Mechanistic-Empirical Pavement Design Guide

Overview and Implementation Issues

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My Purpose

- Status
- Overview of ME PDG
- Products
- Implementation Issues
- Key Points for Future Use
ME Design Guide Status

- Development is complete, software & report submitted to NCHRP.
- NCHRP made all project documents available to States for review in July.
- AASHTO begins process for balloting, software for DARWin ME version - future.
Future Improvements

**NCHRP 9-30**
Experimental Plan for Calibration & Validation of HMA Performance Models for Mix & Structural Design

**NCHRP 1-42**
Top-Down Cracking of HMA Layers

**NCHRP 1-41**
Selection of a Reflection Cracking Model for HMA Layers
ME PDG

An Overview
Pavement Design—Where are We?

State-of-the-Art

State-of-Practice

Empirical
Mechanistic-Empirical
Mechanistic

1993 AASHTO Design Guide

M-E Design Guide

(Schwartz, 2001)
Expanding the Realm of Possibility

Mechanistic-Empirical Design

Climate → Materials → Structure → Damage Accumulation → Distress

Response → Damage → Time

Traffic
Mechanistic-Based Design

- Characterize materials in terms of elastic properties (elastic modulus “E” & Poisson's ratio)
- Characterize climate by temperature and moisture effects on materials
- Characterize traffic loads as distributions of single, tandem, tridem, quad axles
- “Damage or distress” over time is estimated as it occurs in nature: incrementally (month by month)
The 2002 Guide uses a hierarchical approach for determining the design inputs.

<table>
<thead>
<tr>
<th>Input Level</th>
<th>Determination of Input Values</th>
<th>Knowledge of Input Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project/Segment Specific Measurements</td>
<td>Good</td>
</tr>
<tr>
<td>2</td>
<td>Correlations/Regression equations, Regional values</td>
<td>Fair</td>
</tr>
<tr>
<td>3</td>
<td>Defaults, Educated Guess</td>
<td>Poor</td>
</tr>
</tbody>
</table>
## Rigid Pavement Design Strategies

<table>
<thead>
<tr>
<th>Concrete Slab (JPCP, CRCP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Course (unbound, asphalt, cement)</td>
</tr>
<tr>
<td>Sub Base (unbound, stabilized)</td>
</tr>
<tr>
<td>Compacted Subgrade</td>
</tr>
<tr>
<td>Natural Subgrade</td>
</tr>
<tr>
<td>Bedrock</td>
</tr>
</tbody>
</table>
Design/Analysis Process

Foundation Analysis

Climate EICM

Materials Testing

Traffic Analysis

Inputs

Analysis

Modify Strategy

No

Meet Performance Criteria?

Yes

Trial Design Strategy

Pavement Response Model

Distress/Smoothness Prediction Models

Damage Accumulation

Field Data Calibration

Constructability Issues

Viable Alternatives

Life Cycle Cost Analysis

Select Strategy

Strategy Selection

Expanding the Realm of Possibility
Design Criteria

- RUT DEPTH
- FATIGUE CRACKING

Criterion

Design Period

TIME
Design Guide Distress Models

- Distress prediction with mechanistic-based models that are calibrated with field data

<table>
<thead>
<tr>
<th>Flexible Pavements</th>
<th>Rigid Pavements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoothness (IRI)</td>
<td>Smoothness (IRI)</td>
</tr>
<tr>
<td>Fatigue cracking</td>
<td>JPCP fatigue cracking</td>
</tr>
<tr>
<td>Rutting or distortion</td>
<td>JPCP faulting</td>
</tr>
<tr>
<td>Thermal cracking</td>
<td>CRCP punch outs</td>
</tr>
</tbody>
</table>
## Materials Characterization

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Distress</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>Low temp. cracking</td>
<td>( E (E^*) ), ( \mu )</td>
</tr>
<tr>
<td></td>
<td>Repeated load fatigue</td>
<td>Strength (triaxial, ind. tension)</td>
</tr>
<tr>
<td></td>
<td>Rutting</td>
<td>Thermal fracture</td>
</tr>
<tr>
<td>Cementiously Stabilized</td>
<td>Repeated load fatigue</td>
<td>( E, \mu )</td>
</tr>
<tr>
<td></td>
<td>Rutting (lime, fly ash)</td>
<td>Strength (flex., tensile, comp.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thermal expansion/contraction</td>
</tr>
<tr>
<td>Unbound Base/Subbase</td>
<td></td>
<td>( E (M_R), \mu )</td>
</tr>
<tr>
<td></td>
<td>Rutting</td>
<td>Strength (triaxial)</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Rutting</td>
<td>( E (M_R), \mu )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strength (triaxial)</td>
</tr>
</tbody>
</table>
PCC Material Properties

- PCC placement & opening to traffic dates
- PCC strength gain over time
- PCC elastic modulus gain over time
- PCC coefficient of thermal expansion
- PCC Poisson’s ratio and unit weight
- PCC drying shrinkage (ultimate and change over time)
- Seasonal base modulus values
- Time when PCC slab and treated base debonds
- Base erosion index (material, climate, subgrade)
Environmental Module

Enhanced Integrated Climatic Model
Enhanced Integrated Climatic Model

- Inputs:
  - Weather station or location
  - Other inputs: e.g., heat capacity, thermal conductivity, depth of water table

- Output:
  - Hourly temperature profile throughout the pavement
  - Correction factors based on moisture profile and freeze-thaw history to adjust the optimum modulus of unbound layers, relative humidity, precipitation, Freezing Index
Traffic Module

Load Spectra

APPLIED RESEARCH ASSOCIATES, INC.
An Employee-Owned Company
Traffic Data Needs

**Number of axles by (load):**
- Axle type
- Truck type
- Axle load interval

**Number of axles within (volume):**
- Each year
- Season within a year
- Each hour
Design Guide Traffic Levels

- **Level 1**
  - Volume/classification and axle load spectra related to the project (AVC and WIM)

- **Level 2**
  - Regional axle load spectra and project specific volume/classification data

- **Level 3**
  - Regional or default vehicle classification and axle load spectra data
Traffic Module

Output:

- All levels: Avg. daily single, tandem, tridem, and quad axles for each month in the design period
ME PDG Software

Design Guide 2002 - Untitled

This software is furnished only for review by members of the NCHRP 1-37A project panel and is regarded as fully privileged. Dissemination of this software must be approved by the NCHRP.
Program Layout

- General Information
- Inputs
- View Results and Outputs
- Status and Summary
Expanding the Realm of Possibility

Color Coded Status Icons

- **Green** to indicate completed inputs
- **Yellow** to indicate that default values will be used for the design
- **Red** to indicate that these inputs are still needed for the design process
ME PDG Available Now!

http://www.trb.org/mepdg/
ME PDG
Implementation

Implementation Issues
Products You Will See:

- Design Manual
- Software
- Guidelines
- Test Procedures
- User’s Manual
- Training Materials
How will the ME Design Guide change our way of doing business?

<table>
<thead>
<tr>
<th>93-Guide</th>
<th>ME-Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic – ESALs</td>
<td>Many more decisions &amp; educated guesses (assumptions) to make!</td>
</tr>
<tr>
<td>Layer Coefficient, a-value</td>
<td></td>
</tr>
<tr>
<td>Drainage Coefficient, m-value</td>
<td></td>
</tr>
<tr>
<td>Subgrade Resilient Modulus</td>
<td></td>
</tr>
<tr>
<td>Initial PSI</td>
<td></td>
</tr>
<tr>
<td>Temperature/Moisture</td>
<td></td>
</tr>
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</table>
Implementation Questions

Type 1 Questions:
- What are the inputs?
- How do I determine the inputs?
- How do I use the software?

Type 2 Questions:
- How applicable & accurate are the methods to my local conditions/materials?
Implementation Considerations

- Training on design procedure
- Establish design input procedures & database
- Obtain needed lab/field equipment
- State validation & calibration of national models
- Agency acceptance/adoptio
Dual Purpose Plan

Local Calibration

- Rut Depth
- Fatigue Cracking
- Thermal Cracking
- Ride Quality

Number of Test Sections Required for Calibration & Determination of Default Values.

Confirmation of Default Values

- Traffic Materials
- Soils
Summary: Road Map of Implementation Plan Activities

Phase I - Planning

Phase II – Initial Data Collection & Analyses

Phase III – Annual Data Collection, Analyses, & Confirmation
Implementation Efforts

- Mississippi
- Missouri
- Montana
- Utah
- Texas
- Indiana
- Virginia
- Georgia
- Florida
- Arkansas
- New York
Points to Remember about the ME PDG
Point 1!

- ME Design Guide **FAR EXCEEDS** the 1993 AASHTO Design Guide in all areas, but simplicity.

The method is based on tools that **EQUAL OR EXCEED** state-of-the-art!
Point 2!

The hierarchical input procedure allows a user to use the Guide with **NO** major investment.
Point 3!

ME Design Guide:

- A thickness analysis/design process.
- **BUT**, can be used to determine/evaluate other design features.
Point 4!

It’s a pavement design-analysis procedure with **Global**:  
- Correlations to estimate selected inputs.  
- Default values.  
- Calibration factors – **LTPP**.
Point 5

The accuracy or error of the new method **HAS BEEN** quantified.

How accurate is our existing pavement design procedure – the 1993 AASHTO Design Guide?
ME PDG Benefits
Benefits of ME PDG

It Ties Together:
- Structural Design
- Mixture Design
- Construction

Making sure that the design criteria have been meet or exceeded.

Material and Construction Specifications
Benefits of ME PDG

Adequate Structural Design → Crack Resist.

Use of Adequate Materials → Durable

Proper Mixture Design → Stable

Good Production- Constr. Operations → Functional

Pavement Design & Rehab. Strategies
The future of pavement design, & making it better with time!!

Questions