controller timing adjustments. A toggle switch mounted on the cover behind the police panel and a momentary switch operated by the door shall be connected in-line for operation of the lamp.

o. 12-channel NEMA stand-alone conflict monitor with its own power supply and an LCD. The monitor shall have an internal 99 year real-time clock referenced to a 60 Hz AC power line. The clock shall be easily set to the nearest second of the year from the front panel. A crystal oscillator shall be provided to maintain the accuracy of the clock to at least 0.005 percent (50PPM) when on standby power. The clock time and date shall be maintained for at least 1 year during periods of power loss. Automatic corrections shall be made for Daylight Saving Time.

In addition to NEMA requirements, the conflict monitor shall have user selectable features for monitoring simultaneous dual indications on a channel and controller amber clearance intervals. The intersection shall be placed in flashing

operation if the controller amber clearance interval is less than a fixed minimum and when programmed dual indications occur simultaneously on a channel. If power loss occurs after a failure, the conflict monitor shall be capable of displaying, upon restoration of power, the indications on at the time of power loss. The conflict monitor shall log at least nine previous faults and ten power interruptions and restorations by date and time in non-volatile memory.

The conflict monitor shall have an auxiliary connector mounted on the front panel that will allow transfer of data to a printer. Connection of the conflict monitor to the printer shall be accomplished through the use of a cable with a DB-25 male connector on one end for connection to the printer and the appropriate connector on the other end for connection to the conflict monitor auxiliary connector. The Contractor shall furnish two cables to the Department. Upon command, current date and time, monitor configuration, and previous faults and power interruptions and restorations shall be printed in a usable format without disrupting normal monitor operation. Previous faults shall indicate channel indications on and time and date of fault occurrence.

The LCD shall have display indications in conformance with NEMA and the following changes and additions:

(1) four individual indications per channel displaying active red, yellow, green, and walk inputs. Indications shall be displayed using the following symbology: R = red, Y = yellow, G = green, and W = walk. The monitor shall be capable of displaying the indications simultaneously for all active inputs;

(2) amber clearance failure indication

(3) dual indication

(4) program card compatibility phases

(5) date, time, and type of fault condition including channel indications on for logged faults

(6) date and time for power interruptions and restorations

(7) current date and time

p. wired signal, pedestrian, and overlap load switch mounting bases (16) wired for the following from left to right: 8 phases, 4 overlaps, and pedestrian movement for phases 2, 4, 6, and 8

q. 12 solid-state signal load switches (signal and overlap) conforming to NEMA standards, each having LED indicators for active input and output circuits. The load switch shall have a 15-amp rating over the temperature range of -34 °C to +74 °C.

r. 6 flash-transfer relays with a rating of 186.5 H.P. at 120 VAC; 30 AMP, 120/240 VAC; 20 AMP, 28 VDC

s. 1 or more field wiring terminal(s) for each light circuit plus 1 terminal for the common conductors, but not fewer than one for every four signal circuits. Signal common terminals shall be grounded to the cabinet.

t. 2 switches inside the main cabinet on the cover behind the police panel that provide the same functions as the switches in the police panel

u. removable, noncorrosive metal resistor panel (2.32 millimeters minimum) located on the left side near the bottom of the cabinet. The panel shall be of sufficient size to adequately mount four resistors. Resistors shall be mounted horizontally, one below the other, in the following order from top to bottom; phase 1, phase 3, phase 5, and phase 7.

(e) **Signal Heads:** Signal head sections used in installing intersection control beacons and hazard identification beacons shall be the same as those described herein for standard traffic signal head sections.

Cast aluminum signal head sections shall be used for span wire installations, free-swinging mast arm installations, and pedestal-mounted installations that use only slipfitters. Cast aluminum or polycarbonate signal head sections may be used for all other installations.

1. **Traffic signal lamp wattages** shall be as follows: 60-watt lamps for 200-millimeter amber flashers, 100-watt lamps for all other 200-millimeter sections, 100-watt lamps for 300-millimeter amber flashers, and 150-watt amps for all other 300-millimeter sections.

2. **Traffic signal backplates** shall be specifically manufactured for the type and brand of signal heads used to ensure proper fit with a border width of 125 millimeters and shall be without louvers and of one-piece construction with the exception of those for five-section cluster signal heads, which may be a maximum of five pieces.

3. **Standard traffic signal head sections** shall conform to the requirements of the ITE Standard for Vehicle Traffic Control Signal Heads and Section 238 and shall include cap visors.

4. **Selective view traffic signal head sections** shall conform to the requirements of Section 238, shall permit the visibility zone of the indication to be determined optically, and shall not require hoods or louvers. The projected indication shall be selectively visible or veiled within 15 degrees of the optical axis. No indication shall result from external illumination, nor shall one light unit illuminate another unit.

   The optical system and materials shall be composed of a lamp with a collar, an optical limiter-diffuser, and an objective lens. The lamp shall be a three-pronged sealed beam having an integral reflector with stippled cover and shall be coupled to the diffusing element with a collar that includes a specular inner surface. The diffusing element shall be discrete or integral with the convex surface of the optical limiter.

   The optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects 275 to 365 meters away and shall permit an effective veiling mast to be variously applied as determined by the desired visibility zone. The optical limiter shall be provided with a means for positive indexing and shall be composed of heat-resistant glass.

   The objective lens shall be a high-resolution annular incremental lens hermetically sealed within a flat laminant of weather-resistant acrylic or an approved equal. The lens shall be symmetrical in outline and capable of being rotated to any 90-degree orientation about the optical axis without displacing the primary image.

   The optical system shall accommodate the projection of diverse, selected indications to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer. The projected indication shall conform to ITE transmittance and chromaticity standards.

Die-cast aluminum parts shall have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be finished with high-quality baked enamel primer and finish paint. The lens holders and interior of the case shall be optical black.

The signal case and lens holders shall be predrilled for backplates and visors. Hinge and latch pins shall be stainless steel. Access openings shall be sealed with weather-resistant rubber gaskets.

The signal shall mount to a standard 38-millimeter traffic signal fitting as a single section, a multiple section face, or in combination with other signals. The signal section shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal plane while maintaining a common vertical axis through the couplers and mounting. The terminal connection shall permit external adjustment about the mounting axis in 5-degree increments. The signal shall be mountable with ordinary tools and capable of being serviced with no tools.

Attachments, such as visors, backplates, and adapters, shall conform and readily fasten to existing mounting surfaces without affecting the water and light integrity of the signal.

Lamp fixtures shall be composed of a separately accessible housing and integral lamp support; an indexed ceramic socket; and a self-aligning, quick-release lamp retainer. Electrical connection between the case and lamp housing shall be accomplished with an interlock assembly that disconnects the lamp holder when opened. Each signal section shall include a covered terminal block for clip or screw attachment of lead wires. Concealed No. 18 AWG stranded and coded wires shall interconnect sections to permit field connection within any section.

Each signal section shall include an integral means of regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall be at least 97 percent of the uncontrolled intensity at 10,764 lux and shall decrease to 15 ± 2 percent of maximum at less than 10.76 lux. Response shall be essentially instantaneous and proportional to any detectable increase in illumination from darkness to 10,764 lux and damped for any decrease from 10,764 lux.

The intensity controller shall be composed of an integrated directional light sensing and regulating device interposed between

the lamp and wires. It shall be compatible with a 60-Hz input and responsive within the range of 105 to 135 volts. Output may be phase controlled, but the device shall provide a nominal terminal impedance of 1,200 ohms open circuit and a corresponding holding current.

The signal head shall be optically programmed in accordance with the manufacturer's recommendations.

5. **Pedestrian signal heads** shall conform to the requirements of ITE Standards for Pedestrian Traffic Control Signal Indications and the requirements of Section 238.

6. **Lane-use control signal heads** shall conform to the requirements of ITE Standards for Lane-Use Traffic Control Signal Heads and Section 238.

(f) **Illuminated Traffic Control Signs:** Signs shall be square or rectangular weatherproof units. Only internal illumination shall be used. When illuminated, the message shall be white on an opaque background. The sign face or cover shall consist of a polycarbonate lens. The housing shall be sheet aluminum at least 3.17 millimeters in thickness finished with two coats of flat black paint.

The size and arrangement of letters forming the message shall conform to the requirements of the *Federal Standard Highway Signs Booklet* or an adaptation approved by the Engineer. When activated, the message shall be clearly readable at all times at a distance of 60 meters in all atmospheric conditions except dense fog. The message shall be controlled by a time clock or another type of actuation as specified on the plans. Signs shall illuminate instantly without a "warm-up" requirement or a continuously energized ballast. When signs are deenergized, the message shall not be readable.

(g) **Detectors:**

1. **Magnetic detectors** shall consist of a sensitive magnetic circuit housed in a lightweight metal cylinder approximately 50 millimeters in diameter, approximately 500 millimeters in length, and shall be equipped with two 10-meter (minimum) stranded leads.

2. **Magnetic detector amplifiers** shall be solid-state and properly connected to sensor(s) to produce, upon vehicle actuation, an output through a relay that has both normally closed and normally open circuits. A fail-safe design shall be incorporated so that a constant detection signal for control equipment will be provided in the event of a power loss. The unit shall be housed in a

mechanically sound metal enclosure designed to allow stacking of multiple units having maximum dimensions of 75 millimeters in height, 150 millimeters in width, and 200 millimeters in depth. An 8-pin MS connector for making external detector connections, an adjustable sensitivity control, and a visual vehicle actuation indicator shall be provided on the front panel of the amplifier enclosure. The amplifier shall provide stable operation within an ambient temperature range of -34 °C to +57 °C when operating from a 120-volt, 60-Hz, single-phase AC power supply with a nominal power consumption of 5 watts or less. A fuse of a suitable ampere rating shall be provided to protect the power supply of the detector amplifier. Fuses shall be easily replaceable from the front panel.

3. **Inductive loop detectors** shall conform to the requirements of the performance characteristics required by NEMA TS-1.

   The manufacturer of the loop detector amplifier shall provide a certification from an independent testing laboratory that the model furnished complies with NEMA Environmental Standards and Test Procedures.

   Loop detector amplifiers shall be a single-channel, shelf-mounted, relay-output type with indicator lights on the front panel and delay and extension detection features. When the delay feature is used, it shall be inhibited during the green interval of its associated phase. The detector amplifier shall be adequately fused, and fuses shall be easily replaceable from the front panel.

4. **Pedestrian detectors** shall be pushbutton operated at low voltage (not more than 15 volts AC or 24 volts DC).

703.03—Procedures.

Equipment shall be installed so that it is ready for full operation.

(a) **Prosecution of Work:** The Contractor shall not discontinue the operation of an existing signal without the approval of the Engineer. Requests for discontinuance shall be made at least 48 hours in advance.

While modifying or replacing existing traffic signals, the Contractor shall provide necessary traffic controls for maintenance of traffic, as approved by the Engineer. Traffic flow shall be maintained during the modification or replacement. Normal or routine maintenance that is not attributable to the Contractor's operations will remain the responsibility of the Department or local municipality.

When the Contractor begins modifying or replacing existing signal equipment or placing new signal equipment in operation, he shall maintain and repair the equipment until final acceptance. If the equipment malfunctions during the Contractor's working hours or during peak traffic hours as determined by the Engineer, the Contractor shall take immediate action to maintain the normal flow of traffic and make necessary repairs as expeditiously as possible that will cause the least interference with traffic.

The Contractor shall furnish the Engineer with the name and telephone number of the supervisory employee of his company who will be responsible for responding to repair calls during nonworking hours. If a signal malfunctions, the Contractor shall make necessary repairs within 4 hours from the time of notification. If the Contractor fails to make the repairs within 4 hours, the Department may make the repairs in accordance with Section 104. This shall in no way relieve the Contractor of his responsibility for maintaining and completing the work.

When replacing or modifying an existing coordinated signal system, the Contractor is not required to maintain the existing system coordination unless directed to do so by the Engineer.

(b) **Equipment Color:** The color of metal equipment shall be obtained by applying two coats of paint. The color of plastic equipment shall be obtained by impregnating the color into the plastic. When painting of aluminum and galvanized metal equipment is required, the equipment surface shall be treated to ensure adherence of the paint. Signal head color shall be Federal Yellow except the inside of the visors shall be flat black. Backplates (both sides) and signal leveling attachments shall be flat black.

(c) **Refurbishing Existing Equipment:** Existing equipment to be retained shall be cleaned. Existing metal equipment to be retained shall be repainted as specified herein.

(d) **Mounting Controller Cabinets:** Pole-mounted controller cabinets shall be attached to metal poles or signal pedestals by means of brackets secured by encircling clamps made for the purpose and to wood poles by means of lag screws and plates bolted through the back of the cabinet or by encircling clamps made for the purpose.

Ground-mounted cabinets shall be installed on a concrete foundation.

(e) **Installing Signal Heads:** At new or modified traffic signal installations, each signal head shall be covered with a durable, nontransparent cover upon installation. The Contractor shall maintain the cover until the signal is put into operation.

Housings shall be joined at the top and bottom in accordance with the manufacturer's specifications to form complete signals. Unused ends of sockets shall be closed with ornamental cap screws. Joints shall be rendered weatherproof by a suitable combination of lead and steel washers.

1. **Standard and selective view traffic signal heads** shall be installed so that there is at least 2.4 meters between lines drawn perpendicular to the center of any two adjacent signal heads that provide indications to the same approach. The Contractor shall verify the location and alignment of each signal head for orientation to its approach lane(s) prior to installing the signal conductor cable. If the location of the signal head designated on the plans is not oriented correctly with the applicable approach lane(s), the Contractor shall determine the proper location(s) and submit supportive data to the Engineer for review.

   The bottom of the housing of a pedestal-mounted or bracket-mounted signal face adjacent to the pavement shall be at least 2.4 but not more than 4.5 meters above the sidewalk or, in the absence of a sidewalk, above the pavement grade at the center of the roadway.

   Balance adjusters shall be installed with span wire hanger assemblies. Lock washers shall be used with nuts on the balance adjuster, and the vertical eyelet bolt shall have a cotter key inserted through a hole in the center of the bolt. The hole shall be located approximately two threads from the bottom of the bolt. The vertical eyelet bolt shall be secured from movement with a lock nut.

   Serrated teeth on hanger assemblies shall be of the correct number and size to mate properly with the teeth on the signal heads.

   The lowest point of the signal head assembly, including backplates and tether wire attachments, suspended over the roadway shall be at least 4.6 meters for mast arm installations and at least 4.9 meters for span wire installations above the pavement grade at the center of the roadway. The bottom of the signal head housing shall be not more than 5.8 meters above the pavement grade at the center of the roadway for mast arm and span wire installations.

2. **Pedestrian signal heads** shall be mounted with the bottom of the lower signal unit at least 2.2 meters but not more than 3.0 meters above the sidewalk and shall be placed in the line of vision of pedestrians using the applicable crosswalk. When mounted on the same support with vehicular signal indications, signal

groupings shall be at least 0.3 meter apart. Pedestrian indications shall be below vehicular indications.

3. **Lane-use control signal heads** shall be installed to operate in accordance with the *MUTCD*. The lowest point of the signal head assembly suspended above the roadway shall be in accordance with Section 703.03(e)1.

4. **Signal lamps** shall be installed in signal heads in accordance with the ITE Standard for Vehicle Traffic Control Signal Heads.

5. **Backplates** shall be attached with bolts, washers, and lock nuts or self-tapping screws and washers. The number of bolts or self-tapping screws required shall be at least 8 for a three-section signal head assembly, 10 for a four-section assembly, and 12 for a five-section assembly. Bolts, screws, and washers shall be of a noncorrosive metal or shall have a noncorrosive outside coating.

(f) **Installing Illuminated Traffic Control Signs:** Illuminated signs used to control right or left turns shall be mounted directly over or adjacent to the affected traffic lane(s) at the height prescribed for standard traffic signals. When mounted with standard and selective view traffic signal indications, illuminated traffic control signs and signals shall be separated so as to prohibit physical contact.

(g) **Installing Detectors:** The location of detectors shall not deviate more than ±0.6 meter from the location(s) shown on the plans unless the Contractor submits a detailed drawing showing the exact location of the detector(s) in question and secures the written approval of the Engineer. Detector lead-in cable shall be continuous and unspliced from the detector to the detector panel terminals.

Splices between loop or magnetic detector conductors and the lead-in conductors shall be allowed only in signal junction boxes. A separate splice kit shall be used for each lead-in cable. These splices shall be joined, made mechanically secure, and then tested electrically. When the mechanical connection has been shown to be electrically functional under operational conditions, it shall be soldered with a fusible metal or alloy. Each splice shall then be covered with one layer of half-lapped, 19-millimeter self-bonding rubber tape and one layer of half-lapped, 19-millimeter vinyl tape. The tape shall be installed so at least 19 millimeters of the insulation is covered by the tape. The splice shall then be installed in a splice kit.

Detector and detector lead-in cable shall be installed with the slack length coiled in the junction boxes. The coiled length shall be sufficient to allow the cables to extend at least 600 millimeters above the junction boxes.

Detector and detector lead-in cable jackets shall be permanently identified in the controller cabinet and junction boxes. Identifications shall be indicated on nonferrous metal tags or nylon tags attached to the cable with nylon cable ties. The identification shall be stamped or engraved on the metal tags and lettered with permanent ink on nylon tags. Identifications shall be legible and shall conform to the following:

Detector lead-in cable: phase and location (lane and setback distance from stop line) of detector: e.g., 1 NB stop line left-turn lane loop; 2 SB 60 meters through lanes mag.; 6 NB stop line inside through-lane loop; 2 Ped NW Quad

Detector cable: phase and location of detector: e.g., 1 NB left-turn lane loop; 2 SB through-lane mag.; 6 NB inside through-lane loop; 6 NB outside through-lane loop

1. **Magnetic detectors:** Magnetic detectors shall be encased in heavy-wall PVC conduit 75 millimeters in diameter installed in a trench cut to a depth of 380 millimeters and shall be surrounded with at least 75 millimeters of sand. When approved by the Engineer, the sensing element, encased in PVC conduit, may be installed in a hole bored parallel to the surface and at the required depth.

   Magnetic detector circuits shall not be run in the same cable sheath with conductors carrying signal power.

2. **Inductive loop detectors:** Slots shall be sawed into the pavement, cleaned with pressurized water at a minimum of 350 kilopascals, and then dried with filtered compressed air before loop conductors are installed and sealed. Twenty-five millimeter lengths of PE foam backer rod shall be installed in the slot at slot intersection points and on 600-millimeter maximum centers between those points after installation of the loop conductors. The backer rod diameter shall be 13 millimeters for 10-millimeter slots, 16 millimeters for 13-millimeter slots, and 19 millimeters for 16-millimeter slots. Sealant shall conform to the requirements of Section 212. Loops shall be installed in the presence of the Engineer.

   Loop detectors shall not be installed in pavement that has been open cut, repaired, or rebuilt in a manner where the pavement structure is not sound and continuous in the area of the proposed loop installation. When loop detectors are to be installed in existing pavement, the Contractor shall first field inspect the loop locations and advise the Engineer of any such locations that have

been open cut, repaired, or rebuilt. The Engineer will direct the Contractor in locating the loop detectors.

A Megger reading of at least 100M ohms shall be obtained for each loop detector (cable and shield). This test shall be made at 500 volts immediately before the sealant is installed and again after the sealant has set at least 24 hours. Cable shall be disconnected from the detector amplifier during testing.

Loop cable shall be installed without damaging the cable or its insulation. Damaged cables shall be replaced at the Contractor's expense. Cable shall be installed with no kinks or curls and no straining or stretching of the insulation and shall be secured as deep in the slot as possible. When loop cable crosses pavement joints, a 200-millimeter section of flexible plastic sleeve shall be installed to prevent damage from pavement shifts. A blunt object, similar to a wooden paint stirrer, shall be used to seat the loop cable. The two ends of the loop conductor cable between the roadway loop and the junction box shall be twisted together, with approximately two turns per 300 millimeters.

The lead-in cable shield (drain wire) shall be connected to ground at the controller cabinet only. The lead-in cables shall have soldered on spade connectors for attachment to the detector panel terminals. Heat shrink tubing shall be installed over the soldered connections.

3. **Pedestrian detectors:** Pedestrian detectors shall be mounted on supports as indicated on the plans. breakaway connectors shall be installed on conductor cables for pedestrian detectors on pedestal poles. Breakaway connectors shall be fused for the hot conductor and nonfused for the grounded conductor. The location of the breakaway connectors shall be in the hand hole of the pedestal pole.

(h) **Rigging Details:**

1. **Overhead span wire:** Where a 6-millimeter span wire terminates at a wood or steel pole, it shall be attached to a 15-millimeter thimbleye bolt and secured with two 2-bolt clamps. Where a 12-millimeter span wire terminates at a wood or steel pole, it shall be attached to a 19-millimeter thimbleye bolt and secured with two 3-bolt clamps.

Span wires shall be unspliced and unjointed and tightly drawn to the desired height and position while the pole is maintained in the vertical position.

Saddle clamps, strand connectors, and strain insulators shall be designed for the size of the span wire and shall meet or exceed the strength of the span wire.

Down guys shall be used on wood poles and shall be the same type of cable used in span wires. They shall be attached to the pole in the same manner and at the same height as span wires. Lateral guys placed over the roadway shall be strung to maintain a vertical clearance of at least 5.3 meters. Lateral guys and down guys shall be tightly drawn in a manner to secure the pole while its vertical alignment is maintained. Metal or approved plastic gutters shall be installed on down guys. Sidewalk struts shall be provided where the vertical distance from the sidewalk to the down guy is less than 2.4 meters.Integral messenger cable may be used for interconnect cable runs in lieu of span wire support. Signals, signs, or other equipment shall not be suspended from integral messenger cable.

Obstructions shall be bypassed by the use of special brackets or pole extensions.

2. **Tether wire:** Tether wire shall be unspliced and unjointed and attached to a pole by means of a 15-millimeter thimbleye bolt, a two-bolt clamp, and a guy sleeve. Tether wire shall be drawn in a manner to secure the attached signal head against movement caused by wind loads. Signals, signs, or other equipment shall not be suspended from tether wire.

(i) **Testing Equipment:** After energizing the signal installation, the Contractor shall demonstrate to the Engineer that electrical components are in proper working order. Faulty electrical components shall be repaired or replaced by the Contractor at his expense.

Upon completion of electrical tests, the Contractor shall conduct a demonstration test of each signalized intersection for 30 continuous days. The Contractor shall provide personnel to fine-tune and correct deficiencies in traffic signal installation(s) during the 30-day test period at his own expense. If any portion of the signal installation(s) is replaced or repaired, the portion shall be subjected to an additional 30-day test immediately after replacement or repair.

Testing of the traffic signal system master controller and system coordination shall be conducted after completion of the demonstration test of each signalized intersection.

A Phase I test and debugging period of at least four consecutive calendar days shall begin after the system has been installed and

approved by the Engineer. The test period shall conclude with a formal successful demonstration of the proper operation of system functions.

Upon successful completion of the Phase I test, the system shall undergo a Phase II operational test of at least 30 days. During this period, the system shall be programmed to provide on-line traffic control. The Phase II test will be considered complete and the system acceptable when all system functions demonstrate full compliance with the specifications. If failures occur, tests shall be stopped. After corrections are made, a new 30-day test shall commence.

Prior to final acceptance, the Contractor shall furnish the Department written certification that the system control equipment has been installed in accordance with the manufacturer's specifications.

703.04—Measurement and Payment.

Master controllers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include timing data, timing implementation, training, controller cabinets, back panels, power panels, detector panels, auxiliary panels, circuit diagrams, manufacturer's instructions, relays, auxiliary equipment, flexible cables, grounding systems, transient protection devices, radio frequency interference filters, wiring, and fittings.

Controllers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include timing data, timing implementation, training, controller cabinets, back panels, power panels, detector panels, auxiliary panels, police panels, thermostatically controlled fan units in the cabinet with a vent, flashers, local flasher switches, radio frequency interference filters, signal switches, main switches, police hand controls, conflict monitors, flasher relay assemblies, power relays, signal control assemblies, lamp receptacles and ground fault convenience receptacles, circuit diagrams, flexible cables, grounding systems, transient protection devices, and fittings.

Traffic signal head sections will be measured in units of each and will be paid for at the contract unit price per each. This price shall include mountings, lamps, molded terminal blocks, visors, backplates, fittings, realignments, and optical adjustments.

Pedestrian signal heads will be measured in units of each and will be paid for at the contract unit price per each. This price shall include mountings, lamps, visors, fittings, and realignments.

Detector amplifiers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include connecting cables and fittings.

Magnetic detector sensing elements will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the sensing element with leads, PVC conduit, trenching, backfilling, compacting, boring, sand, and repairing the pavement structure.

Pedestrian pushbuttons will be measured in units of each and will be paid for at the contract unit price per each. This price shall include fittings and sign(s).

Flashers for flashing beacons will be measured in units of each and will be paid for at the contract unit price per each. This price shall include cabinets, mounting hardware, transient protection devices, radio frequency interference filters, power panels, grounding systems, and fittings.

Saw cuts will be measured in meters and will be paid for at the contract unit price per meter. This price shall include cutting, cleaning, drilling, disposing of surplus material, backer rods, and loop sealant material.

Hanger assemblies will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pipe, brackets, clamps, balance adjusters, tether wire attachments, leveling devices, and fittings.

Illuminated traffic control signs will be measured in units of each and will be paid for at the contract unit price per each. This price shall include enclosure cabinets, sign messages, lens, lamps, internal electrical wiring and components, louvers, mounting attachments, grounding systems, and fittings.

Tether wire will be measured in meters from connection point to connection point and will be paid for at the contract unit price per meter. This price shall include thimbleye bolt assemblies and fittings.

Span wire will be measured in meters, from connection point to connection point, and will be paid for at the contract unit price per meter. This price shall include thimbleye bolt assemblies, conductor cable supports, and fittings.

Cable terminal enclosures will be measured in units of each and will be paid for at the contract unit price per each. This price shall include weatherproof enclosures, foundations, terminals, terminal panels or racks, grounding systems, and fittings.

Loop detector cable and lead-in cable will be measured and paid for in accordance with the requirements of Section 700.05.

Cleaning, painting, and grouting of existing equipment retained in signal modifications will not be measured for separate payment but will be considered incidental to other items of work.

Payment will be made under:

Pay Item	Pay Unit
Master controller	Each
Controller	Each
Traffic signal head section (Size and type)	Each
Pedestrian signal head (Standard)	Each
Detector amplifier (Type)	Each
Magnetic detector sensing element (Standard)	Each
Pedestrian pushbutton	Each
Flasher	Each
Saw cut	Meter
Hanger assembly (Standard, [ ]-way)	Each
Illuminated traffic control sign	Each
Tether wire (Size)	Meter
Span wire (Size)	Meter
Cable terminal enclosure (Standard)	Each

SECTION 704—PAVEMENT MARKINGS AND MARKERS

704.01—Description.

This work shall consist of establishing the location of pavement markings and installing pavement markings, pavement markers, and reflectorized material on specified pavements in accordance with these specifications, and the *MUTCD* and as directed by the Engineer.

704.02—Materials.

The Contractor shall use an approved inventory tracking system for all materials received from the manufacturer. Shipment of materials from such inventory shall be accompanied by the following certification:

Material shipped under this certification has been tested and approved by VDOT as indicated by laboratory test numbers listed hereon.

_____

Signature and Title

A copy of the certified delivery ticket shall be given to the Engineer upon delivery of the material.

(a) **Pavement markings:**

1. **Type A** shall conform to the requirements of Section 231.

2. **Type B** shall conform to the requirements of Section 246.

(b) **Glass beads** shall conform to the requirements of Section 234.

(c) **Pavement markers** shall conform to the requirements of Section 235.

704.03—Procedures.

The Contractor shall have a certified Pavement Marking Technician present during pavement marking operations.

Pavement markings shall be installed on new roadways prior to opening the roadway to traffic. Pavement marking installation shall be completed within the time limits herein on resurfaced roadways or other roadways where the pavement markings have been obscured and the roadway is open to traffic unless otherwise directed by the Engineer. Exceptions to the time limits specified will be granted only for weather restrictions, and installation of epoxy resin pavement markings on new pavement shall not commence until after 24 hours of final surface placement.

Pavement marking installation on roads having traffic volumes of 10,000 ADT or more shall be completed within 24 hours after resurfacing or obscuring of the existing markings.

Pavement marking installation on roads having traffic volumes between 3,000 and 10,000 ADT shall be completed within 48 hours after resurfacing or obscuring of the existing markings.

Pavement marking installation on roads having traffic volumes of less than 3,000 ADT shall be completed within 72 hours after resurfacing or obscuring of the existing markings.

If the Contractor will not have pavement markings installed within the time limits specified, the Contractor shall install Type D construction pavement markings within the same time limits and maintain such until the final pavement markings can be installed. The cost of installing, maintaining, and removing the Type D construction pavement markings shall be borne by the Contractor with no cost to the Department.

TABLE VII-1
Pavement Markings

Type	Class	Name	Surface Temp at Time of Application	Film Thickness mm (mils)	Pavement Surface	Application Limitations
A	—	Traffic paint	7 °C+	0.380 ± 0.025 when wet (15 ± 1)	AC[1] HCC[1]	May be applied directly after paving operations.
B	I	Thermoplastic alkyd	10 °C+	2.286 ± 0.125 when set (90 ± 5)	AC	May be applied directly after paving operations.
	I	Thermoplastic hydrocarbon	10 °C+	2.286 ± 0.125 when set (90 ± 5)	AC	Do not apply less than 30 days after paving operations.
	II	Polyester resin	10 °C+	0.380 ± 0.025 when wet (15 ± 1)	HCC	Needs to be coned.
	III	Epoxy resin	10 °C+	0.380 ± 0.025 when wet (15 ± 1)	AC	Pavement surface shall be at least 1 year old at time of application.
					HCC	Remove curing compounds and surface laitance before application.
	IV	Preformed tape, plastic backed	10 °C+	No less than 1.525 (60) and no more than 2.286 (90)	AC HCC	Do not use unless there is roadway lighting. Install in accordance with manufacturer's recommendations.
	V	Preformed tape, foil backed	10 °C+	No less than 0.610 (24)	AC HCC	Use only where traffic is free rolling with no twisting or starting motions. Install in accordance with manufacturer's recommendations.
C	—	Temporary tape	Manufacturer's recommendations	No less than 0.635 (25)	AC HCC	For limited use in construction zone pavement marking.
D	—	Removable tape	Manufacturer's recommendations	No less than 0.760 (30)	AC HCC	Construction zone pavement marking.

[1]AC = asphalt concrete; HCC = hydraulic cement concrete.

(a) **Pavement Markings:** Pavement markings shall be white or yellow markings as required by the *MUTCD* for the specific location or as specified by the Engineer and shall be installed in accordance with Table VII-1 unless otherwise recommended by the manufacturer and approved by the Engineer. The Contractor shall furnish a copy of the manufacturer's installation recommendations to the Engineer.

The Contractor shall perform quality control testing for application thickness and glass bead rate in accordance with VTM-94 at the beginning of each workday and every 3 hours thereafter. Testing shall be performed in the presence of the Engineer.

The Contractor shall maintain a daily log (Form C-85) for both temporary and permanent pavement markings and markers. Entries in the log shall be made in ink and be legible, and the log shall be signed by the Contractor and delivered to the Engineer by the end of each workday.

Pavement line markings shall consist of stop lines, crosswalks, and solid or skip lines used for, but not limited to, dividing lanes, marking edges, channelizing, outlining and marking safety zones around objects, and forming islands and parking lot stalls.

Crosswalks and stop lines shall be installed using Type B, Class I or IV, markings.

Sold lines or skip lines shall be installed using Type A or Type B markings as specified.

Pavement message markings shall be installed using Type B, Class I, IV, or VI markings, and shall include school zone markings, railroad crossing markings, and elongated arrows and word messages.

The Contractor shall protect the public from damage attributable to pavement marking operations. The Contractor shall be responsible for the complete preparation of the pavement surface, including, but not limited to, removing dust, dirt, loose particles, oily residues, curing compounds, concrete laitance, residues from eradication, and other foreign matter immediately prior to installing pavement markings. The pavement surface shall be dry at the time of installation when tested in accordance with VTM-94. Marking material shall not be applied within 24 hours following rain or other inclement weather.

Liquid markings shall be applied so as to prevent splattering and overspray and shall be protected from traffic until track free by the use of guarding or warning devices as necessary. If a vehicle crosses

a marking and tracks it or if splattering or overspray occurs, the affected marking and resultant tracking shall be removed and new markings applied at the Contractor's expense.

Pavement markings shall be applied evenly with a uniform application, present a uniform appearance, exhibit good workmanship, and be clearly visible at all times.

Glass beads shall be applied at the rate specified herein and shall be evenly distributed over the entire surface of the marking. Beads shall be applied to the surface of liquid markings by a bead dispenser attached to the applicator that shall dispense beads simultaneously on and in the just-applied marking. The bead dispenser shall be equipped with a cut-off control synchronized with the cut off of the applied marking material so that the beads are applied totally to the completed line. Beads shall be applied while the liquid marking is still fluid. Approximately 70 percent of beads shall be buried in the marking, and the remaining 30 percent shall be 50 to 60 percent embedded in the surface. Beads installed on crosswalks and stop lines on roadways with curbs only (no gutter) may be hand applied for 600 millimeters at the end of each line next to the curb with 100 percent of the beads embedded 50 to 60 percent in the surface. Markings found to be unacceptable shall be removed, and new markings applied at the Contractor's expense.

1. **Type A markings:** Paint shall be selected from the Department's approved list and may be applied to asphalt concrete and hydraulic cement concrete pavements. Paint shall not be applied over existing pavement markings of other materials unless the marking is 90 percent removed. Paint may be applied over existing paint markings.

   Paint shall be applied with a line painting machine that is capable of hot spraying paint directly onto the pavement surface with a uniformity of feed through its nozzles for widths of 100 through 200 millimeters. The machine shall be capable of applying two pavement stripes, either solid or skip, at the same time when double line markings are required. Paint tanks on the equipment shall be equipped with a mechanical agitator, and paint shall be thoroughly mixed and heated such that it will not track within 60 seconds after its application.

   Non-truck mounted equipment shall be self-propelled and regulated to allow for calibration of the amount of material applied.

   Glass beads shall be applied to the surface of the paint at the rate of 0.72 kilogram per liter of paint.

2. **Type B markings:** Equipment shall be capable of providing mixing, heating, and agitation of material. Material shall be uniformly heated throughout the system in accordance with the manufacturer's recommendations. Thermoplastic material shall be maintained in the heating kettle and applied to the road surface at a minimum temperature of 204 °C. Heating kettles shall be equipped with an automatic thermostatic control device. The Contractor shall furnish a properly calibrated infrared instrument for the purpose of measuring the actual temperature of molten thermoplastic material. Multi-component material shall be applied using internally injected guns for the mixing of catalyst and hardener.

   Non-truck mounted equipment for application of thermoplastic material shall be of the screed extrude type with a screw drive or shall be self-propelled and regulated to allow for calibration of the amount of material applied. Non-truck mounted equipment for application of polyester and epoxy resin material shall be self-propelled and regulated to allow for calibration of the amount of material applied.

   a. **Thermoplastic (Class I)** material shall be applied only on asphalt concrete pavements and shall be applied by screed extrude, ribbon gun, or spray equipment.

      Thermoplastic shall not be applied over existing pavement markings of other materials unless the marking is 90 percent removed. Thermoplastic may be applied over existing thermoplastic markings. For concrete bridge decks that occur in asphalt roadways, Type B, Class VI, tape shall be used.

      Primer/adhesive shall be applied to asphalt concrete surfaces more than two years old and shall be from the same manufacturer as the thermoplastic.

      Glass beads shall be applied to the surface of the marking at the rate of 3.18 kilograms per 9.29 square meters.

   b. **Polyester resin (Class II)** material shall be applied only on hydraulic cement concrete pavements. Polyester resin shall not be applied over existing pavement markings of other materials unless the marking is 90 percent removed. Polyester resin may be applied over existing polyester resin markings.

      Glass beads shall be applied to the surface at the rate of 0.96 kilogram per liter of material.

c. **Epoxy resin (Class III)** material shall be applied only to asphalt concrete pavement more than one day old and hydraulic cement concrete pavement. Epoxy resin shall not be applied over existing pavement markings unless the existing marking is 90 percent removed.

Glass beads shall be applied by the gravity method to the surface at the rate of 3 kilograms per liter of material.

d. **Preformed tape** shall be selected from the Department's approved list and shall be installed in accordance with the manufacturer's recommendations and as denoted herein. Tape may be applied to asphalt concrete and hydraulic cement concrete pavements. Tape may be installed immediately following the final rolling of the new asphalt concrete surface. Tape shall not be applied over existing pavement markings of other materials unless the marking is 90 percent removed. Tape may be applied over existing tape markings of the same type.

Primer/adhesive shall be used for all installations except when tape is applied immediately following the final rolling of the new asphalt concrete surface and shall be from the same manufacturer as the tape.

Tape for pavement line markings shall be applied by an application cart as recommended by the manufacturer. Tape shall be tamped into place with a tamper cart with the mass recommended by the manufacturer. The use of a vehicle to ride over the markings for tamping will not be permitted.

(b) **Eradication:** Eradication of pavement markings for restriping when required shall be in accordance with Section 512 except only 90 percent removal of the existing markings is required.

(c) **Pavement Markers:**

1. **Snow-plowable raised pavement markers** shall be installed by cutting two parallel grooves into the pavement at the depth and dimensions recommended by the manufacturer. Grooves shall be parallel to the adjacent pavement marking. Grooves shall be cut with saw blades having a diameter to match the curvature of the steel casting bottom and keels. Keel surfaces shall be free from scale, dirt, oil, grease, or any other contaminant that might reduce bonding.

Casting keels shall be bonded in the saw-cut grooves in the manner recommended by the manufacturer of the marker. The

bonding material shall be from the Department's approved list or as recommended by the manufacturer of the marker. Noses of the casting shall be installed flush with the pavement surface. The installed height of the raised pavement marker shall be approximately 13 millimeters above the pavement surface.

The top of reflectors shall be mounted flush with the top of the casting.

2. **Recessed pavement markers** shall be installed by cutting a slot in the pavement. The slot shall be parallel to the adjacent pavement marking. The slot shall be wide enough for the marker to fit freely into the slot and deep enough to allow the use of epoxy adhesive. The installed top of the marker shall be flush with the pavement surface or not more than 2 millimeters below the pavement surface.

   The marker shall be bonded in the cut slot in accordance with the manufacturer's recommendations. Bonding material shall be from the Department's approved list or as recommended by the manufacturer of the marker.

3. **Raised pavement markers** shall be bonded to the pavement surface in accordance with the manufacturer's recommendations. Bonding material shall be from the Department's approved list or as recommended by the manufacturer of the marker except epoxy shall not be used on asphalt concrete pavements.

704.04—Measurement and Payment.

Pavement line markings will be measured in meters and will be paid for at the contract unit price per meter. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement message markings will be measured in units of each per location for the symbol or word specified and will be paid for at the contract unit price per each. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement markers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include prismatic retroreflectors, pavement cutting, adhesive, and castings.

Eradication of pavement markings will be measured and paid for in accordance with Section 512.

Payment will be made under:

Pay Item	Pay Unit
Pavement line marking (Type and/or class and width)	Meter
Pavement message marking (Message)	Each
Pavement marker (Type, [ ]-way, and or type pavement)	Each Each

SECTION 705—LIGHTING SYSTEMS

705.01—Description.

This work shall consist of furnishing, installing, and testing proposed lighting systems and modifying or relocating existing systems in accordance with these specifications and in reasonably close conformity to the lines and details shown on the plans or as established by the Engineer.

705.02—Materials.

Photoelectric controls shall conform to the requirements of Section 238.

705.03—Procedures.

The Contractor shall verify or locate the origin of the power source and verify voltage when modifying, removing, or relocating existing electrical systems and shall advise the Engineer at least 48 hours prior to the anticipated time of deenergizing any portion of the electrical system. Work shall be performed in accordance with the requirements of NEC and the standards of the local power company.

(a) **Luminaires for Roadway Lighting:** Luminaires shall be installed in accordance with the manufacturer's recommendations. Luminaires shall be adjusted for maximum illumination and uniformity on the pavement or sidewalk as directed by the Engineer.

(b) **Sign Luminaires:** Luminaires shall be shielded to eliminate glare or extraneous light on the roadway and shall provide a maximum-to-minimum uniformity ratio of 1:1 to 6:1 when installed. When tested at the center of a 3-meter-square test panel, the luminaire shall provide at least 323 average initial lux and a gradient (ratio of illumination on any two adjacent 0.09 square meter of sign surface) of 2:1 or less.

(c) **High-Mast Luminaire Assemblies:** Assemblies shall consist of a head frame assembly; luminaire ring; luminaire(s); winch assembly; a fail-safe mechanism to prevent accidental lowering of the luminaire ring; and incidentals necessary to raise, lower, and supply and control power to the luminaire ring. When an electric drill is required for raising and lowering the assembly, one drill shall be provided for each set of five high-mast luminaire assemblies or fraction thereof.

1. **The lowering system** shall be compatible with the lighting pole and capable of raising and lowering a luminaire ring with eight luminaires.

2. **The head frame assembly, luminaire ring, and canopy** shall be of a material that is resistant to weather, corrosion, and ultraviolet rays. The centering arms of the assembly shall provide stabilization of the luminaire ring during raising and lowering operations and shall maintain contact with the lighting pole for at least 2/3 of its length. A fail-safe latching mechanism shall be included in the head frame assembly that will remove the tension from the lowering cables when the luminaire ring is attached.

3. **The winch assembly** shall include power cables of 600 volt, multiconductor No. 10 (minimum), UL type SO; lowering cables of stranded stainless steel having a breaking strength of at least 28,500 newtons per cable; and a 13-millimeter heavy-duty reversing electric drill or electric motor suitable for operation at the voltage shown on the plans. The winch assembly shall have a remote control that allows operation at least 4.5 meters from the lighting pole and shall be designed for lowering and raising the assembly by hand.

4. **A junction box with a prewired terminal block** shall be furnished on the lowering ring with provisions for a photoelectric control. A circuit breaker shall be mounted in the hand hole area of the lighting pole. A watertight twist-lock power receptacle and plug shall be provided for deenergizing the luminaire ring during raising and lowering operations and providing power for testing luminaires in the lowered position.

(d) **Ballast:** The ballast shall be compatible with the luminaire and shall be a multivolt type capable of operating on 120-, 208-, 240-, and 277-volt electrical services. Ballasts for luminaires with lamp wattages of 150 watts or less may be nonregulating or regulating, having a power factor of more than 90 percent. Ballasts for luminaires with lamp wattages more than 150 watts shall be regulating. Nonregulating ballasts shall regulate lamp wattage within a line voltage variation of ±5 percent. Regulating ballasts shall regulate lamp wattage within a line voltage variation of ±10 percent. The

Contractor shall certify that ballasts serving high-pressure sodium luminaires have a volt-watt characteristic curve that intersects the lamp voltage limit lines at points between the wattage limit lines throughout the full range of the lamp life and rated ballast line voltages. The basic and allowed variable volt-watt characteristic curves shall not intersect the wattage limit lines.

Ballasts and starting aids shall be capable of operating with the lamp in an open condition for 6 months without significant loss of ballast life and starting the lamp at temperatures as low as -29 °C.

(e) **Control Centers:** Enclosures for control centers shall be NEMA 3R with provisions for locking. Electrical equipment shall be UL listed for the use indicated on the plans.

(f) **Testing Electrical Components:** After energizing the lighting system, the Contractor shall demonstrate to the Engineer that electrical components are in working order. Faulty components shall be repaired or replaced by the Contractor at his expense.

The Contractor shall perform an operational test of the completed system under normal operating conditions for at least 3 consecutive days. Defective materials or improper installations shall be corrected by repairs or replaced by the Contractor at his expense.

705.04—Measurement and Payment.

Luminaires will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the body, slipfitters, refractors, ballast, reflectors, sockets with lamps, conductor cables to the termini at the base, photoelectric controls and sockets, adjustment, and testing. Luminaires for sign lighting will not be measured for separate payment but shall be included in the price for overhead and bridge-mounted sign structures.

High-mast luminaire assemblies will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the luminaire rings, lowering devices with head frames and assembly, winch assembly, electric raise/lower units, lowering cables, conductor cables to the termini at the base, luminaire units, lamps, photoelectric controls and sockets, testing, and adjustments.

Control centers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include conduits, metal enclosures, ground rods, conductor cables, anchor bolts and templates, excavating, concrete, safety switches, panel boards, contractors, circuit breakers, photoelectric controls, terminal blocks, selector switches, testing, and adjustment.

Payment will be made under:

Pay Item	Pay Unit
Luminaire (Size and type)	Each
High-mast luminaire assembly (Number of luminaires, size, and type)	Each
Control center (Standard and type)	Each

INDEX

Abbreviations and acronyms, 3
Acceptance of work, 47
Admixtures for hydraulic cement concrete, 184
Advertisement, Notice of, 5
Aggregate base course, 360
Aggregate base material, 141
Aggregates
  acceptance procedures, 126
  certification, 127
  coarse, 131
  crusher run, 135
  fine, 129
  handling and storing, 127
  lightweight, 136
  nonpolishing, 127, 151, 390, 439
Air pollution, 81
Allaying dust, 616
Alteration of character of work, 28
Alteration of quantities, 28
Aluminum alloy, 219
Anchor bolts
  installation procedures, 525, 599, 690
  materials, 213
Anchors, *see* Bearing devices and anchors
Archeological findings, 83
Arches, filled spandrel, 417
Arrows, electronic, 618
Asphalt concrete
  acceptance, 160
  job-mix formula, 153
  materials, 150
  mixture, preparation, 169
  payment adjustment system, 162
  plant requirements, 165
  referee system, 163
  storage system, 169
  testing, test, 158
  types of mixtures, 156
Asphalt concrete pavement
  compacting, 380
  density requirements, 381
  equipment, 374
  placing and finishing, 375, 378
  priming, 377
  samples, 385
  tolerances, 385
Asphalt materials, 150
Asphalt plant, 165
Asphalt surface treatment, 368
Attenuators, impact, 621
Award of contract, 23

Backfill
  culverts, 305, 313
  porous, 135
  replacing undercut excavation, 322
  storm drains, 305, 313
  structures, 322
Bar chair supports, 482
Bar mats, 209
Barricades, 77
Barrier service, 619
Barriers
  delineators, 706
  silt, 318
  sound walls, 640
  traffic, 619
  see also Median barriers
Base course, 141, 360
Basements, demolition, 635
Batcher, certification of, 128
Beads, glass, 241
Bearing areas, bridge seat, 462
Bearing devices and anchors
  materials, 246
  placement procedures, 522
Bearing piles, 421
Bedding materials, 246
Bidders
  disqualification, 20
  prequalification, 15
  requirements, 15
Bids, 5, 18
Bolts, 214
Bonds
  bid, 15
  contract, 24, 27
Borrow, 321

Box culverts, 309, 451
Breakaway support systems, 693
Brick, 208
Bridges
  asphalt overlay removal, 582
  conduit, 615
  construction over navigable waters, 80
  deck construction, 459
  deck grooving, 464
  deck overlay, 547
  deck repair, 545
  drainage aprons and chutes, 591
  finishing concrete, 462
  guardrail attachments, 643
  joints, 454, 460
  latex concrete, 543, 547
  lighting systems, 577
  median barriers, 530
  opening to traffic, 464
  seat bearing areas, 505
  widening, 542
Bronze alloy, 221
Buildings
  demolition, 634
  use by Contractor, 634
Burning, 81

Cables
  aerial, 693
  color coding, 695
  conductor, 693
  interconnect, 696
  lighting conductor, 695
  lighting systems, 746
  loop detector lead in, 721
  materials, 253
  signal, 695
  splicing, 694
Caissons, drilled in, 415
Calcium chloride, 616
Castings, 211
Catch basins, 209
Cement, hydraulic
  stabilization, 350
  types, 184
Channel preservation, 413
Channelizing devices, 619
Check dams, 318
Cisterns, 320
Claims
  damage, responsibility, 78
  disposition, 48
  extension of time, 48, 89
  submission, 48
Cleanup, 36
Clearing and grubbing, 299
Clearing parcels, 634
Cofferdams, 415
Combustibles, disposal of, 299
Common carrier rates, 110
Compaction
  see Density
  see Asphalt concrete
  see Hydraulic cement concrete
Concrete pavement
  see Asphalt concrete pavement
  see Hydraulic cement concrete pavement
Conduit systems
  bridges, 577
  traffic control, 696
Construction joints,
  hydraulic cement concrete, 454
Contract
  alteration, 28
  award, 23
  bond requirements, 24
  cancellation of award, 24, 27
  calendar day, 90
  contract time, 89
  default, 92
  documents, 25
  eliminated items, 104
  execution and approval, 27
  extension of contract time, 89
  failure to execute, 27
  fixed date, 90
  liquidated damages, 92
  miscellaneous provisions, 110
  Notice to Proceed, 86
  provisions, 40
  quantities, 28
  subcontracting, 86
  termination, 94
  time limit, 89

Contract documents
ambiguity in, 18, 40
coordination, 40
list, 25
Contractors
cooperation, 43
insurance, 25, 64
limitation of operations, 87
progress schedule, 89
prosecution of work, 86
responsibility for work, 84
separate contracts, 43
termination of responsibility, 95
Control strips, density, 382
Copper alloy, 221
Corps of Engineer Permits, 60
Crib walls, 605
Culverts
see Box culverts
see Pipe
Curb and gutter, 589
Curb cut ramps, 592
Curing materials, 205
Cut, *see* Excavation

Damp-proofing
application procedures, 571
materials, 180
Definitions, 5
Delineators
installation procedures, 707
materials, 242, 706
Demolition basements, 635
buildings, 634
pavement, 609
structures, 557
Density
aggregate base course, 361
asphalt concrete pavement, 411
cement-stabilized courses, 354
control strips, 338
embankments, 325
hydraulic embankments, 328
lime-stabilized courses, 348
pipe backfill, 305
shoulders, 343
subbase courses, 357
subgrade, 341
Department-furnished material, 53
Detectors, *see* Traffic signals
Detours
during construction, 32
temporary, 623
Direct tension indicators, 214
Dismantling structures, 557
Disposal areas, 54
Drainage aprons and chutes,
bridge, 591
Drainage structures, 301
Drop inlets, 311
Dust, allaying, 616

Earth berms, 317
Earthwork
construction procedures, 319
erosion control, 316
hydraulic, 327
shrinkage/swell, 331
slopes, 320, 324, 325, 329
surplus material, 329
tolerances, 329
Easements, 85
Elastomeric pads
bridges, 525
materials, 246
sound barrier walls, 642
Elastomeric expansion dams, 579
Electrical components, 251
Electrical service bridge lighting
systems, 577
roadway traffic control, 708
temporary signalization, 6216
Electronic arrows, 618
Eliminated items, 104
Embankments, *see* Earthwork
End sections
installation procedures, 302
materials, 301
Endwalls, 305, 311
Energy dissipators, 592
Engineer
definition, 8
duties and authority, 36
Entrance gutter, 589
Environmental protection
air pollution, 81

erosion control, 79
forests, 82
noise pollution, 82
siltation control, 79
stipulations, 79
water pollution, 80
Epoxy mastic coating, 226
Epoxy resin systems, 266
Epoxy-coated steel, 210
Equal Employment Opportunity, 111
Equipment
character, 92
rental, 102
warranties, 51
Erosion and siltation control, 78, 335
Escrow, 24, 109
Excavation
borrow, 321, 332
minor structure, 322, 332
overhaul, 329
presplitting, 331
regular, 320
rock, 320, 330
slopes, 329
structure, 413
undercut, 322, 332
Expansion dams, elastomeric, 579
Explosives, use of, 77, 320
Extra work, 101

Fabric, *see* Geosynthetics
Falsework
installation procedures, 446
working drawings, 37
Federal-aid provisions, 62
Fences
construction procedures, 606
materials, 261
Fertilizer
application procedures, 668
materials, 274
Field office, 629
Fill
procedures, 323
see also Embankment
Filter cloth, *see* Geosynthetics
Fire hydrants, 652, 659
Fixed object attachments, 601
Flaggers, 32, 63, 618
Floors
plank, 576
steel grid, 526
Flumes, paved, 591
Fly ash, 185, 260
Force account work, 101
Forest fires, 82
Forgings, steel, 211
Forms
concrete, 439
corrugated metal bridge deck, 441
prestressed deck panel, 443
removal, 456
Foundations
retaining walls, 603
sound barrier walls, 644
structures, 414
traffic control devices, 691
Frames and covers
installation procedures, 311, 313, 653
materials, 211

Gabions, 683
Galvanized surfaces, painting, 539
Galvanizing, 240
Geosynthetics
installation procedures, 318, 336
materials, 281
Girders
concrete, 451
steel, 487
Glass beads, 241
Grades, lines, and stakes, 44
Grading operations, 34, 316
Gratuities, 87
Gravel, crushed, 135
Grout, 203
Grubbing, 299
Guaranty
material, 22, 51
proposal, 20
return of proposed guaranty, 24

Guardrail
installation procedures, 598
materials, 206
Gutters, 589

Handrails, 594
Hauling
public roads, 47
rate, 110
route, 35
Health standards, 120
Herbicides
materials, 271
spraying procedures, 680
Historic sites, 83
Holidays, 44
Hydraulic cement concrete
acceptance tests, 198
classification of mixtures, 194
consolidation, 447
construction joint bonding, 454
construction joint exposure to tidal waters, 455
curing, 456
equipment, 192
finishing surfaces, 462
forms, 456
latex modified, 188, 195, 547
materials, 187
mixing, 199
placement procedures, 202, 447
pneumatic placement, 452
prestressed, 466
protection, 457
silicone treatment, 458
tremie, 452
Hydric soil, 272
Hydraulic cement concrete pavement
cold weather protection, 402
consolidation, 399
curing, 401
depth, 409
dowels, 398
equipment, 391
finishing, 401
form removal, 406
forms, 391, 394
grade preparation, 393
joints, 396
opening to traffic, 408
patching, 611
placement procedures, 393, 395
reinforcing steel placement, 393
rideability, 402
slipforming, 392
straightedging, 400, 404
test, beam, 395
texturing, 401
tolerances, 409
Hydroseeding, 258, 668, 669

Impact attenuators, 621
Inspection
materials, 51
work, 45
Inspectors, duties and authority, 45
Insurance
railroad, 65
workers' compensation, 25

Joint materials, 170
Joint sealer, elastomeric, 578
Joints
see Asphalt concrete pavement
see Bridges
see Construction joints
see Hydraulic cement concrete pavement
Junction boxes
drainage, 314
electrical, 252, 699

Labor and wages, 111
Latex modified concrete, 188, 195, 547
Latex modifier, 188
Liability of public officials, 85
Light poles, steel for, 213, 689
Lighting systems, 748
Lime
agricultural application, 259, 668
stabilization, 260, 346
types, 260
use in asphalt concrete, 151
Limitation of operations, 87

Lines, grades, and stakes, 44
Liquidated damages, 92
Local material sources, 51
Lumber, 244
Luminaires, 746

Mailbox, 36
Maintaining traffic, 616
Maintenance during construction, 31
Major contract items, 29
Manholes
  drainage, 307, 311
  materials, 208
  sanitary sewer, 653
Masonry units, 208
Material Safety Data Sheet, 56, 126
Materials
  acceptance, 50, 52, 126
  control, 50
  critical, 87
  found on project, 56
  furnished by Contractor, 54
  furnished by Department, 53, 59
  handling, 58
  inspection, 51
  local sources, 51
  on hand, payment, 107
  patented, 61
  rights and uses, 56
  sampling, 56, 125
  shipping rates, 110
  source of supply, 50
  storage, 58
  testing, 56, 125
  unacceptable, 58
  warranties, 22, 51
Measurement and payment, 95
Median barriers
  bridge, 530
  concrete, 590
  steel, 598
Median strips, 590
Mineral fillers, 128
Mineralogical findings, 83
Minimum wage, 111
Minority Business Enterprises, 117
Mobilization, 628
Modification of existing items, 614
Mortar, 203
Mowing, 681
Mulch
  application procedures, 668
  materials, 276

Nationwide federal permit, 60
Navigable waters
  bridge over, 77
  construction over or adjacent to, 77
Newspaper boxes, 36
Notch toughness, 212
Notice of Advertisement, 5
Notice to Proceed, 10, 86
Nuclear gage, 325, 358, 361, 381, 631

Obscuring roadway, 609
Office, field, 629
Opening section of project to traffic, 83
Overhaul, 329
Overruns, 29
Overseeding, 668

Paint, 221, 534
Painting of metal, *see* Protective coating of metal
Paleontological findings, 83
Parapets, 530
Patching
  bridges, 545
  hydraulic cement concrete pavement, 611
Patent, 61
Paved ditches and flumes, 589
Pavement
  demolition, 609
  planing, 632
  see also Asphalt concrete pavement
  see also Hydraulic cement concrete pavement
Pavement markers
  installation procedures, 744
  materials, 241

Pavement markings
  eradicating, 622
  installation procedures, 622, 623, 624, 741
  materials, 283
Payment
  altered quantities, 101
  bond, 24
  escrow account, 106
  final, 108
  materials on hand, 107
  partial, 105
  scope, 100
  withholding, 105
Performance bond, 24
Permits, 60
Piles
  bearing, 421
  bearing capacities, 430, 436
  cast in place, 424
  driving, 428
  length determination, 426
  loading tests, 432
  materials, 421
  order list, 427
  penetration, 430
  preboring, 438
  precast, 432
  protection, 426
  sheet, 419
  splicing, 422
  steel or steel pile shells, 425
  timber, 421, 435
  tips, 428, 480
  tolerances, 430
Pilot vehicles, 618
Pipe arches
  installation procedures, 305
  materials, 232
Pipe culverts, jacked methods, 302
Pipe installation
  drainage, 302
  underdrains, 585
  water and sewer, 649
Pipe, types of, 232
Pits and quarries, 51
Plan quantities, 99
Planing pavement, 632
Plans, 37, 39, 40
Plants for roadside development
  materials, 278
  planting, 672
Pneumatic placement of concrete, 452
Poles, 692
Pollution, 80
Posts
  erosion control, 262, 264, 265
  fence, 606
  guardrail, 207, 598
  sign, 692
Precast drainage structures, 307
Precast structures, furnishing and erecting, 39
Preservatives, wood, 265
Prestressed concrete, 466
Prestressing tendons, 210
Prime coat asphalt, 377
Profilograph, 385, 403
Progress of work, 86
Progress schedule, 89
Project acceptance, 48
Proposals, 17
Protection and restoration of landscape and property, 78, 108
Protective coating of metal
  environmental protection, 539
  existing structures, 538
  general procedures, 532
  materials, 532
  new structures, 537
  painting galvanized surfaces, 539
Pruning, 676

Quantities
  alteration, 28, 101
  compensation for altered quantities, 101
  measurement, 95
  plan, 99
  proposal, 17
Quarries, 51

Railings, 528

Railway-highway provisions, 63
Reconstructing existing structures, 542
Recycled material
  asphalt pavement, 152
  hydraulic cement concrete, 132, 136
Reflective sheeting, 290, 701
Reinforced steel
  installation procedures, 480
  materials, 209
Relocating existing items, 614
Removal and disposal of structures and obstructions, 35
Removal of unacceptable and unauthorized work, 46
Repairing existing structures, 542
Reseeding/Overseeding, 668
Restoration
  property, 78, 108, 647
  work performed by others, 62
Retaining walls, 602
Retroreflectors, 241
Right of way, 85
Right-of-way monuments
  installation procedures, 539
  materials, 204
Riprap
  materials, 135
  placement procedures, 559
Rubble gutter, grouted, 590

Safety standards
  during construction, 120
  public, 62
Salt (sodium chloride and calcium chloride), 616
Sanitary provisions, 62
Sanitary sewer facilities, 646, 653
Scales, 95
Seal coat, 366
Seed
  application procedures, 668
  materials, 272
Select material, 137
Septic tanks, 320, 335, 447
Settlement boxes, 318
Settlement plates, 327
Shop drawings, *see* Working drawings
Shoulders, 341
Sidewalks, 594
Sign islands, 590
Sign structures, 689, 692
Signalization, temporary, 621
Signals, *see* Traffic Signals
Signs
  erection, 704
  fabrication, 700
  posts, 689, 692
  sheeting, protecting, 703
  storage, 703
  temporary, 617
  transporting, 703
  warning, 77
Silt barriers, 318
Siltation control, 79, 316
Site of work, examination, 19
Size limitations, 47
Slag
  aggregate, 132
  use in hydraulic cement concrete, 190
Slides, removal, 331
Slope protection, 562, 566
Sod
  materials, 277
  placement procedures, 671
Sodium chloride, 258
Soil retention coverings, 280, 679
Soil stabilization mats
  installation procedures, 679
  materials, 280
Source of supply, 50
Specialty items, 86
Specifications
  materials, conformance with, 125
  coordination with contract documents, 40
Spraying, herbicide, 680
Spring boxes, 311
Stakes, lines, and grades, 44
Steel forgings, 211
Steel shafting, 211
Steel, structural, 212

Steel structures
bolt holes, 490, 496
bolt tension, 498
erection procedures, 495
fabrication procedures, 485
falsework, 503
handling and storing, 495
painting, 503, 537
straightening and curving, 487, 503
welding, 486
working drawings, 485
Steps, 597
Stone, 135
Storm drains, 301
Structural plate, 238
Structural steel, 212, 484
Stud shear connectors, 213, 493
Stumps, 299, 665
Subbase materials, 141
placement procedures, 357
Subcontracting, 86
Subgrade, 341
Subsurface data, 17
Suppliers, debarred, 23
Surcharge, 327
Surface course, 370
Surface treatment, 368
Surplus material, disposal of, 329
Suspension of work, 91

Tack coat, 362
Tanks, underground, 320
Technicians, certification and classification, 128
Temporary structures, 35
Timber
disposition, 299
merchantable, 300
preservatives, 246
structures, 572
Time limits, 89, 92
Topsoil
application procedures, 666
materials, 272
Traffic barrier service, 619
Traffic control devices
delineators, 241, 706
pavement markings and markers, 738
signs, 700
temporary, 617
see also Traffic signals
Traffic signals
controllers and cabinets, 710, 717, 730
detectors, magnetic, inductive loop, 728, 733
flashers, 717
signal heads, 725
testing and demonstration, 735
Trainees on construction projects, 637
Transplanting, 673
Trees
planting, 674
pruning, 676
removal, 299, 665
replacement, 678
wells and walls, 682

Undercut excavation, 322, 332
Underdrains
installation procedures, 585
materials, 585
outlet markers, 586
structure excavation, 413
Underruns, 29
Unions, 115
Unsuitable material, removal of, 322
Utilities
adjustments, 647
Contractor's responsibility, 84, 416
Utility coordinator, 636

Value engineering proposals, 29
Virginia Test Methods, 126

Wages, 111
Walls
retaining, 602
sound barrier, 640
Warning lights, 618
Warning signs and barricades, 77

Warranties, 22, 51
Water, 186
Water facilities
  disinfecting mains, 657
  placement, 649
  testing, 653
Water gates, 608
Water supply, protection of, 80, 84, 648
Waterproofing
  materials, 180
  procedures, 569
Waterstops
  installation procedures, 461
  materials, 180
Weight limitations, 47
Welder certification, 487
Welds
  reinforcing steel, 483
  structural steel, 486
Wells, 320, 635
Wire mesh, 209
Wood products, 244
Work
  acceptance, 47
  alteration of character, 28
  authority to begin, 86
  Contractor's responsibility, 84
  examination of site, 17
  failure to complete on time, 92
  inspection, 45
  prosecution, 86
  removal of unacceptable and unauthorized, 46
  suspension, 91
Workers, character of, 88
Workers' compensation insurance
  certificate, 25
Working drawings, 37
Wrenches, calibrated, 499

NOTES

NOTES

NOTES

NOTES