2007 Virginia Concrete Conference

Highlights of the new ME Design Procedure for Concrete Pavements

Mechanistic-Empirical Pavement Design Guide??
• The Design Guide represents a major change in the way we do design. It brings the designer closer to reality and considers traffic, structural features, materials, construction, and climate far more than ever before.
• This means the designer now will be more involved in the design and expected performance of pavements.

Limitations AASHTO Loadings

1972 AASHTO Interim Guide for the Design of Pavement Structures
• “While the Guides were under evaluation, AASHO initiated research studies within NCHRP for the purpose of developing a more theoretical or “rational” method for structural design of highway pavements.”

What’s Being Used (2003 survey)

The “Rational Method” gets a push
• Process initiated by Joint Task Force on Pavements
  - Irvine, California: March 1996
• Development of the 2002 Guide for Design of New and Rehabilitated Pavement Structures
  - NCHRP 1-37A
  - Awarded to ARA: February 1998
  - Product Submitted: February 2004
  - Cost $7 million

<table>
<thead>
<tr>
<th>Design Procedures</th>
<th>DOTs</th>
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<td>1972 AASHTO Guide</td>
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<td>1986 AASHTO Guide</td>
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<td>1993 AASHTO Guide</td>
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<td>Agency’s own pavement design guide or combination of AASHTO/Agency design procedures</td>
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What is Mechanistic Design?

- Fundamental Engineering Theories and Material Properties used to calculate critical strains in the pavement due to traffic load

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NCHRP 1-37a Product Includes:

- Comprehensive Pavement Design Procedure
- Structural Analysis Software
- Available at: [www.trb.org/mepdg/](http://www.trb.org/mepdg/)

Major Advantages of MEPDG

- Improved traffic characterization
- Ability to deal with changing load types

ESAL_{18k} Load Spectra

Materials

- Enhanced definition of material properties
- Relate material properties to performance
- Material Aging

Layer Coefficient Modulus

Climate

- Site specific climate considerations
  - Material properties effected by climate
  - PCC Joint openings, Curling / Warping

Extrapolated from Ottawa, IL 800 Weather Sites

The Big Picture

Climate Inputs

- Transfer Functions

Material Properties

- Predicted Performance

Mechanistic Analysis

Traffic
Empirical Portion of MEPDG

Predicted Performance vs. Observed Performance

β = Empirical Shift Factor

PCC Pavement Design Types

<table>
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<tr>
<th>Design Types</th>
<th>Pavement Types</th>
<th>PCC Property Inputs</th>
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<td>New Construction</td>
<td>JPCP, CRCP</td>
<td>New PCC</td>
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<tr>
<td>Restoration</td>
<td>JPCP</td>
<td>Existing PCC</td>
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<tr>
<td>Rehabilitation (BCO/UBCO)</td>
<td>JPCP, CRCP</td>
<td>New and existing PCC</td>
</tr>
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PCC Rehabilitation

- Not included in DG
  - CRCP Restoration
  - JRCP
  - Ultra-thin whitetopping

Levels of Input

- Level 1: Project Level Direct Testing
- Level 2: Correlation w/ Standard Test
- Level 3: Default Data

M-E Guide Outputs: Rigid

- Transverse Cracking
- Punchout
- Joint Faulting

PCC Material Properties for Design Inputs

- Design Guide requires inputs for PCC material properties in 4 groups
  - General Properties
  - Structural Properties
  - Thermal Properties
  - Shrinkage Properties
- Input requirements vary with pavement types and design input levels
General Properties

- PCC Unit Weight (ρ)
- Poisson’s Ratio (ν)

Thermal Properties

- Coefficient of Thermal Expansion
- Other Thermal Properties
  - Surface Short-Wave Absorptivity
  - Thermal Conductivity
  - Heat Capacity

Shrinkage Properties

- Ultimate Shrinkage
- Reversible Shrinkage
- Time to develop 50% of Ultimate Shrinkage

Slab Curling and Warping

- Slab wetter on top
  - Positive gradient
- Slab less wet on top
  - Negative gradient

Strength Properties

- Modulus of Elasticity
- Modulus of Rupture

Strength Properties

- Compressive Strength
**Strength Properties**

- Modulus of Rupture or Compressive Strength to predict Elastic Modulus

**Using MEPDG for Design**

- Iterative Process
- Use one or more distress predictions for failure criteria
- State specific guidance is necessary
  - Pavement Design Manual
  - Distress criteria and limits
  - Design parameters to change
- Do not throw out past experience

**Inadequate Design**

**Adequate Design**

**Local Calibration for States**

**Do standards & materials differ from LTPP?**
- Yes - Re-calibrate
- No - Confirm national results

**How?**
- Database of materials properties (confirm level 2 inputs)
- Database of default values (confirm level 3 inputs)
- Use LTPP as a starting point
- Add performance data available in the local area

**Using MEPDG for Design**

- Develop catalog of input values or files
- Guidance on use of Default values
  - Is it important?
  - Can I test it?
  - Will I test it?
- Design catalogs are an option
- Have a in-house expert
Major Advantages

- Modular system that allows for incremental enhancement
- Produces a more reliable design
- No longer dependent on the extrapolation of out-dated empirical relationships
- Excellent for forensic analysis
  - Answers “What if.....” questions

Integration

Pavement Design
Materials Selection
Communication
Pavement Management
Construction

Connection to Innovative Contracting

- Warranty
- Performance Related Specifications
- LCCA
- Design / Build
- Dispute Resolution Analysis

Longer Term Goals

- All pavement design systems need:
  - Quality Materials Characterization
  - Quality Traffic Data
  - Calibrated to local conditions
- The MEPDG is one tool for a designer
  - Focused on the structural design aspects
  - Has limitations

Questions

- www.trb.org/mepdg
- www.fhwa.dot.gov/pavement

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