Overview

Introduction

MEPDG – Where are we now

MEPDG – Inputs, Outputs, and Sensitivity

Implementation Timeframe

Some DOT’s Already Underway

Others are Awaiting Other Efforts:

- NCHRP Projects
- FHWA Research Projects
- Copy Other State Approaches
- AASHTO Adoption
- Windfall from Gas Tax Revenues
- Hell Freezes Over

DARWin ME Timeline

Sunset Previous AASHTO Design Software

Fall 2007

- Sign intellectual property agreement with TRB

Winter 2007/2008

- Contract to review source code
  - Identify if modifications are needed for making software modular
  - Interface with third party software

DARWin ME Timeline (cont.)

Summer 2008

- Issue project solicitation proposal package for funding commitments

Fall 2008

- Select contractor
- Commence development shortly thereafter (Early 2009)
Good News, Bad News

- **Bad News**
  - There’s a lot going on
  - We are going to tell you about it

- **Good News**
  - MEPDG does it all for you in the background

What’s New in Flexible Design?

**HMA Materials**

- **1993 Guide**
  - Layer Coefficient
  - Structural Number

- **M-E Guide**
  - Dynamic Modulus (Master curves)
  - Binder and Volumetric

Asphalt Design Theory

- Climate Inputs
- Structure & Material Properties
- Predicted Performance
- Traffic
- Mechanistic Analysis
- Transfer Functions

What’s New in Flexible Design

- Analysis models – Layered Elastic
- Distress based on material performance
  - Fatigue – bottom up
  - Rutting
  - Thermal cracking
- Overall performance
  - Ride (IRI)

Asphalt Modulus is not Constant

- Changes with Load Pulse Duration
- Accumulated Damage
- Aging
- Temperature

Asphalt Stiffness, $E$

$$E = \frac{\sigma}{\varepsilon}$$

Hooke’s Law
Load Pulse

- Slows as you go deeper (Considered)
- Changes dependent on vehicle speed (Not Considered)

Global Aging System

- Field aging (surface hardening) depends on mean annual air temperature
- \( \log \log \eta = A + \text{VTS} \log T_R \)

Aging

\[ \begin{align*}
\text{AC1(1):} & \quad h=0.5 \\
\text{AC1(4):} & \quad h=1.0 \\
\text{AC1(7):} & \quad h=2.0
\end{align*} \]

Level 2 & 3

- Level 1: Project Level Direct Testing
- Dynamic Modulus
- Level 2: Correlation w/ Standard Test
  - Witczak’s Equation
- Level 3: Default Data
  - Witczak’s Equation

Asphalt Mix Master Stiffness Curve

- Cold and Fast vs. Hot and Slow

2008 SEAUPG CONFERENCE-BIRMINGHAM, ALABAMA
Level 2 & 3

- Correlate AC Modulus ($E^*$) with Binder properties and Mixture Volumetrics
- Compatible with SuperPave Mixture and Binder Testing

Witczak Equation for Computing $E^*$

$$\log E^* = 3.75 + 0.029 \rho_{200} - 0.0018 (\rho_{200})^2 - 0.0028 \rho_t - 0.058 V_s - 0.8022 \left( \frac{V_{hiv}}{V_{hiv} + V_s} \right) + 3.872 - 0.002 \rho_4 + 0.004 \rho_{10} - 0.00002 (\rho_{10})^2 + 0.0055 \rho_{28}$$

Has been replaced by $G^*$ and $\sin \delta$ in version 1.0

Binder properties used in:

- Aging model
- Dynamic Modulus Shift factors
- Witczak Equation
- Thermal cracking model

Conventional Binder Tests can be used In-place of Performance Grading

Categories of Inputs for HMA

<table>
<thead>
<tr>
<th>Input</th>
<th>Used to predict</th>
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<tbody>
<tr>
<td>Asphalt Mix Properties</td>
<td>- Stiffness of the Mix</td>
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<td>- Mechanistic response</td>
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<td>- Fatigue Cracking</td>
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<td>- Creep Compliance/Thermal Cracking</td>
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<tr>
<td>Asphalt Binder Properties</td>
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<tr>
<td>General Properties</td>
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Asphalt Mix Properties

- Laboratory Determined Dynamic Modulus of the Mix ($E^*$)
  - Definition: Ratio of Cyclic Stress to Elastic Strain under sinusoidal compression loading, controlled temperature/frequency conditions
  - Enter values of laboratory determined dynamic modulus at different test temperatures and frequencies
  - Test Protocol: ASTM D 3497
  - Typical value: 600 ksi
Asphalt Mix Properties, Cont’d
- **Aggregate Gradation**
  - Definition: Cumulative percentages from the grain size distribution curve:
    - % retained on 3/4 in. Sieve
    - % retained on 3/8 in. Sieve
    - % retained on No. 4 Sieve
    - % passing No. 200 Sieve
  - Test Protocol: ASTM C 136

Asphalt Binder Properties
- **Option 1: Superpave Binder Test Data - Laboratory Determined Complex Shear Modulus (G*) of the Binder**
  - Definition: Ratio of shear stress to shear strain under sinusoidal shear loading, controlled temperature/frequency conditions
  - Enter values of laboratory determined shear modulus and phase angle at different test temperatures and 10 rad/sec. angular frequency
  - Test Protocol: AASHTO PP1

Asphalt Binder Properties, Cont’d
- **Option 2: Conventional Binder Test Data**
  - Enter values for:
    - Softening Point (P)
    - Absolute Viscosity (P, @ 140 F)
    - Kinematic Viscosity (CS, @ 275 F)
    - Specific Gravity
    - Penetrations (number of entries, value [0.1 mm], temperature (F))
    - Brookfield Viscosities (number of entries, value [CP], temperature (F))
  - Test Protocols: AASHTO T49-93, T53-92, TP48

Asphalt Binder Properties, Cont’d
- **Option 1: Superpave Binder Grading**
  - Select from table of performance gradings as a function of the minimum pavement design temperature ("low") and the average seven-day maximum pavement design temperature ("high")
  - AASHTO MP1-93

Asphalt Binder Properties
- **Option 2: Conventional Viscosity Grade**
  - Select grade from available options:
    - AC 2.5
    - AC 5
    - AC 10
    - AC 20
    - AC 80
    - AC 40
    - ASTM D 3381

Asphalt Binder Properties, Cont’d
- **Option 3: Conventional Penetration Grade**
  - Select grade from available options:
    - Pen 40 - 50
    - Pen 60 - 70
    - Pen 85 - 100
    - Pen 120 - 150
    - Pen 200 - 300
  - ASTM D 946
Asphalt Concrete General Properties

- **Reference Temperature** – used to build “mastercurves” of dynamic modulus as a function of load frequency and temperature; default 70 F

- **Volumetric Properties (at time of construction)**
  - Effective Binder Content (%): The percent by mass of binder in a total mixture which is not absorbed into aggregate
  - Air Voids (%): The percent by volume of air in the mixture
  - Total Unit Weight (pcf): The ratio of total weight by total volume of the mixture

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Asphalt Concrete General Properties

- **Poisson’s Ratio**: Ratio of horizontal to vertical elastic strain
  - Option 1: Enter value (default 0.35)
  - Option 2: Enter predictive model parameters a and b
- **Thermal Conductivity**: A measure of the uniform flow of heat through a unit thickness, when two faces of unit area are subjected to a unit temperature differential
  - Used to predict temperature profile in AC layer
  - Calculated: ASTM E 1952 (default value 0.67 BTU /hr-ft deg F)

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Thermal Cracking Inputs

- **Heat Capacity**: Heat required to raise the temperature of a unit mass of material by unit temperature
  - Used to predict temperature profile in AC layer
  - Calculated: ASTM D 2766
  - Default value 0.23 BTU /lb-ft

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Thermal Cracking Inputs, Cont’d

- **Creep Compliance**: ratio of strain over stress in the *static* creep test (psi –1)
  - Either import file with creep compliance data or enter values in table as a function of temperature and loading time (only one temperature 14 F used in Level 2)

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MEPDG Calculations

- **Temperatures**:
  - computed every six minutes
  - Up to Seven Asphalt Sub-layers

- **Traffic**:
  - Assume normal distribution divided into five sub-seasons (quintiles) to represent temperature conditions when 20% of the traffic is applied.
Endurance Limit - Perpetual Pavement

- Theory: Very low strain levels at the bottom of an asphalt pavement do not contribute to the fatigue damage and can be neglected.

Things to remember

- All pavement design systems need:
  - Quality Materials Characterization
  - Recognizes Climate with Design
  - Quality Traffic Data
  - Calibrated to local conditions

- The MEPDG has raised the bar for each of these criteria......

Evolution

- The MEPDG is not perfect.....BUT;
- The MEPDG provides a reasonable and structured platform for continuous improvement.

Thank You!

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