



**M-E Design Inputs**

Southeast Asphalt User Producer Group  
Bill Vavrik  
19 November 2008

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This slide features a blue background with a collage of transportation images (trucks, cars, planes) in the top left corner. A white arrow icon is in the bottom left. The title 'M-E Design Inputs' is centered in white. Below it, the presenter's name and date are listed. The footer contains the company logo and name.

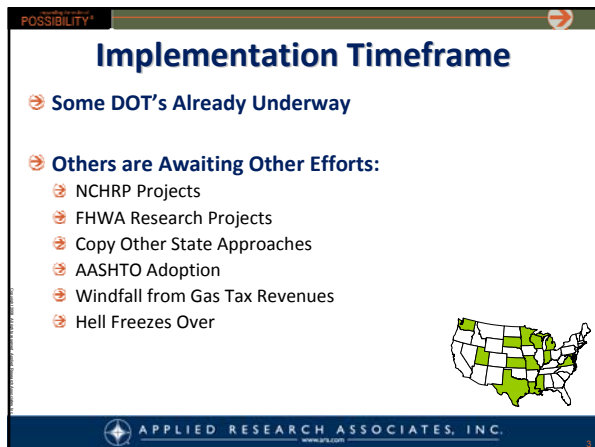


**Overview**

- Introduction
- MEPDG – Where are we now
- MEPDG – Inputs, Outputs, and Sensitivity


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The slide has a white background with a faint image of a white cup and pens on a grid. The title 'Overview' is at the top. Three bullet points are listed. The footer contains the company logo and name.



**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




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This slide has a white background. The title 'Implementation Timeframe' is at the top. It contains two main bullet points, with the second one having a sub-list. A map of the United States with some states highlighted in green is on the right. The footer contains the company logo and name.



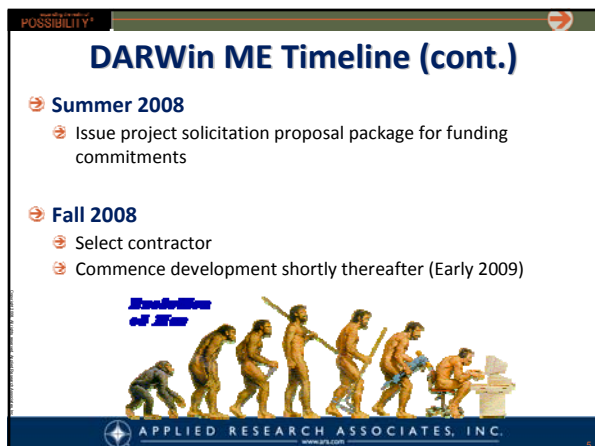
**DARWin ME Timeline**

- 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




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This slide has a white background. The title 'DARWin ME Timeline' is at the top. It contains three main bullet points, with the last one having a sub-list. An illustration of a person standing next to a tree is on the right. The footer contains the company logo and name.




**DARWin ME Timeline (cont.)**

- Summer 2008
  - Issue project solicitation proposal package for funding commitments
- Fall 2008
  - Select contractor
  - Commence development shortly thereafter (Early 2009)



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This slide has a white background. The title 'DARWin ME Timeline (cont.)' is at the top. It contains two main bullet points, each with a sub-list. An illustration of the 'Evolution of Man' is at the bottom. The footer contains the company logo and name.



**Overview**

- Introduction
- MEPDG – Where are we now
- MEPDG – Inputs, Outputs, and Sensitivity

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This slide is identical to the first 'Overview' slide, featuring a white background with a faint image of a white cup and pens on a grid. The title 'Overview' is at the top. Three bullet points are listed. The footer contains the company logo and name.

**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





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**What's New in Flexible Design?**

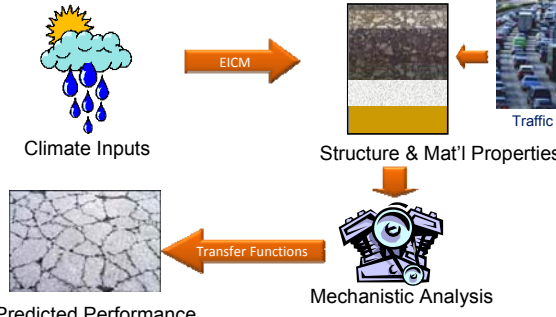
**HMA Materials**

<b>1993 Guide</b>	<b>M-E Guide</b>
Layer Coefficient	Dynamic Modulus (Master curves)
Structural Number	Binder and Volumetric

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**Asphalt Design Theory**



Climate Inputs

Structure & Mat'l Properties

Traffic

Mechanistic Analysis


Transfer Functions

Predicted Performance

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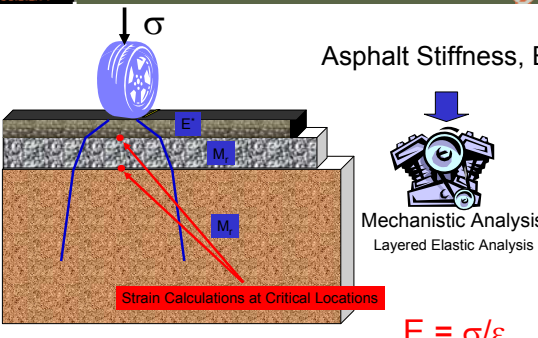
**What's New in Flexible Design**

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



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**Asphalt Modulus is not Constant**



Asphalt Stiffness,  $E^*$

Mechanistic Analysis  
Layered Elastic Analysis

Strain Calculations at Critical Locations


$E = \sigma / \epsilon$

Hooke's Law

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**Asphalt Modulus is not Constant**

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



**Asphalt is Time-Temperature Dependent**

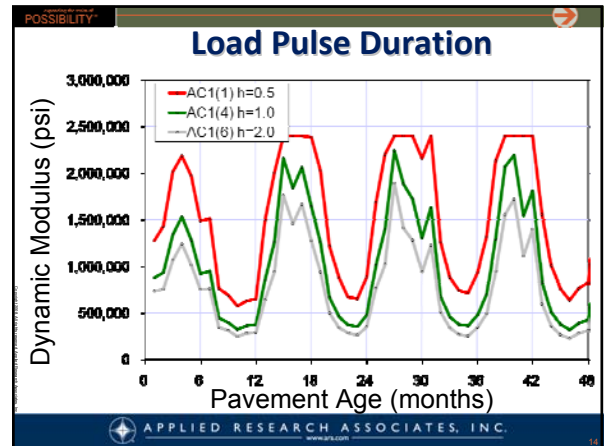
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### Load Pulse

- Slows as you go deeper Considered
- Changes dependent on vehicle speed

Not Considered

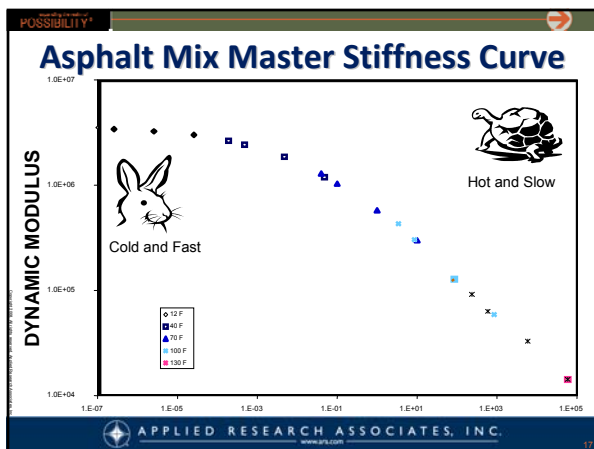
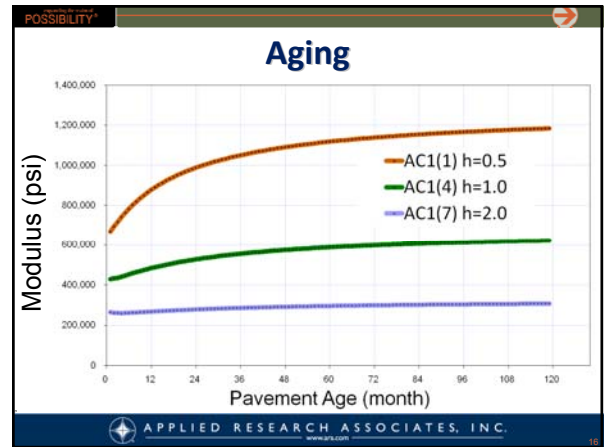
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### Global Aging System

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

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### Level 2 & 3

Asphalt Mixture Characterization

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

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**Level 2 & 3**

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

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**Witczak Equation for Computing  $E^*$**   
 **$f$  (Gradation, Volumetric, and Binder Properties)**  
**Level 2 & 3**

$$\log E^* = 3.75 + 0.029 \rho_{200} - 0.0018(\rho_{200})^2 - 0.0028\rho_4 - 0.058 V_a - 0.8022 \left( \frac{V_{beff}}{V_{beff} + V_a} \right) + \frac{3.872 - 0.002 \rho_4 + 0.004 \rho_{38} - 0.00002(\rho_{38})^2 + 0.0055 \rho_{34}}{1 + e^{(-0.603 - 0.313 \log(f) - 0.393 \log(\eta))}}$$

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

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**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**

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**ASPHALT MATERIAL PROPERTY AND DESIGN INPUTS**

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**Categories of Inputs for HMA**

Input	Used to predict
Asphalt Mix Properties	<ul style="list-style-type: none"> <li>Stiffness of the Mix</li> <li>Mechanistic response</li> </ul>
Asphalt Binder Properties	<ul style="list-style-type: none"> <li>Fatigue Cracking</li> <li>Creep Compliance/ Thermal Cracking</li> </ul>
General Properties	

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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

Input	1	2	3
Level	√		

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**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

Input	1	2	3
Level		√	√

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**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

Input	1	2	3
Level	√	√	

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**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

Input	1	2	3
Level	√	√	

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**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

Input	1	2	3
Level			√

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**Asphalt Binder Properties, Cont'd**

- **Option 2: Conventional Viscosity Grade**
  - Select grade from available options:
    - AC 2.5
    - AC 5
    - AC 10
    - AC 20
    - AC 30
    - AC 40
  - ASTM D 3381

Input	1	2	3
Level			√

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**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

Input	1	2	3
Level			√

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**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

Input	1	2	3
Level	√	√	√

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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)

Input	1	2	3
Level	√	√	√

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**Asphalt Concrete General Properties**

- ☞ **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

Input	1	2	3
Level	√	√	√

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**Thermal Cracking Inputs**

- ☞ **Average Tensile Strength at 14 F :** Maximum stress that a material is capable of resisting under axial tensile loading from the indirect tensile strength test.
- ☞ **Creep Test Duration:** select either 100 or 1000 sec.
- ☞ **Mix Coefficient of Thermal Contraction (in/in/oC) –** Change in linear dimension per unit length or change in volume per unit volume per degree of temperature change. Either enter value or compute from:
  - ☞ Mixture VMA (voids in mineral aggregate)
  - ☞ Aggregate Coefficient of Thermal Contraction

Input	1	2	3
Level	√	√	√

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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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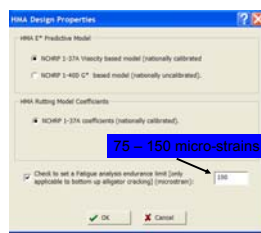
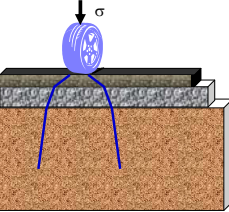
**MEPDG Calculations**

- ☞ **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.

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**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.



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**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.....

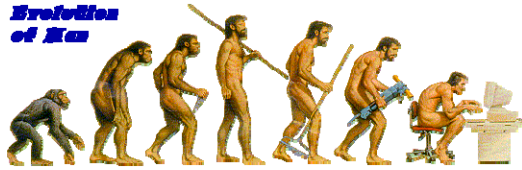
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**Evolution**

⇒ The MEPDG is not perfect.....BUT;

⇒ The MEPDG provides a reasonable and structured platform for continuous improvement.

*Evolution of Man*



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**Thank You!**

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