Mechanistic-Empirical Design Implementation

John D’Angelo
Federal Highway Administration
Office of Pavement Technology
Design of New Flexible Pavements

Mechanistic-Empirical Methodology
Existing AASHTO Pavement Design Guide

• Empirical design methodology based on AASHO Road Test in the late 1950s

• Several editions:
  – 1961 Interim Guide
  – 1972
  – 1986
    • Resilient modulus, rehabilitation, reliability
  – 1993
    • Improved rehabilitation
    • Current version
AASHO Road Test (late 1950s)
1950s Vehicle Loads...

Figure 23. Test vehicles, showing typical axle arrangements and loadings.

(AASHO, 1961)
Mechanistic-Empirical Design

• *Mechanistically* calculate pavement response (i.e., stresses, strains, and deflections) due to:
  – Traffic loading
  – Environmental conditions

• Accumulate *damage* over time

• *Empirically* relate damage over time to pavement distresses, e.g.:
  – Cracking
  – Rutting
  – Faulting

• *Calibrate* predictions to observed field performance
Mechanistic-Empirical Pavement Design Software (NCHRP 1-37A)

- Software & guide available online to download.
- Each SHA and FHWA Division received copies.
- Limited tech support through NCHRP.
- Guide currently under independent review through NCHRP 1-40 project.
Benefits

• Compatible with Superpave system
• Major Improvement for Flexible Pavement Design
• Most Comprehensive Approach for Structural Design
• Provides Link Between -
  – Structural Design
  – Asphalt Mixture Design
Benefits

• Wide Range of Pavement Structures
  – New
  – Rehabilitated

• Direct Consideration of Major Factors
  – Traffic – Direct Consideration of Over-Weight Trucks
  – Climate
  – Materials – Different HMA/Aggregate Materials
  – Support – Foundation & Existing Pavement

■ Multiple Acceptance Criteria
  ■ Distress, smoothness
Benefits

• Uses Best Available Mechanistic-Empirical Models
  – Rutting, Fatigue Cracking, Thermal Cracking, Smoothness

• Models Calibrated Using LTPP Data

• Includes Method for Local Calibration
FHWA Design Guide
Implementation Team
DGIT

- **Office of Pavement Technology**
  - Leslie Myers – Asphalt Team
  - Sam Tyson – Concrete Team

- **Turner-Fairbank Highway Research Center**
  - Katherine Petros – Advanced Models Team

- **Resource Center**
  - Monte Symons – TST Team
  - Timothy Barkley - Communications Specialist

- **Division Office**
  - John Sullivan – Division Administrator
PURPOSE

To support & educate State highway agencies and industry in development & implementation of Mechanistic-Empirical Pavement Design

Facilitating Implementation of Mechanistic-Empirical Pavement Design
1-Day Workshops

Facilitating Implementation of Mechanistic-Empirical Pavement Design

Eight workshops throughout US in 2004

Participants from:

- 35 States
- 5 local highway agencies
- 20 universities
- HMA and PCC industry
- Consultants

Approximately 800 people will have attended by close of workshop program in the end of October 2004
Increase Understanding: NHI Course

NHI Course
Introduction to Using M-E Pavement Design Guide & Software

• Hands-on format with computers loaded with software
• Focus on user, not theory
  • Pre-req NHI #131064 or similar training
• Objective is for audience to be capable of performing flexible, rigid, rehab designs

STATUS: preparing RFP
Materials/Design Engineers 3-day Workshops

- **Objective**: Educate M/D engineers on what is required for obtaining Level 1 materials inputs to design guide
  - Asphalt materials inputs
  - Concrete materials inputs
  - Soils/Unbound Granular materials inputs

- Workshop, Laboratory and Software Modules
DGIT 3-day Workshops

• Pilot in January 2005
  – Additional 3 - 4 in FY 2005
  • Max Attendance: 40 participants / session
  • Location: State materials laboratory
  • Audience: State DOT Materials Engineers, Design Engineers, Senior test technicians from State labs, industry reps, State design consultants

• Delivery by DGIT-HQ and RC staff
  • Lab module supported by HQ mobile labs

Utah, Missouri, Connecticut, Virginia
Support of AASHTO & NCHRP 1-40

Lead States Group

• Identify States who have implementation plans
• Invite DOTs for First Lead States Group meeting
  • December 13-14, 2004 at TFHRC
  • First topic: implementation plans
• Coordinate with NCHRP/JTF
• DG User Group national meeting planned in March 05

Pooled-Fund Studies

• Budgetary issues
Lead States (based on FHWA Division Office 2003 questionnaire)
Additional Information

NCHRP 1-37A Design Guide User Comments database

http://www.fhwa.dot.gov/pavement/dgitdata.htm

Design Guide Implementation Team
dgit@fhwa.dot.gov

www.fhwa.dot.gov/pavement/dgit.htm
Local Calibration Example for Flexible Pavements
Contracted with Pennsylvania Transportation Institute

Collaboration of traffic, materials, & design engineers

Flexible pavement sections constructed in 2001 - 2003
SISSI Project

Long-Range Plan for Using Results from Superpave In-Situ Stress/Strain Investigation for Validation of Mechanistic-Empirical Pavement Design Guide

Planned budget: $2.4 million
Life of project: 5 years
  - Renewable for additional 5 years

Cooperation between PennDOT Research & Maintenance/Operations departments
Objective:
To provide data for validation & regional calibration of new M-E models
- Materials characterization
- Load-response information
- Traffic & environmental data
- Performance measures from Superpave sections
Typical Calibration Section

SISSI
Layer Thicknesses for Blair Plank Road Site

<table>
<thead>
<tr>
<th>Layer</th>
<th>Measured Thicknesses</th>
<th>Design Thicknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A inch</td>
<td></td>
<td>1.6 inch</td>
</tr>
<tr>
<td>0.5-in HMA Wearing Course</td>
<td>2.4 inch</td>
<td>2 inch</td>
</tr>
<tr>
<td>0.75-in HMA Binder Course</td>
<td>6.6 inch</td>
<td>7.2 inch</td>
</tr>
<tr>
<td>1-in HMA Base Course</td>
<td></td>
<td>8 inch</td>
</tr>
<tr>
<td>Subbase 2A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Instrumentation

• **Tranducers**
  - Temperature profiles, frost depth, moisture

• **Pressure cells, Strain gauges, Deflectometers**
  - Traffic loading response
  - Pressure on subgrade & subbase layers
  - Tensile strain at bottom of each HMA layer
  - Deflection of each layer

• **Data collection stations**
  - Weather station → environmental data
  - Weigh-in-motion station → traffic information
Testing for Materials Characterization

- Subgrade and Unbound Subbase
- Asphalt Binders
- Asphalt Mixture
  - Volumetric tests
  - Mechanistic characterization

Testing for Pavement Response

- Falling Weight Deflectometer
- Coring
- Trench Sections
- Weigh-in-Motion
- Climatic Database
New Mechanistic Empirical
Design Guide

The Pavement designers can

• Create more efficient and cost-effective designs
• Improve design reliability
• Improve rehabilitation design
• Reduce life cycle costs
• Increase support for cost allocation