

8

ROLLER PATTERNS, CONTROL STRIPS, AND TEST SECTIONS

LEARNING OUTCOMES

- Understand the procedures and methods for establishing the roller pattern
- Understand the procedures and methods for establishing the control strip
- Understand the procedures and methods for evaluating aggregate test sections

INTRODUCTION

In order to determine if maximum density in the field has been achieved, we must first establish a target density. The actual density tests are taken in the field and compared to that ideal or target density to determine whether the tests pass or fail. The following flow chart demonstrates the appropriate methods used to establish the targets and then the corresponding testing methods used to determine density in place for both soil and aggregate materials.

This chapter will discuss the establishment of a target density for aggregates by means of a roller pattern and control strip using the nuclear gauge method of testing.

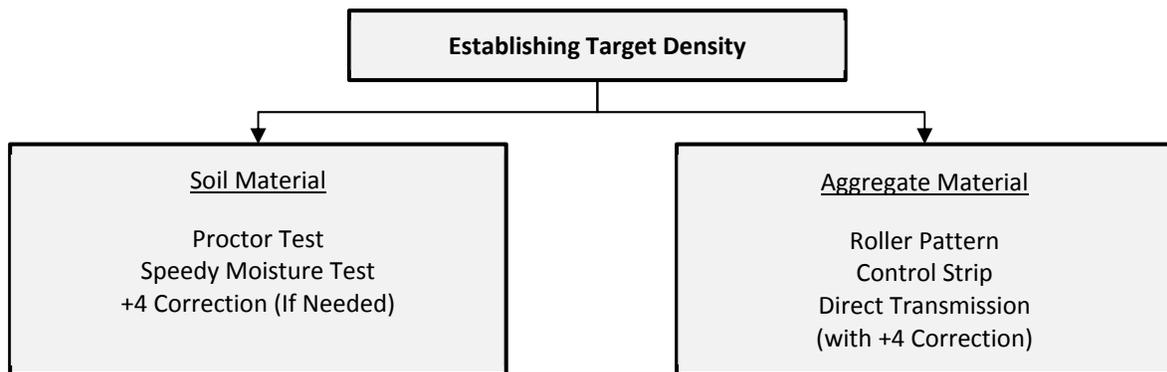


Figure 8.1: Testing Methods for Establishing Target Densities

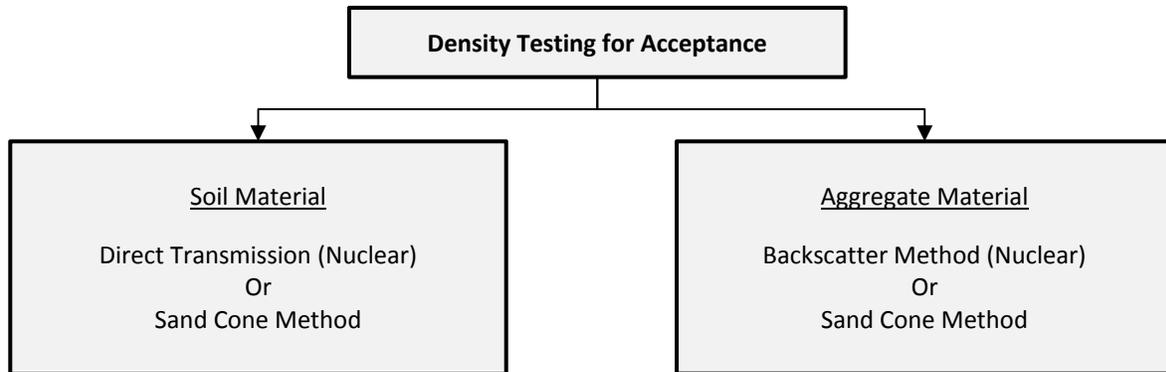


Figure 8.2: Testing Methods for Material Acceptance

TESTING PROCEDURES FOR AGGREGATE BASE, SUBBASE, AND SELECT MATERIALS (Roller Pattern, Control Strip, Direct Transmission, and Acceptance Testing)

Before any acceptance testing can be performed on aggregate base, subbase, or select material, a roller pattern, control strip, and direct transmission test must be established. A roller pattern/control strip is a section of roadway on which the construction technique (placing, compacting, and shaping) of the material to be tested has been closely monitored and evaluated. A direct transmission test (VTM-10 Appendix D) is taken at the end of the control strip to compare its results to the Theoretical Maximum Density as established in accordance with VTM-1.

There are three requirements that must be met by the roller pattern/control strip/direct transmission test:

- 1) Roller Pattern – the establishment of a graphical comparison between roller passes and the density achieved; this gives the number of passes needed on the material to achieve the required density.
- 2) Control Strip – the determination of the average dry density of the control strip, which has been rolled according to the pattern established by the roller pattern; this provides the Control Values, which govern the acceptance of the Test Sections.
- 3) Direct Transmission Test – the comparison of the results of a direct transmission test to the Theoretical Maximum Density in accordance with VTM-1; this verifies that the Control Strip attained the maximum density achievable and therefore may be used to govern the Acceptance Test Sections.

Before the construction of a control strip, the Inspector and Contractor should be familiar with VDOT Specification Section 304. A copy of this Specification is located in Appendix C. If assistance is needed in setting up the roller pattern and control strip, contact the District Materials' Engineers office.

Initial Requirements:

- A. A roller pattern must be established for each control strip. Before establishing these tests, communication with the contractor is fundamental to achieving accurate test results.

- B. The results of the roller pattern are recorded on Form TL-53, the control strip on Form TL-54, the direct transmission test on Form TL-124 and the test section on Form TL-55.
- C. All equipment should remain off the control strip until the material has been placed on the entire area.
- D. After the material has been placed, the roller and water truck are the only two pieces of equipment allowed on the control strip until maximum density has been obtained.

ROLLER PATTERN CONSTRUCTION

Equipment needed:

- Portable Nuclear Moisture-Density Gauge
- 6 foot charger cord
- Reference Standard Block
- Leveling Plate/Drill Rod Guide
- Drill Rod with Extraction Tool
- Hammer
- Compaction Equipment (that is typical for the rest of the project)

The material used to construct the Roller Pattern must also be representative of the material that will be used for the Control Strip and Test Sections. A change in material will require a new roller pattern.

NOTE: For base, subbase and select material, the Backscatter method can be used.

Roller Pattern Procedure:

NOTE: A set of forms at the end of this chapter follows this procedure step by step through the readings and calculations.

- 1) Establish an area at least 10 feet from any structure and 33 feet from any other radioactive sources to take the Standard Counts. The area should be firm, such as a concrete or asphalt slab, or well compacted soil with a minimum density of 100 lbs/ft³. Allow the 3440 gauge to complete a 4 minute count cycle with the gauge on the standard block. Be sure the standard counts you get a “P” next to each of them indicating they pass. These readings should be recorded on the top of the TL-53, TL-54, TL-55 and TL-124.
- 2) Select a level and uniform section of roadway that is large enough for the roller pattern (about 75 feet long for the typical application width – an area of at least 100 yd²). Place the material on this section of roadway at the proper loose depth before any rolling is started. For shoulder material, the Roller Pattern should be sufficient length, so as to have an area of at least 100 yd². The material must be compacted uniformly from bottom to top and in the same manner as the remainder of the job.

The moisture content of aggregates should be kept as near optimum as possible throughout the rolling operation. Water must be added when needed to maintain optimum moisture in accordance with

Section 308 and 309 of the Road and Bridge Specifications during the compaction process. Section 309.05 states after mixing and shaping each layer shall be compacted at optimum moisture within ± 2 percentage points of optimum.

- 3) Make passes with the roller over the entire surface of the roller pattern. One pass is counted each time the roller crosses the test site. Make sure the previous pass has been completed over the entire surface before the next pass is started. When testing aggregates, take a nuclear test for density and one for moisture in the 15-second mode, using the Backscatter Method. This test should be made at three randomly selected points with good surface conditions. Try to spread the 3 tests over most of the 75 foot section, making sure not to test any closer than 18" to an unsupported edge. Be sure to mark the exact location of each test. If paint is used to mark the test locations, be careful not to paint the gauge (use a template). Record the dry density and percent moisture on TL-53 and obtain the total and average for both moisture and density. Plot the average dry density versus the number of roller passes on the graph. All further tests for the roller pattern must be made in the same 3 locations, with the gauge source rod pointing in the same direction as the first test.

Make 2 more passes with the roller over the entire surface of the Roller Pattern, and again take 3 density and moisture readings in the exact same location as the first test. Record these readings under Test No. 2 and plot this second result in the same manner as for Test No. 1.

- 4) Continue rolling and testing until the roller pattern reaches its maximum density before decreasing or until the graph levels off. To be sure this is a sufficient degree of compaction, make one additional roll over the entire surface and test again.

NOTE: When the increase in dry density for a Roller Pattern on granular base is less than 1 lb/ft^3 to the maximum dry density, make one additional pass. If the density does not increase by 1 lb/ft^3 with the additional pass, the rolling should be discontinued.

There may be instances where a decrease in density rather than a small increase will occur. This usually is due to a false break where the density levels off well before maximum density is achieved. If this happens, examine the material and if no fracture of the material is visible, continue the rolling process until the maximum density can be obtained. Over-rolling can also cause a decrease in density. Consideration should be given to the number of passes already made and the materials involved – making certain that the break occurring in the Roller Pattern curve is not greater than 1.5 lbs/ft^3 . If the break is greater than 1.5 lbs/ft^3 , recompact the material to its maximum dry density based on the peak value of the Roller Pattern curve.

Criteria for Establishing a New Roller Pattern:

A new Roller Pattern should be established:

- Whenever there are multiple lifts of material
- Change in Source of material
- Change in compaction equipment
- Visual change in subsurface or subgrade conditions
- Change in gradation or type of material
- Change in depth of lift

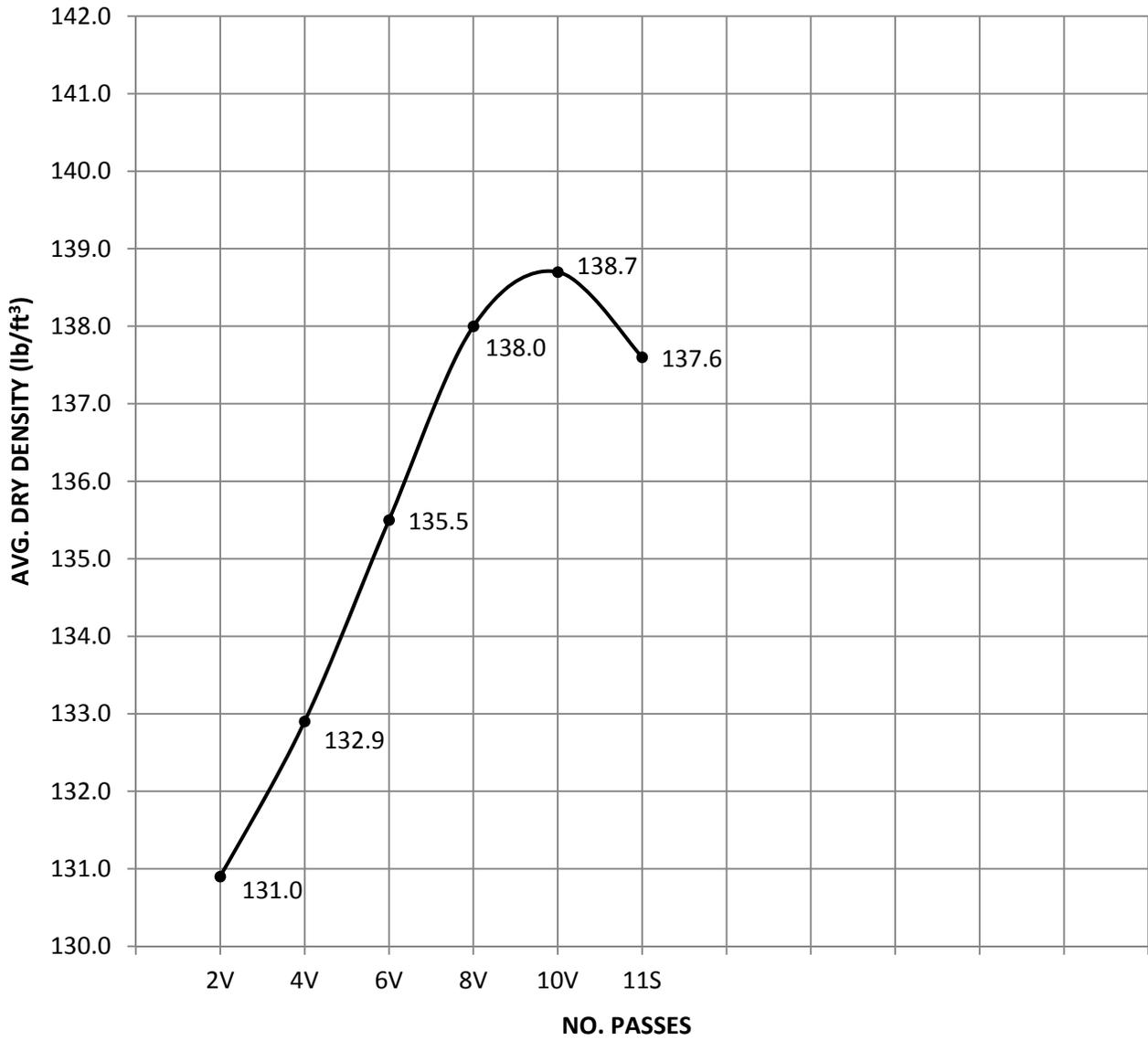
Form TL-53 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR ROLLER PATTERN**

Report No. 1-21A-1 Nuclear Gauge Model No. 3440 Serial No. 23456
 Date 06/22/2015 Project No. 0066-029-F19, C501 Route No. 66
 FHWA No. IM-NH-66-1 County Fairfax
 Section No. _____ Station No. 600+00 ft. (m.) to Station 600+75 ft. (m.)
 Type Material _____ Aggregate Base Type I (21A) Width 12 ft. (m.)
 Optimum Moisture 5.2 Optimum Moisture Range 3.2 – 5.2
 Remarks Roller Pattern #1 ("V" is for Vibratory and "S" is for Static)

STANDARD COUNT DATA					
Density <u>2830</u>			Moisture <u>701</u>		
TEST NO.	DRY DENSITY	MOISTURE	TEST NO.	DRY DENSITY	MOISTURE
Test No. 1 No. of Passes 2V			Test No. 6 No. of Passes 11S		
Sta. 600+00	137.2	4.4	Sta. 600+00	138.5	4.8
Sta. 600+40	131.8	5.3	Sta. 600+40	136.8	5.3
Sta. 600+75	123.9	4.4	Sta. 600+75	137.6	5.5
Total	392.9	14.1	Total	412.9	15.6
Average	131.0	4.7	Average	137.6	5.2
Test No. 2 No. of Passes 4V			Test No. 7 No. of Passes		
Sta. 600+00	137.4	4.8	Sta.		
Sta. 600+40	132.4	6.2	Sta.		
Sta. 600+75	128.9	4.9	Sta.		
Total	398.7	15.9	Total		
Average	132.9	5.3	Average		
Test No. 3 No. of Passes 6V			Test No. 8 No. of Passes		
Sta. 600+00	137.8	4.2	Sta.		
Sta. 600+40	134.2	5.8	Sta.		
Sta. 600+75	134.5	5.3	Sta.		
Total	406.5	15.3	Total		
Average	135.5	5.1	Average		
Test No. 4 No. of Passes 8V			Test No. 9 No. of Passes		
Sta. 600+00	138.6	4.6	Sta.		
Sta. 600+40	137.2	5.2	Sta.		
Sta. 600+75	138.3	4.6	Sta.		
Total	414.1	14.4	Total		
Average	138.0	4.8	Average		
Test No. 5 No. of Passes 10V			Test No. 10 No. of Passes		
Sta. 600+00	139.3	4.2	Sta.		
Sta. 600+40	137.3	5.0	Sta.		
Sta. 600+75	139.5	5.3	Sta.		
Total	416.1	14.5	Total		
Average	138.7	4.8	Average		

ROLLER PATTERN CURVE



Comments:

By: _____

Title: _____

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR ROLLER PATTERN**

Report No. 1-21A-1 Nuclear Gauge Model No. 3440 Serial No. 23456
 Date 06/22/2015 Project No. 0066-029-F19, C501 Route No. 66
 FHWA No. IM-NH-66-1 County Fairfax
 Section No. _____ Station No. 600+00 ft. (m.) to Station 600+75 ft. (m.)
 Type Material _____ Aggregate Base Type I (21A) Width 12 ft. (m.)
 Optimum Moisture 5
 Remarks Roller Pattern #1 (V is for Vibratory)

Averages for Dry Density and Moisture must be calculated for each of the three (3) individual tests performed

Dry Density

1) $137.2 + 131.8 + 123.9 = 392.9$
 2) $392.9 \div 3 = 131.0 \text{ lbs/ft}^3$ (Average)

Moisture

1) $4.4 + 5.3 + 4.4 = 14.1$
 2) $14.1 \div 3 = 4.7\%$ (Average)

Density		2830		701	
TEST NO.	DRY DENSITY			DENSITY	MOISTURE
Test No. 1 No. of Passes 2V					
Sta. 600+00	137.2	4.4	Sta. 600+00	138.5	4.8
Sta. 600+40	131.8	5.3	Sta. 600+40	136.8	5.3
Sta. 600+75	123.9	4.4	Sta. 600+75	137.6	5.5
Total Average	392.9 131.0	14.1 4.7	Total Average	412.9 137.6	15.6 5.2
Test No. 2 No. of Passes 4V			Test No. 7 No. of Passes		
Sta. 600+00	137.4	4.8	Sta.		
Sta. 600+40	132.4	6.2	Sta.		
Sta. 600+75	128.9	4.9	Sta.		
Total Average	398.7 132.9	15.9 5.3	Total Average		
Test No. 3 No. of Passes 6V			Test No. 8 No. of Passes		
Sta. 600+00	137.8	4.2	Sta.		
Sta. 600+40	134.2	5.8	Sta.		
Sta. 600+75	134.5	5.3	Sta.		
Total Average	406.5 135.5	15.3 5.1	Total Average		
Test No. 4 No. of Passes 8V					
Sta. 600+00	138.6		Sta.		
Sta. 600+40	137.2		Sta.		
Sta. 600+75	138.3	4.6	Sta.		
Total Average	414.1 138.0	14.4 4.8	Total Average		
Test No. 5 No. of Passes 10V					
Sta. 600+00	139.3		Sta.		
Sta. 600+40	137.3		Sta.		
Sta. 600+75	139.5	5.5	Sta.		
Total Average	416.1 138.7	14.5 4.8	Total Average		

Test 6 is < than Test 5

- Break is < 1.5 lbs/ft³
- Indicates an acceptable break
- Stop rolling operation
- Roller Pattern is 10 passes in vibratory mode (10V)

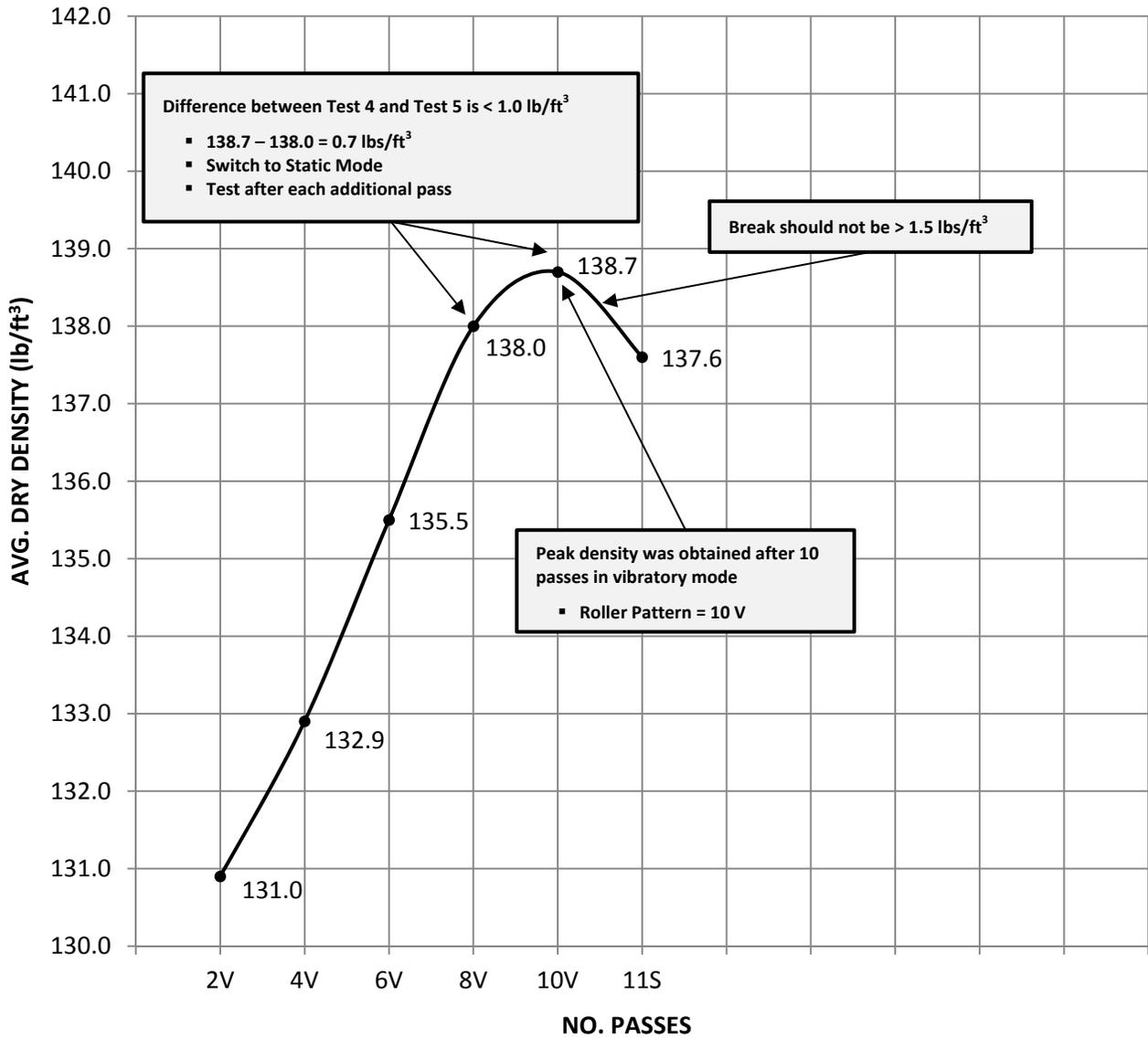
Difference between Test 3 and Test 4 is > 1.0 lb/ft³

- $138.0 - 135.5 = 2.5 \text{ lbs/ft}^3$
- Continue making passes in Vibratory Mode
- Continue testing after two additional passes

Difference between Test 4 and Test 5 is < 1.0 lb/ft³

- $138.7 - 138.0 = 0.7 \text{ lbs/ft}^3$
- Switch to Static Mode
- Test after each additional pass

ROLLER PATTERN CURVE



Comments:

By: _____

Title: _____

THE CONTROL STRIP

Control Strip Procedure:

- 1) To prepare a Control Strip, place the material under the same conditions as outlined in Step 3 of the Roller Pattern, on an additional section of roadway approximately 300 feet in length and one travel lane in width. After placement, this area is to be rolled the number of passes determined in the Roller Pattern to achieve the peak density.
- 2) To determine the density of the Control Strip, use the Backscatter Method in the 1 minute mode. Take 10 nuclear readings for moisture and density over the entire section. The results are added and an average is obtained on Form TL-54. This dry density should be within 3.0 lbs/ft³ of the Roller Pattern peak density. The control (target) values of 95% and 98% of the average dry density can now be determined. These are used to determine the acceptance of the Test Sections.
- 3) Direct Transmission – The dry density average that has been established from the Control Strip needs to meet two criteria in order to be acceptable for use with the remaining test sections.
 - a) The average dry density from the control strip should be within 3.0 lbs/ft³ of the Roller Pattern peak density.
 - b) At the completion of the Control Strip, a verification test will be performed when testing aggregates using the direct transmission method with a nuclear moisture density gauge, or other methods approved by the Materials Engineer. At the completion of the test, the density of aggregate material shall be compared to the theoretical maximum density as determined in accordance with the requirements of VTM-1. The density shall conform to the following:

<u>% Retained on No. 4 Sieve</u>	<u>% Minimum Density</u>
0 – 50	95
51 – 60	90
61 – 70	85

NOTE: Percentages of material will be reported to the nearest whole number. The requirements for percent density referenced above, apply to the direct transmission method for aggregate only. See Chapter 7 for procedure. Record the results on the TL-124 Form.

- 4) Once the Control Strip dry density has been accepted – the remainder of the TL-54 can be completed.
- 5) After the direct transmission test passes and the Control Strip dry density has been accepted – the target values should be transferred to the TL-55 (Test Section).

Determining the Control (Target) Values from the Control Strip Testing:

The control (target) values for the rest of the density testing on a given project are set at 98% and 95% of the average dry density determined by the Control Strip.

Using the control values:

- The average of the five readings from the Test Section must be equal to or greater than 98% of the Control Strip dry density.
- Each individual reading from the Test Section must be equal to or greater than 95% of the Control Strip dry density.

For shoulder material:

- The average density must be 95% (± 2 percentage points) of the Control Strip dry density.
- Each individual density must be 95% (± 5 percentage points) of the Control Strip dry density.

Form TL-54 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR CONTROL STRIP**

Report No.	<u>1-21A-2</u>	Date	<u>06/22/2015</u>
Route No.	<u>66</u>	Project No.	<u>0066-029-F19, C501</u>
FHWA No.	<u>IM-NH-66-1</u>	County	<u>Fairfax</u>
Type Material	<u>Aggregate Base Type I (21A)</u>	Width	<u>12</u>
Station No.	<u>601+25</u>	ft. (m.) to Station	<u>604+25</u>
Model No.	<u>3440</u>	Serial No.	<u>23456</u>
Remarks	<u></u>		

STANDARD COUNT DATA					
Density		<u>2830</u>		Moisture	
		<u>701</u>			
	STATION	REFERENCE TO CENTER LINE FT. (M)	LANE	DRY DENSITY (LB/FT ³) DRY UNIT MASS (KG/M ³)	MOISTURE CONTENT
1	601+25	3 FT. RT.	EBL	138.0	4.9
2	601+50	9 FT. RT.	EBL	139.2	5.3
3	602+00	6 FT. RT.	EBL	138.5	4.8
4	602+25	9 Ft. Rt.	EBL	139.3	5.4
5	602+75	3 Ft. Rt.	EBL	138.7	4.9
6	603+00	6 Ft. Rt.	EBL	139.1	5.1
7	603+50	9 Ft. Rt.	EBL	139.0	4.7
8	603+75	6 Ft. Rt.	EBL	139.2	5.2
9	604+00	3 Ft. Rt.	EBL	139.0	4.6
10	604+25	9 Ft. Rt.	EBL	140.5	6.1
TOTAL:				1390.5	
AVERAGE:				139.1	

5.2 OPTIMUM MOSTURE REQUIRED (From Producer or Materials Division)

3.2 – 7.2 OPTIMUM MOISTURE RANGE

$(\underline{139.1}) \times 0.95 =$
Dens. Avg. 132.1 INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR TEST SECTION

$(\underline{139.1}) \times 0.98 =$
Dens. Avg. 136.3 AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR TEST SECTION

BY: _____

TITLE: _____

Form TL-54 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR CONTROL STRIP**

Report No.	<u>1-21A-2</u>	Date	<u>06/22/2015</u>
Route No.	<u>66</u>	Project No.	<u>0066-029-F19, C501</u>
FHWA No.	<u>IM-NH-66-1</u>	County	<u>Fairfax</u>
Type Material	<u>Aggregate Base Type I (21A)</u>	Width	<u>12</u>
Station No.	<u>601+25</u>	ft. (m.) to Station	<u>604+25</u>
Model No.	<u>3440</u>	Serial No.	<u>23456</u>
Remarks	<u></u>		

An overall average Dry Density must be calculated from each of the ten (3) individual tests performed

1) $138.0 + 139.2 + 138.5 + 139.3 + 138.7 + 139.1 + 139.0 + 139.2 + 139.0 + 140.5 = 1390.5$

2) $1390.5 \div 10 = 139.1 \text{ lbs/ft}^3$

Avg. Control Strip Density must within 3.0 lbs/ft³ of Roller Patter Peak Density

DENSITY (LB/FT ³) DRY UNIT MASS (KG/M ³)	MOISTURE CONTENT
	701
1	4.9
2	5.3
3	4.8
4	5.4
5	4.9
6	5.1
7	4.7
8	5.2
9	4.6
10	6.1
TOTAL:	
	1390.5
AVERAGE:	139.1

Average Control Strip Density

OPTIMUM MOSTURE REQUIRED (From Producer or Materials Division)

The Optimum Moisture Required cannot be determined until after the +4 Correction for Optimum Moisture is made on the Form TL-124 (Report on Nuclear Embankment Densities)

$(139.1) \times 0.95 =$
Dens. Avg. 132.1

$(139.1) \times 0.98 =$
Dens. Avg. 136.3

INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR TEST SECTION

AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR TEST SECTION

BY: _____
TITLE: _____

Form TL-124 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)**

Report No. 1-21A-3 Date 06/22/2015 Sheet No. 1 of 1
 Route No. 66 County Campbell
 Project No. 0066-029-F19, C501
 FHWA No. IM-NH-66-1
 Testing for Aggregate Base Type I (21A)
 Model No. 3440 Serial No. 23456 Calibration Date 02/10/2015

STANDARD COUNT DATA					
Density <u>2830</u>		Moisture <u>701</u>			
Test No.		1	2	3	4
Location	Station ft. (m)	603+00			
of	Ref. to center line ft. (m)	5' Rt. C/L			
Test	Elevation				
Compaction Depth of Lift in. (mm)		6"			
Method of Compaction		Vibratory			
A. Wet Density (lbs/ft ³), Wet Unit Mass (kg/m ³)		= 140.9			
B. Moisture Unit Mass (lbs/ft ³ or kg/m ³)		= 7.0			
C. Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) (A-B)		= 133.9			
D. Moisture Content (B ÷ C) x 100		= 5.2			
E. Maximum Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) Lab Proctor or One Point Proctor		= 132.8			
F. Percent Optimum Moisture from Lab or One Point Proctor		= 10.7			
G. Percent of Plus #4, (plus 4.75 mm)		= 58.0			
H. Corrected Max. Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)		= 145.4			
I. Corrected Optimum Moisture		= 5.2 3.2 - 7.2			
J. Percent Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) (C ÷ E) x 100 or (C ÷ H) x 100		= 92.1			
K. Percent Minimum Density Required		= 90.0			

Comments:

BY: _____

TITLE: _____

Form TL-124 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)**

Report No. 1-21A-3 Date 06/22/2015 Sheet No. 1 of 1
 Route No. 66 County Campbell
 Project No. 0066-029-F19, C501
 FHWA No. IM-NH-66-1
 Testing for Aggregate Base Type I (21A)
 Model No. 3440 Serial No. 23456 Calibration Date 02/10/2015

STANDARD COUNT DATA					
Density <u>2830</u>		Moisture <u>701</u>			
Test No.		1	2	3	4
Location	Station ft. (m)	603+00			
of	Ref. to center line ft. (m)	5' Rt. C/L			
Test	Elevation				
Compaction Depth of Lift in. (mm)		6"			
Method of Compaction		Vibratory			
A. Wet Density (lbs/ft ³)	<div style="border: 1px solid black; padding: 5px;"> <p>Nuclear Gauge Display Panel</p> <p>% PR = 100.8%</p> <p>DD = 133.9</p> <p>WD = 140.9</p> <p>M = 7.0 M% = 5.2</p> </div>	= 140.9	Gauge		
B. Moisture U ₁ (%)		= 7.0	Gauge		
C. Dry Density (lbs/ft ³)		= 133.9	Gauge		
D. Moisture Content (B ÷ C) x 100		= 5.2	Gauge		
E. Maximum Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)		= 132.8	Materials		
F. Percent of Fine (- 4) Material	<div style="border: 1px solid black; padding: 5px;"> <p>Determined by Proctor on the Fine (- 4) Material</p> <p>Joint Proctor</p> </div>	= 10.7	Materials		
G. Percent of Plus #4, (plus 4.75 mm)		= 58.0	Materials		
H. Corrected Max. Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)		= 145.4	See Page 8-15 & 8-16		
I. Corrected Optimum Moisture	= 5.2	See Page 8-15 & 8-16			
J. Percent Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) (C ÷ E) x 100 or (C ÷ H) x 100	= 92.1	See Page 8-15 & 8-16			
K. Percent Minimum Density Required	= 90.0	Appendix C			

Comments:

BY: _____

TITLE: _____

Form TL-124 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)**

Report No. 1-21A-3 Date 06/22/2015 Sheet No. 1 of 1
 Route No. 66 County Campbell
 Project No. 0066-029-F19, C501
 FHWA No. IM-NH-66-1
 Testing for Aggregate Base Type I (21A)
 Model No. 3440 Serial No. 23456 Calibration Date 02/10/2015

STANDARD COUNT DATA					
Density <u>2830</u>		Moisture <u>701</u>			
Test No.		1	2	3	4
Location	Station ft. (m)	603+00			
of	Ref. to center line ft. (m)	5' Rt. C/L			
Test	Elevation				
Compaction Depth of Lift in. (mm)		6"			
Method of Compaction		Vibratory			
A.	Corrected Dry Density for +4 Aggregate	=	140.9	Corrected Moisture for +4 Aggregate $(P_c W_c + P_i W_i) \times 100$ $[(0.58 \times 0.012) + (0.42 \times 0.107)] \times 100$ $[(0.007) + (0.045)] \times 100$ $[0.052] \times 100 = 5.2\%$	
B.	$D_f \times D_c$	=	7.0		
C.	$(P_c \times D_i) + (P_i \times D_c)$	=	133.9		
D.	132.8×156.0	=	5.2		
E.	$(0.58 \times 132.8) + (0.42 \times 156.0)$	=	132.8		
F.	$\frac{20,716}{77.0 + 65.5} = \frac{20,716}{142.5} = 145.4 \text{ lbs/ft}^3$	Proctor	=	10.7	
G.	Percent of Plus #4, (plus 4.75 mm)	=	58.0		
H.	Corrected Percent Density	ss (kg/m ³)	=	145.4	
I.	$(\text{Dry Density} \div \text{Corrected +4 Density}) \times 100$		=	5.2	
J.	$(133.9 \div 145.4) \times 100$		=	3.2 - 7.2	
K.	$(0.9209) \times 100$		=	92.1	
	% Density = 92.1%		=	90.0	Appendix C
Comments:					

BY: _____

TITLE: _____

Calculations for Direct Transmission Test take within the Control Strip

Information from Quarry or Materials Division:

- A. Total Percent Passing the No. 4 Sieve = 42% (This is the -4 Material) (**$P_f = 0.42$**)
Therefore: $100 - 42 = 58\%$ (This is the +4 Material) (**$P_c = 0.58$**)
- B. Specific Gravity of the +4 Material = 2.50
Therefore: $2.50 \times 62.4 = 156.0 \text{ lbs/ft}^3$ (**$D_c = 156.0$**)
- C. Absorption Rate of the +4 Material = 0.2%
Therefore: $0.2 + 1 = 1.2\%$ (**$W_c = 0.012$**)
- D. Lab Proctor Information
Maximum Dry Density of the -4 Material = 132.8 lbs/ft^3 (**$D_f = 132.8$**)
Optimum Moisture of the -4 Material = 10.7% (**$W_f = 0.107$**)

Maximum Dry Density (+4 Material)

$$\frac{D_f \times D_c}{(P_c \times D_f) + (P_f \times D_c)}$$

$$\frac{132.8 \times 156.0}{(0.58 \times 132.8) + (0.42 \times 156.0)}$$

$$\frac{20,716.8}{(77.0) + (65.5)}$$

$$\frac{20,716.8}{142.5}$$

Corrected Dry Density = 145.4 lbs/ft^3

Optimum Moisture (+4 Material)

Formula $[(P_c W_c) + (P_f W_f)] \times 100$

Step 1 $[(0.58 \times 0.012) + (0.42 \times 0.107)] \times 100$

Step 2 $[(0.007) + (0.045)] \times 100$

Step 3 0.052×100

Corrected Optimum Moisture = 5.2%

Form TL-54 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR CONTROL STRIP**

Report No.	<u>1-21A-2</u>	Date	<u>06/22/2015</u>
Route No.	<u>66</u>	Project No.	<u>0066-029-F19, C501</u>
FHWA No.	<u>IM-NH-66-1</u>	County	<u>Fairfax</u>
Type Material	<u>Aggregate Base Type I (21A)</u>	Width	<u>12</u>
Station No.	<u>601+25</u>	ft. (m.) to Station	<u>604+25</u>
Model No.	<u>3440</u>	Serial No.	<u>23456</u>
Remarks	<u></u>		

STANDARD COUNT DATA					
	Density	<u>2830</u>		Moisture	<u>701</u>
	STATION	REFERENCE TO CENTER LINE FT. (M)	LANE	DRY DENSITY (LB/FT ³) DRY UNIT MASS (KG/M ³)	MOISTURE CONTENT
1	601+25	3 FT. RT.	EBL	138.0	4.9
2	601+50	9 FT. RT.	EBL	139.2	5.3
3	602+00	6 FT. RT.	EBL	138.5	4.8
4	602+25	9 Ft. Rt.	EBL	139.3	5.4
5	602+75	3 Ft. Rt.	EBL	138.7	4.9
6	603+00	6 Ft. Rt.	EBL	139.1	5.1
7	603+50	9 Ft. Rt.	EBL	139.0	4.7
8	603+75	6 Ft. Rt.	EBL	139.2	5.2
9	604+00	3 Ft. Rt.	EBL	139.0	4.6
10	604+25	9 Ft. Rt.	EBL	140.5	6.1

5.2

The Optimum Moisture Required (corrected for the +4 material) can now be transferred from the Form TL-124 (Line I) to the Form TL-54 (Report on Nuclear Control Strip)

- Once complete, the Optimum Moisture values can then be transferred to the Form TL-55 (Report on Nuclear Test Section)

3.2 – 7.2 OPTIMUM MOISTURE RANGE

(139.1) x 0.95 =
Dens. Avg. 132.1

(139.1) x 0.98 =
Dens. Avg. 136.3

Now that the Direct Transmission Test has passed and validated the control strip, the 95% and 98% control (target) values can also be transferred to the Form TL-55 (Report on Nuclear Test Section)

- These values will be used to evaluate the Test Sections for acceptance

OR

R TEST

BY: _____

TITLE: _____

TEST SECTIONS

- 1) Next will be the testing of the Test Sections. Each test section for aggregate base, subbase, and select materials will be 0.5 miles (2640 ft.) in length per application width.

The length of test sections for shoulders will be the same as the mainline, if possible test alternating sides.

- 2) The test section is rolled the number of passes determined by the Control Strip. Five (5) readings will be made in the one minute mode on each test section for both density and moisture using the same method of test used on the Roller Pattern and Control Strip. These values are recorded on the TL-55. Each individual reading must be at least 95% of the Control Strip dry density and the average of the five readings must be at least 98% of the Control Strip dry density and the moisture readings must fall within the optimum moisture range.

For aggregate shoulder material, an average density of 95% (± 2 percentage points) of the Control Strip dry density, with individual densities within 95% (± 5 percentage points) of the Control Strip dry density is required. No other test will be required, unless specified by the Engineer.

NOTE: If test section readings are significantly above or below the target values by more than 8 lbs/ft³, another control strip (and target density) should be established.

Form TL-55 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR TEST SECTION**

Report No.	1-21A-2	Date	06/22/2015
Route No.	66	Project No.	0066-029-F19, C501
FHWA No.	IM-NH-66-1	County	Fairfax
Type Material	Aggregate Base Type I (21A)	Width	12
Section No.	1	Station No.	604+25
Model No.	3440	Serial No.	23456
Remarks			

STANDARD COUNT DATA	
Density <u>2830</u>	Moisture <u>701</u>

- 5.2 **OPTIMUM MOISTURE REQUIRED % (From Producer or Materials Division)**
- 3.2 – 7.2 **OPTIMUM MOISTURE RANGE**
- 132.1 **INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED
(95% of Control Strip Density from TL-54A)**
- 136.3 **AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED
(98% of Control Strip Density from TL-54A)**

Test No.	Station ft. (m)	Lane	Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)	Moisture Content	Pass (P) Fail (F)
1	606+26	EBL	138.3	5.3	P
2	610+89	EBL	139.7	5.0	P
3	615+59	EBL	139.0	5.3	P
4	620+18	EBL	138.9	5.2	P
5	626+66	EBL	139.2	5.4	P
Average			139.0		P

Comments:

BY: _____

TITLE: _____

Form TL-55 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR TEST SECTION**

Report No.	<u>1-21A-2</u>	Date	<u>06/22/2015</u>
Route No.	<u>66</u>	Project No.	<u>0066-029-F19, C501</u>
FHWA No.	<u>IM-NH-66-1</u>	County	<u>Fairfax</u>
Type Material	<u>Aggregate Base Type I (21A)</u>	Width	<u>12</u>
Section No.	<u>1</u>	Station No.	<u>604+25</u> ft. (m.) to Station <u>630+65</u> ft. (m.)
Model No.	<u>3440</u>	Serial No.	<u>23456</u>
Remarks	<u></u>		

Density 2830

5.2 ← **OPTIMUM MOISTURE REQUIRED % (From Producer or Materials Division)**

3.2 – 7.2 ← **OPTIMUM MOISTURE RANGE**

132.1 ← **INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED (95% of Control Strip Density from TL-54A)**

136.3 ← **AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED (98% of Control Strip Density from TL-54A)**

All Optimum Moisture and Density Control (Target) Values have been transferred from the bottom of the Form TL-54 (Report on Nuclear Control Strip)

Each individual Dry Density must be at least 132.1 lbs/ft³

Test No.	Station ft. (m)	Lane	Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)	Moisture Content	Pass (P) Fail (F)
			138.3	5.3	P
			139.7	5.0	P
			139.0	5.3	P
			138.9	5.2	P
5	626+66	EBL	139.2	5.4	P
Average			139.0		P

An overall average Dry Density must be calculated from each of the five (5) individual tests performed

1) $138.3 + 139.7 + 139.0 + 138.9 + 139.2 = 695.1$

2) $695.1 \div 5 = 139.0 \text{ lbs/ft}^3$

Comments:

The average Dry Density must be at least 136.3 lbs/ft³

Each individual Moisture reading must fall within the 3.2 to 7.2 range

For the test section to pass, the following conditions must be met:

- Each individual Dry Density reading must be at least 132.1 lbs/ft³
- The average Dry Density must be at least 136.3 lbs/ft³
- Each individual Moisture reading must fall within the 3.2 to 7.2 range

If any test section readings are significantly above or below the control (target) values by more than 8 lbs/ft³, another Control Strip should be established

BY: _____

TITLE: _____

RANDOM SAMPLING OF CONSTRUCTION MATERIALS

This section provides guidelines for the selection of random locations or times at which samples or tests of construction materials are to be taken. Highway construction materials are typically accepted or rejected based on the test results of small representative samples. Consequently, acceptance or rejection of materials is highly dependent on how well a small sample represents a larger quantity of material. If the samples are not truly representative of the larger quantity, acceptable material could be rejected, or substandard material accepted. Correct sampling methods are critical to the validity of the sample test results. Sampling performed incorrectly will lead to test results that do not reflect the true characteristics of the material or product being tested.

The actions required to obtain a good sample (such as how to take the sample, where to take it, what tools to use and the size of sample) are covered in the appropriate materials control program and guidelines specified by the agency for use on the project. Reference should be made to these instructions on sampling requirements.

When a sample is not representative or random, it is said to be biased. Examples of biased sampling that should not be used include sampling an embankment at a given interval, such as every 500 cubic yards (yd³); sampling borrow material at a given frequency, such as every fifth truckload; or taking samples at a given time frequency, such as every hour on the hour. Random sampling is used to eliminate bias in selecting a location or time for sampling. A random sample is any sample which has an equal chance of being selected from a large quantity. In other words, there is an equal chance for all locations and all fractions of a large quantity of material to be sampled.

Random unbiased samples must represent the true nature of the material. Samples should not be obtained on a predetermined basis or based on the quality of the material in a certain area. If sampling is not performed on a random basis, the quality of the sample can be artificially modified causing the sample to no longer be representative of the larger quantity. Specifications will identify lot size, location and frequencies for sampling and testing. A lot is defined as a given quantity of material that is to be sampled. The lot is a predetermined unit which may represent a day's production, a specified quantity of material, a specified number of truckloads, or an interval of time. Agencies will usually specify the lot size and sampling frequency. Although these frequencies may appear to be a violation of random sampling, they are given as a minimum amount of sampling, not as a specific frequency. Lots are often divided into sublots. The number of sublots used to represent the lot will be determined by the agency and specifications. It may be necessary to take multiple samples and combine them to represent a unit. For example, three samples may be taken from a borrow source and combined to form a composite sample. Several composite samples will then be tested to determine the compliance of a subplot or lot to the specifications. The use of random samples from sublots is referred to as stratified random sampling. Stratified random sampling assures that samples are taken throughout the entire lot and are not concentrated in one area of the lot (see Figure 1.18).

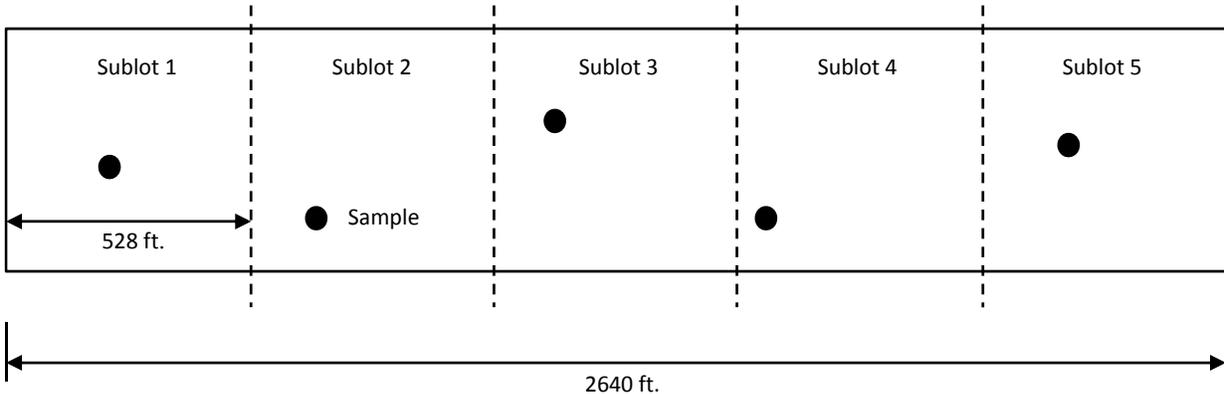


Figure 1.3: Illustration of Random Test Site Locations

Quality control/quality assurance specifications are developed based on statistical theory, which is valid only when random sampling is performed. QC/QA specifications are statistically based on a normal distribution (bell curve) of material production. If samples are biased or not random, the test results will not fit in the normal distribution, and the QC/QA specification will no longer be valid.

Random sampling is usually accomplished with the use of random number generators or tables of random numbers. Most calculators and computers contain a random number generator that merely requires the operator to hit a button. The automated random number generators use programmed tables of random numbers similar to the tables included later. A random numbers table is simply a random arrangement of numbers.

ASTM D 3665 is a method for determining random locations or time intervals for sampling and testing. Individual states within the Mid-Atlantic Region have developed various random numbers tables that are much easier to use and less time consuming. The Table on page 8-26 is an example of a table used for selecting test locations on aggregate subbase or base. It is not important which table or method is used as long as random numbers are incorporated into the selection process.

A Test Section for aggregate subbase or base is half a mile per paver width. Each test section is divided into 5 sublots of 528 feet ($2640 \text{ feet} \div 5 = 528 \text{ feet}$). One reading is taken in each sublot.

To use the table, select a random starting point on the table by tossing a pencil upon the page or blindly pointing out a location with the finger. Since you will need five sets of numbers, use the location selected and the next four beneath it. The column to the left is used to determine the distance from the beginning of each sublot and the corresponding columns to the right are used to determine the offset distance from the reference line based on the paver width.

RANDOM NUMBER TABLE							
Distance from Start of Sublot (ft.)	Distance from Reference Line						
	Paver Width						
	8 feet	9 feet	10feet	11 feet	12 feet	13 feet	14 feet
201	2	4	5	5	8	9	12
136	4	4	7	8	11	5	8
78	4	6	8	5	3	4	6
9	5	2	5	9	11	4	8
129	5	4	3	9	4	10	12
106	5	3	7	8	8	10	9
27	2	3	7	6	3	4	7
140	2	5	3	8	3	10	2
182	2	2	8	5	10	5	10
156	3	3	7	6	3	6	10
22	5	5	8	2	5	3	7
232	4	3	4	2	7	6	8
57	5	4	3	2	7	8	10
201	2	2	7	5	9	3	8
136	6	5	8	7	7	4	11
78	6	4	2	2	5	5	3
9	3	2	6	3	6	9	11
129	3	5	3	8	3	4	4
244	3	3	3	3	8	2	6
189	2	7	3	9	5	2	5
208	4	5	4	5	10	9	5
128	5	7	8	6	4	4	5
98	3	3	8	8	9	2	10
200	2	4	5	6	10	2	8
78	3	4	8	6	3	6	11
185	4	5	2	6	7	10	3
3	2	4	7	7	3	6	12
96	6	3	7	3	9	8	11
17	4	6	8	9	8	8	8
228	3	7	6	5	2	5	4
230	5	4	8	6	5	10	10
73	2	5	8	6	5	6	9
109	4	4	4	4	6	8	11
181	3	6	6	9	3	9	4
252	4	3	4	3	3	9	11
96	4	4	2	2	2	9	11
43	4	7	5	7	6	3	11
71	4	6	5	6	4	4	12
9	3	3	3	9	6	10	11
157	5	5	7	9	6	9	12

Example Problem:

The contractor has applied the dense graded aggregate layer to the right lane of a two lane roadway beginning at Station 604+25 with a paver width of 12 feet. The right side will be used to measure the offset distances. Five (5) sets of numbers are needed to determine where the tests will be performed.

Random numbers from Random Number Table (Block One):

<u>Distance from Start of Sublot</u>	<u>Distance from Reference Line</u>
201	8
136	11
78	3
9	11
129	4

Determine the Station Number at the beginning of each subplot. Remember, the Test Section is half a mile per paver with and is divided into five (5) sublots of 528 feet in length.

Beginning Station Number of Sublot 1:	604+25	+	<u>5 28</u>	←	Length of Sublot (ft)
Beginning Station Number of Sublot 2:	609+53	+	<u>5 28</u>		
Beginning Station Number of Sublot 3:	614+81	+	<u>5 28</u>		
Beginning Station Number of Sublot 4:	620+09	+	<u>5 28</u>		
Beginning Station Number of Sublot 5:	625+37	+	<u>5 28</u>		
Ending Station Number of Sublot 5:	630+65				

To determine the test locations, add the Distance from Start of Sublot selected from the Random Number Table to the beginning station number of each subplot. Use the numbers from the Random Number Table under Distance from Reference Line to measure the offset from the right side of the subplot.

Station No. at Beginning of Each Sublot	+	Distance from Start of Sublot	=	Station No. of Each Test Location	Distance from Reference Line (ft)
604+25	+	201	=	606+26	8
609+53	+	136	=	610+89	11
614+81	+	78	=	615+59	3
620+09	+	9	=	620+18	11
625+37	+	129	=	626+66	4

CHAPTER 8 – STUDY QUESTIONS

- 1) True or False. Before a Roller Pattern can be set the subgrade must be approved, compaction equipment must be approved and material to be tested must be placed at uniform depth.
- 2) _____ compares compactive effort vs. density.
- 3) When must a new Roller Pattern be set up?

- 4) _____ is the testing method in which the gauge is placed on the surface of the material to be tested and the source rod is lowered to the first notch.
- 5) When taking a nuclear reading near an unsupported edge, _____ is the minimum distance from the edge that an accurate nuclear reading can be taken.
- 6) A _____ is taken at the end of the control strip to verify the results.
- 7) The control strip dry density must be within _____ of the roller pattern peak density.
- 8) A roller pattern on aggregate covers _____, a control strip covers _____ and a test section covers _____ per paver width.
- 9) The Contractor has applied the dense graded aggregate layer to the right lane of a two-lane roadway beginning at Station 25 + 25. Using the numbers from the Random Number Table given below, calculate and determine the test location for each density and moisture reading for this test section, which is 12 feet wide. Remember not to test any closer than 18 inches to an unsupported edge.

<u>Distance from Start of Sublot</u>	<u>Distance from Reference Line</u>
181	3
252	3
96	2
43	6
71	4

There are 5,280 feet in a mile. A Test Section is _____ mile per paver width or _____ feet. _____ tests will be performed in the test section. _____ ÷ _____ = _____.

Sublot 1 _____ Feet
Sublot 2 _____ Feet
Sublot 3 _____ Feet
Sublot 4 _____ Feet
Sublot 5 _____ Feet

Beginning Station No. 25+25

Station No. _____

Station No. _____

Station No. _____

Station No. _____

Ending Station No. _____

Test No.	Station No. at Start of Each Sublot	+	Distance from Start of Sublot	=	Station No. of Each Test Location	Distance from Reference Line (ft)
		+		=		
		+		=		
		+		=		
		+		=		
		+		=		

CHAPTER 8 – PRACTICE PROBLEMS
NOTE: Each Practice Problem contains 4 Parts

Practice Problem Number 1
Nuclear Density Testing of Aggregates
Step 1 – Roller Pattern

A. Given the following information, complete the following worksheet (Form TL-53)

Station Numbers for Test Locations	<table border="1"> <tr><td>21+00</td></tr> <tr><td>21+35</td></tr> <tr><td>21+75</td></tr> </table>	21+00	21+35	21+75																														
21+00																																		
21+35																																		
21+75																																		
	<table border="0"> <tr><td>Test 1</td><td></td><td></td><td></td><td></td></tr> <tr><td>2V Passes</td><td></td><td></td><td></td><td></td></tr> <tr><td>Density</td><td></td><td>Moisture</td><td>Density</td><td>Moisture</td></tr> <tr><td>125.4</td><td></td><td>5.1</td><td>134.7</td><td>5.5</td></tr> <tr><td>124.9</td><td></td><td>5.2</td><td>133.7</td><td>4.9</td></tr> <tr><td>125.3</td><td></td><td>5.6</td><td>134.8</td><td>5.1</td></tr> </table>	Test 1					2V Passes					Density		Moisture	Density	Moisture	125.4		5.1	134.7	5.5	124.9		5.2	133.7	4.9	125.3		5.6	134.8	5.1			
Test 1																																		
2V Passes																																		
Density		Moisture	Density	Moisture																														
125.4		5.1	134.7	5.5																														
124.9		5.2	133.7	4.9																														
125.3		5.6	134.8	5.1																														
	<table border="0"> <tr><td>Test 2</td><td></td><td></td><td></td><td></td></tr> <tr><td>4V Passes</td><td></td><td></td><td></td><td></td></tr> <tr><td>Density</td><td></td><td>Moisture</td><td>Density</td><td>Moisture</td></tr> <tr><td>128.4</td><td></td><td>5.4</td><td>135.5</td><td>5.2</td></tr> <tr><td>127.5</td><td></td><td>5.1</td><td>135.0</td><td>5.1</td></tr> <tr><td>128.5</td><td></td><td>4.9</td><td>135.4</td><td>4.9</td></tr> </table>	Test 2					4V Passes					Density		Moisture	Density	Moisture	128.4		5.4	135.5	5.2	127.5		5.1	135.0	5.1	128.5		4.9	135.4	4.9			
Test 2																																		
4V Passes																																		
Density		Moisture	Density	Moisture																														
128.4		5.4	135.5	5.2																														
127.5		5.1	135.0	5.1																														
128.5		4.9	135.4	4.9																														
	<table border="0"> <tr><td>Test 3</td><td></td><td></td><td></td><td></td></tr> <tr><td>6V Passes</td><td></td><td></td><td></td><td></td></tr> <tr><td>Density</td><td></td><td>Moisture</td><td>Density</td><td>Moisture</td></tr> <tr><td>131.8</td><td></td><td>5.1</td><td>134.0</td><td>4.9</td></tr> <tr><td>131.0</td><td></td><td>5.0</td><td>133.5</td><td>5.0</td></tr> <tr><td>132.1</td><td></td><td>4.9</td><td>134.1</td><td>5.1</td></tr> </table>	Test 3					6V Passes					Density		Moisture	Density	Moisture	131.8		5.1	134.0	4.9	131.0		5.0	133.5	5.0	132.1		4.9	134.1	5.1			
Test 3																																		
6V Passes																																		
Density		Moisture	Density	Moisture																														
131.8		5.1	134.0	4.9																														
131.0		5.0	133.5	5.0																														
132.1		4.9	134.1	5.1																														

B. How many passes should be made for Test 5? Why?

How many passes should be made for Test 6? Why?

C. Should this be considered an acceptable Roller Pattern? Why?

Form TL-53 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR ROLLER PATTERN**

Report No. 1-21A-1 Nuclear Gauge Model No. 3440 Serial No. 23456
 Date 06/22/2015 Project No. 0095-029-F14, C502 Route No. 95
 FHWA No. NH (95) - 1 County Fairfax
 Section No. 1 Station No. 21+00 ft. (m.) to Station 21+75 ft. (m.)
 Type Material Aggregate Base Type I (21A) Width 12 ft. (m.)
 Optimum Moisture _____ Optimum Moisture Range _____
 Remarks _____

STANDARD COUNT DATA					
Density <u>2847</u>			Moisture <u>695</u>		
TEST NO.	DRY DENSITY	MOISTURE	TEST NO.	DRY DENSITY	MOISTURE
Test No. 1 No. of Passes			Test No. 6 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 2 No. of Passes			Test No. 7 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 3 No. of Passes			Test No. 8 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 4 No. of Passes			Test No. 9 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 5 No. of Passes			Test No. 10 No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		

ROLLER PATTERN CURVE

AVG. DRY DENSITY (lb/ft³)



NO. PASSES

Comments:

By: _____

Title: _____

Practice Problem Number 1
Nuclear Density Testing of Aggregates
Step 2 – Control Strip

A. Complete the following worksheet (Form TL-54) using the data below and answer the following questions.

B. How many roller passes were required to attain the maximum density on the Control Strip (Use the information from Step 1 – Form TL-53)

C. Does the test pass the moisture criteria?

D. Is the Control Strip within tolerance of the Roller Pattern?

Test No.	Density Readings	Moisture Readings
1	134.8	5.4
2	135.2	5.3
3	135.6	5.4
4	135.5	5.4
5	135.3	5.4
6	135.3	5.1
7	135.2	5.5
8	135.8	5.4
9	135.3	5.1
10	134.7	5.0

Practice Problem Number 1
Nuclear Density Testing of Aggregates
Step 3 – Control Strip (Direct Transmission Test)

- A. Use the information below to complete the following worksheet (Form TL-124) and answer the following questions.

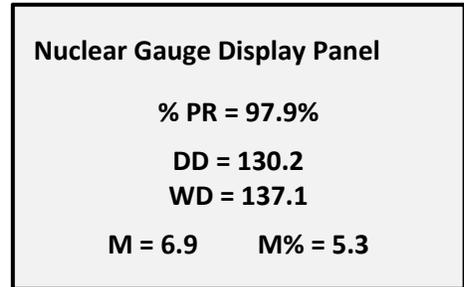
Information from Quarry or Materials Lab:

Percent Passing the No. 4 Sieve = 46%
 Therefore, the percent of +4 Material = _____

Specific Gravity of the +4 Material = 2.40
 Therefore, the density of the +4 Material = _____

Absorption Rate of the +4 Material = 0.2%

Lab Proctor Information
 Maximum Dry Density of the -4 Material = 133.0 lbs/ft³
 Optimum Moisture of the -4 Material = 10.1%



- B. What is the minimum density required?

- C. Does the test pass?

- D. Does this test validate the Roller Pattern and Control Strip Target Density?

Form TL-124 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)**

Report No. 1-21A-3 Date 06/22/2015 Sheet No. 1 of 1
 Route No. 95 County Fairfax
 Project No. 0095-029-F14, C502
 FHWA No. NH(95)-1
 Testing for Aggregate Base Type I (21A)
 Model No. 3440 Serial No. 23456 Calibration Date 02/10/2015

STANDARD COUNT DATA					
Density <u>2847</u>		Moisture <u>695</u>			
Test No.		1	2	3	4
Location	Station ft. (m)	22+25			
of	Ref. to center line ft. (m)	2' Rt. C/L			
Test	Elevation				
Compaction Depth of Lift in. (mm)		6"			
Method of Compaction		Vibratory			
A. Wet Density (lbs/ft ³), Wet Unit Mass (kg/m ³)		=			
B. Moisture Unit Mass (lbs/ft ³ or kg/m ³)		=			
C. Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) (A-B)		=			
D. Moisture Content (B ÷ C) x 100		=			
E. Maximum Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) Lab Proctor or One Point Proctor		=			
F. Percent Optimum Moisture from Lab or One Point Proctor		=			
G. Percent of Plus #4, (plus 4.75 mm)		=			
H. Corrected Max. Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)		=			
I. Corrected Optimum Moisture		=			
J. Percent Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) (C ÷ E) x 100 or (C ÷ H) x 100		=			
K. Percent Minimum Density Required		=			

Comments:

BY: _____

TITLE: _____

Practice Problem Number 1
Nuclear Density Testing of Aggregates
Step 4 – Test Section

- A. Transfer the Optimum Moisture, Optimum Moisture Range, Individual Dry Density Requirement, and Average Dry Density Requirement from the Control Strip (Form TL-54) to the proper place on the Test Section worksheet (Form TL-55).
- B. Given the following nuclear density and moisture readings, complete the Form TL-55.

Test 1	Test 2	Test 3				
<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 136.4</p> <p>WD = 144.1</p> <p>M = 7.7 M% = 5.1</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 135.0</p> <p>WD = 142.3</p> <p>M = 7.3 M% = 5.4</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 136.5</p> <p>WD = 143.8</p> <p>M = 7.3 M% = 5.0</p>				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 50%;">Test 4</th> <th style="width: 50%;">Test 5</th> </tr> </thead> <tbody> <tr> <td style="border: 1px solid black; padding: 10px;"> <p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 133.2</p> <p>WD = 140.2</p> <p>M = 7.0 M% = 5.3</p> </td> <td style="border: 1px solid black; padding: 10px;"> <p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 136.0</p> <p>WD = 142.9</p> <p>M = 6.9 M% = 5.1</p> </td> </tr> </tbody> </table>		Test 4	Test 5	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 133.2</p> <p>WD = 140.2</p> <p>M = 7.0 M% = 5.3</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 136.0</p> <p>WD = 142.9</p> <p>M = 6.9 M% = 5.1</p>	
Test 4	Test 5					
<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 133.2</p> <p>WD = 140.2</p> <p>M = 7.0 M% = 5.3</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 136.0</p> <p>WD = 142.9</p> <p>M = 6.9 M% = 5.1</p>					

- C. Does this test pass? Why?

- D. If the test does not pass, what corrective action should be taken?

- E. What are the beginning and ending station numbers of the first Test Section?

Form TL-55 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR TEST SECTION**

Report No.	1-21A-4	Date	06/22/2015
Route No.	95	Project No.	0095-029-F14, C502
FHWA No.	NH(95)-1	County	Fairfax
Type Material	Aggregate Base Type I (21A)	Width	12
Section No.	1	Station No.	25+25
Model No.	3440	Serial No.	23456
Remarks			

STANDARD COUNT DATA	
Density <u>2830</u>	Moisture <u>701</u>

_____ **OPTIMUM MOISTURE REQUIRED % (From Producer or Materials Division)**

_____ **OPTIMUM MOISTURE RANGE**

_____ **INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED
(95% of Control Strip Density from TL-54A)**

_____ **AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED
(98% of Control Strip Density from TL-54A)**

Test No.	Station ft. (m)	Lane	Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)	Moisture Content	Pass (P) Fail (F)
1	27+06	WBL			
2	33+05	WBL			
3	36+77	WBL			
4	41+52	WBL			
5	47+08	WBL			
Average					

Comments:

BY: _____

TITLE: _____

CHAPTER 8 – PRACTICE PROBLEMS

Practice Problem Number 2
Nuclear Density Testing of Aggregates
Step 1 – Roller Pattern

A. Given the following information, complete the following worksheet (Form TL-53)

Report No: 3-21ACTA-1 Nuclear Gauge Model No: 3440 Nuclear Gauge Serial No: 23456 Date: Use today's date Route: 0007 Project No: 0007-053-121, C501 FHWA No: None County: Loudon Section No: 1	Station No: 900+00 to 900+75 Type Material: Aggregate Base Type I (21A) Pavement Width: 12 Optimum Moisture: 5.1 Optimum Moisture Range: Must be calculated Remarks: 1 st Lift 6" Compacted Depth, Roller Pattern No. 3, Vibratory Roller Standard Counts: Density – 2864 Moisture – 709
--	---

Station Numbers for Test Locations 900+00, 900+35, and 900+75

Test 1 – After 2V Passes		Test 5 – After 10V Passes	
Density	Moisture	Density	Moisture
115.4	5.3	132.1	5.3
114.6	5.1	131.6	4.3
116.1	4.9	132.6	5.9
Test 2 – After 4V Passes		Test 6 – After 12V Passes	
Density	Moisture	Density	Moisture
118.9	5.3	132.2	5.2
118.6	5.2	131.7	5.0
119.1	5.3	132.7	5.2
Test 3 – After 6V Passes		Test 7 – After 13 (1S) Passes	
Density	Moisture	Density	Moisture
121.9	5.1	131.8	4.4
121.0	4.9	131.7	5.2
122.9	5.3	131.8	5.8
Test 4 – After 8V Passes			
Density	Moisture		
129.2	5.5		
128.1	4.8		
130.2	5.0		

B. Should this be considered an acceptable Roller Pattern? Why?

Form TL-53 (Rev. 07/15)

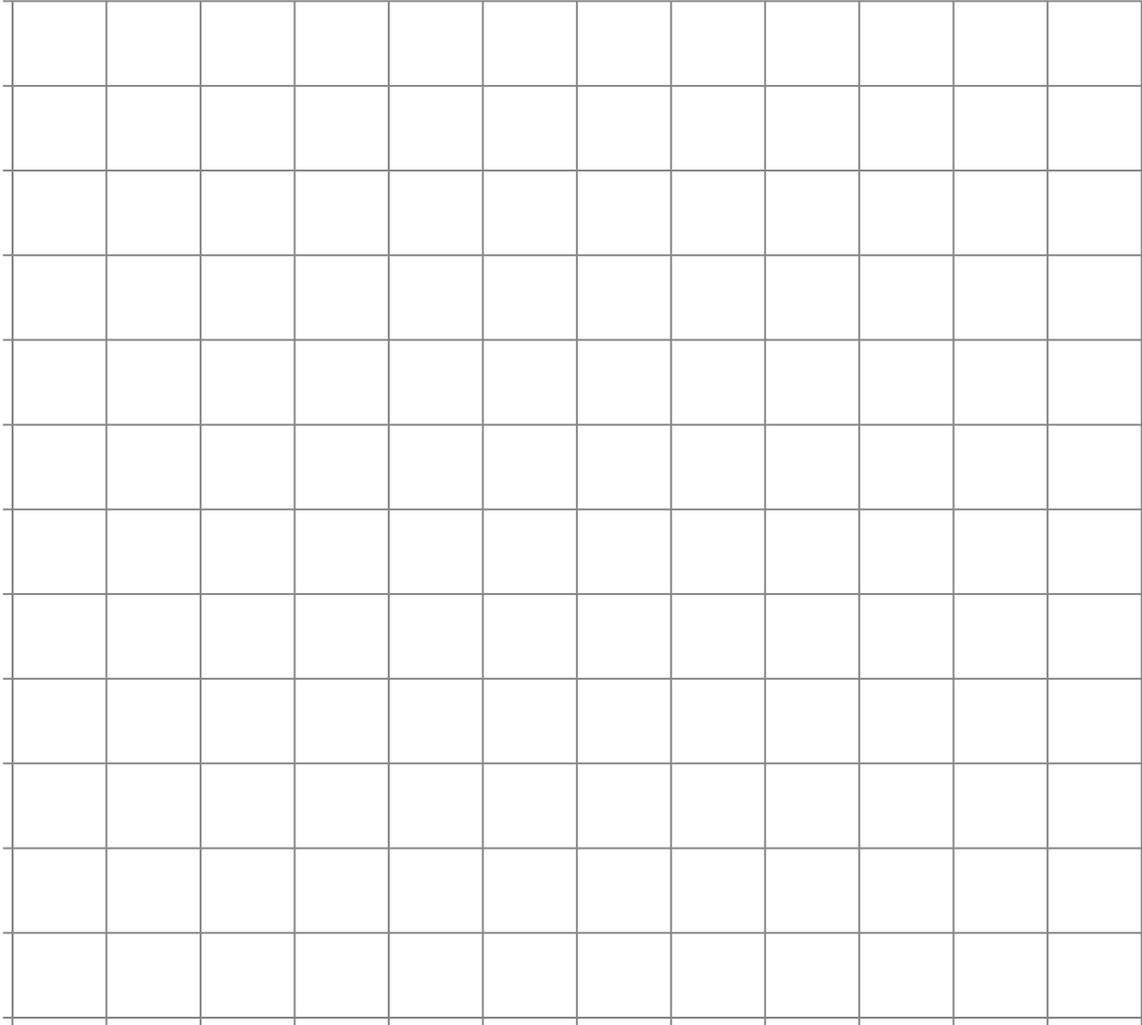
**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR ROLLER PATTERN**

Report No. _____ Nuclear Gauge Model No. _____ Serial No. _____
 Date _____ Project No. _____ Route No. _____
 FHWA No. _____ County _____
 Section No. _____ Station No. _____ ft. (m.) to Station _____ ft. (m.)
 Type Material _____ Width _____ ft. (m.)
 Optimum Moisture _____ Optimum Moisture Range _____
 Remarks _____

STANDARD COUNT DATA					
Density _____			Moisture _____		
TEST NO.	DRY DENSITY	MOISTURE	TEST NO.	DRY DENSITY	MOISTURE
Test No. 1			Test No. 6		
No. of Passes			No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 2			Test No. 7		
No. of Passes			No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 3			Test No. 8		
No. of Passes			No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 4			Test No. 9		
No. of Passes			No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		
Test No. 5			Test No. 10		
No. of Passes			No. of Passes		
Sta.			Sta.		
Sta.			Sta.		
Sta.			Sta.		
Total Average			Total Average		

ROLLER PATTERN CURVE

AVG. DRY DENSITY (lb/ft³)



NO. PASSES

Comments:

By: _____

Title: _____

Practice Problem Number 2
Nuclear Density Testing of Aggregates
Step 2 – Control Strip

- A. Using the same “header” information in Step 1, as well as the given below, complete the Control Strip (Form TL-54) and Direct Transmission (Form TL-124) worksheets.

Report No: 3-21ACTA-2 (Form TL-54)
 Station No: 901+25 to 904+25
 Report No: 3-21ACTA-3 (Form TL-124)
 Station No. for Direct Transmission Test: 902+70 (Offset 9 Ft. Lt.)
 Gauge Calibration Date: 12/10/2015

- B. How many roller passes were required to attain the maximum density on the Control Strip (Use the information from Step 1 – Form TL-53)

- C. Does the test pass the moisture criteria?

- D. Is the Control Strip within tolerance of the Roller Pattern?

- E. Does the Direct Transmission Test validate the Control Strip Dry Density? (See Page 8-49)

Test No.	Station No.	Ref. To C/L	Lane	Density Readings	Moisture Readings
1	901+25	3 Ft. Lt.	WBL	132.8	5.6
2	901+75	9 Ft. Lt.	WBL	132.7	5.7
3	902+00	6 Ft. Lt.	WBL	132.9	5.6
4	902+30	3 Ft. Lt.	WBL	132.6	5.8
5	902+70	6 Ft. Lt.	WBL	133.0	5.2
6	903+00	9 Ft. Lt.	WBL	132.5	5.7
7	903+35	9 Ft. Lt.	WBL	132.7	5.1
8	903+70	3 Ft. Lt.	WBL	132.7	5.8
9	904+00	6 Ft. Lt.	WBL	132.5	5.2
10	904+25	9 Ft. Lt.	WBL	132.8	5.5

Form TL-54 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR CONTROL STRIP**

Report No. _____ Date _____
 Route No. _____ Project No. _____
 FHWA No. _____ County _____
 Type Material _____ Width _____
 Station No. _____ ft. (m.) to Station _____ ft. (m.) to Nuclear Gauge
 Model No. _____ Serial No. _____
 Remarks _____

STANDARD COUNT DATA					
Density _____			Moisture _____		
	STATION	REFERENCE TO CENTER LINE FT. (M)	LANE	DRY DENSITY (LB/FT ³) DRY UNIT MASS (KG/M ³)	MOISTURE CONTENT
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
TOTAL:					
AVERAGE:					

_____ OPTIMUM MOSTURE REQUIRED (From Producer or Materials Division)

_____ OPTIMUM MOISTURE RANGE

(_____) x 0.95 = _____ INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR
 Dens. Avg. _____ TEST SECTION

(_____) x 0.98 = _____ AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIREMENT FOR TEST
 Dens. Avg. _____ SECTION

BY: _____

TITLE: _____

Practice Problem Number 2
Nuclear Density Testing of Aggregates
Step 3 – Control Strip (Direct Transmission Test)

- A. Use the information below to complete the following worksheet (Form TL-124) and answer the following questions.

Information from Quarry or Materials Lab:

Percent Passing the No. 4 Sieve = 43%
 Therefore, the percent of +4 Material = _____

Specific Gravity of the +4 Material = 2.50
 Therefore, the density of the +4 Material = _____

Absorption Rate of the +4 Material = 0.3%

Lab Proctor Information
 Maximum Dry Density of the -4 Material = 133.0 lbs/ft³
 Optimum Moisture of the -4 Material = 10.1%

Nuclear Gauge Display Panel	
% PR = 100.5%	
DD = 133.6	
WD = 140.8	
M = 7.2	M% = 5.4

- B. What is the minimum density required?

- C. Does the test pass?

Form TL-124 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)**

Report No. _____ Date _____ Sheet No. 1 of 1
 Route No. _____ County _____
 Project No. _____
 FHWA No. _____
 Testing for _____
 Model No. _____ Serial No. _____ Calibration Date _____

STANDARD COUNT DATA					
Density _____		Moisture _____			
Test No.		1	2	3	4
Location	Station ft. (m)				
of	Ref. to center line ft. (m)				
Test	Elevation				
Compaction Depth of Lift in. (mm)					
Method of Compaction					
A. Wet Density (lbs/ft ³), Wet Unit Mass (kg/m ³)		=			
B. Moisture Unit Mass (lbs/ft ³ or kg/m ³)		=			
C. Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) (A-B)		=			
D. Moisture Content (B ÷ C) x 100		=			
E. Maximum Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) Lab Proctor or One Point Proctor		=			
F. Percent Optimum Moisture from Lab or One Point Proctor		=			
G. Percent of Plus #4, (plus 4.75 mm)		=			
H. Corrected Max. Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)		=			
I. Corrected Optimum Moisture		=			
J. Percent Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³) (C ÷ E) x 100 or (C ÷ H) x 100		=			
K. Percent Minimum Density Required		=			

Comments:

BY: _____

TITLE: _____

Practice Problem Number 2
Nuclear Density Testing of Aggregates
Step 4 – Test Section

A. Testing at the minimum frequency: With the Test Section beginning at Station No. 904+25 and having a paving width 12 feet, choose five (5) test site location using the following random numbers.

<u>Distance from Start of Sublot</u>	<u>Distance from Reference Line</u>
101	4
106	8
27	3
140	3
182	10

There are 5,280 feet in a mile. A Test Section is _____ mile per paver width or _____ feet. _____ tests will be performed in the test section. _____ ÷ _____ = _____.

Sublot 1 _____ Feet	Beginning Station No. _____
Sublot 2 _____ Feet	Station No. _____
Sublot 3 _____ Feet	Station No. _____
Sublot 4 _____ Feet	Station No. _____
Sublot 5 _____ Feet	Station No. _____
	Ending Station No. _____

Test No.	Station No. at Start of Each Sublot	+	Distance from Start of Sublot	=	Station No. of Each Test Location	Distance from Reference Line (ft)
		+		=		
		+		=		
		+		=		
		+		=		
		+		=		

- B. Transfer the Optimum Moisture, Optimum Moisture Range, Individual Dry Density Requirement, and Average Dry Density Requirement from the Control Strip (Form TL-54) to the proper place on the Test Section worksheet (Form TL-55).
- C. Given the following nuclear density and moisture readings, complete the Form TL-55 using the same header information from the preceding problems (except use the correct Report Number: 3-21ACTA-4).

Test 1	Test 2	Test 3				
<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 132.3</p> <p>WD = 139.8</p> <p>M = 7.5 M% = 5.7</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 131.2</p> <p>WD = 138.4</p> <p>M = 7.2 M% = 5.5</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 130.6</p> <p>WD = 137.4</p> <p>M = 6.8 M% = 5.2</p>				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 50%;">Test 4</th> <th style="width: 50%;">Test 5</th> </tr> </thead> <tbody> <tr> <td style="border: 1px solid black; padding: 10px;"> <p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 131.3</p> <p>WD = 138.0</p> <p>M = 6.7 M% = 5.1</p> </td> <td style="border: 1px solid black; padding: 10px;"> <p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 129.6</p> <p>WD = 137.4</p> <p>M = 7.8 M% = 6.0</p> </td> </tr> </tbody> </table>		Test 4	Test 5	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 131.3</p> <p>WD = 138.0</p> <p>M = 6.7 M% = 5.1</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 129.6</p> <p>WD = 137.4</p> <p>M = 7.8 M% = 6.0</p>	
Test 4	Test 5					
<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 131.3</p> <p>WD = 138.0</p> <p>M = 6.7 M% = 5.1</p>	<p>Nuclear Gauge Display Panel</p> <p>% PR = ____%</p> <p>DD = 129.6</p> <p>WD = 137.4</p> <p>M = 7.8 M% = 6.0</p>					

- D. Does this test pass? Why?

- E. At what station is Test 4 to be taken from?

- F. At what station does Sublot 2 begin?

- G. How many feet from the reference line is Test 5 to be taken?

Form TL-55 (Rev. 07/15)

**VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT ON NUCLEAR TEST SECTION**

Report No. _____	Date _____
Route No. _____	Project No. _____
FHWA No. _____	County _____
Type Material _____	Width _____
Section No. _____	Station No. _____ ft. (m.) to Station _____ ft. (m.)
Model No. _____	Serial No. _____
Remarks _____	

STANDARD COUNT DATA	
Density _____	Moisture _____

_____ OPTIMUM MOISTURE REQUIRED % (From Producer or Materials Division)

_____ OPTIMUM MOISTURE RANGE

_____ INDIVIDUAL DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED
(95% of Control Strip Density from TL-54A)

_____ AVERAGE DRY DENSITY (lbs/ft³), DRY UNIT MASS (kg/m³) REQUIRED
(98% of Control Strip Density from TL-54A)

Test No.	Station ft. (m)	Lane	Dry Density (lbs/ft ³), Dry Unit Mass (kg/m ³)	Moisture Content	Pass (P) Fail (F)
1					
2					
3					
4					
5					
Average					

Comments:

BY: _____

TITLE: _____

