

The New Mechanistic-Empirical Pavement Design Guide: Implementation and Other Issues...or


What in the world is going on?



Kevin D. Hall, Ph.D., P.E.
University of Arkansas
Department of Civil Engineering


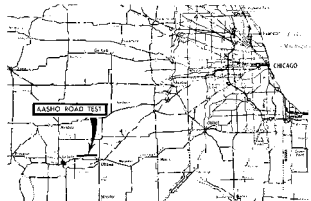

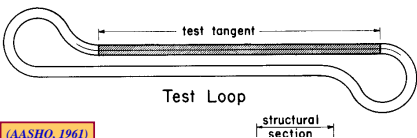
Southeastern Asphalt User-Producer Group
Nashville, Tennessee – December 2005

First things first...



- What is the mechanistic-empirical pavement design guide (MEPDG)?
 - A product of NCHRP 1-37a
 - With refinements under NCHRP 1-40
 - A pavement *analysis* tool
 - Provides predictions of pavement distress, given a trial structural pavement section
- What is it NOT?
 - An official AASHTO product (yet)
 - A traditional “design” program (yet?)
 - (likely) in its final form


Memory Lane: the AASHTO Road Test (late 1950's)

(AASHTO, 1961)

The AASHTO Road Test
History and Description of Project
National Academy of Sciences
National Research Council

AASHTO Pavement Design (current)



$$\log_{10} W_{18} = Z_r * S_w + 9.36 * \log_{10} (SN + 1) - 0.20 + \frac{\log_{10} \left[\frac{\Delta PSI}{4.2 - 1.5} \right]}{0.40 + \frac{1094}{(SN + 1)^{5.18}}} + 2.32 * \log_{10} M_r - 8.07$$


Flexible pavement design:
the *answer* is structural number (SN)

Then you break SN into layers:




$$SN \leq (a_{ACHM} * d_{ACHM}) + (a_{base} * d_{base})$$

The *design* is layer thickness


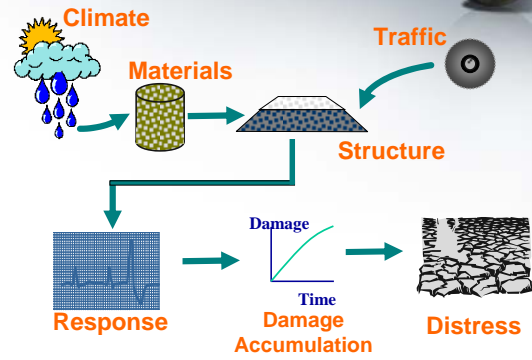
MEPDG: Flexible Pavements



- Distress Models
 - Fatigue Cracking (bottom up)
 - Rutting
 - Thermal Cracking
 - Roughness (IRI)

Mechanistic-Empirical Design/Analysis: The “nickel tour”

Climate → Materials → Structure → Response → Damage Accumulation → Distress

Traffic → Structure

Structure → Response

Response → Damage Accumulation

Damage Accumulation → Distress

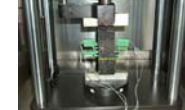
**MEPDG:
Materials Inputs**

- Complicating Factors
 - LOTS MORE!!!!
 - Some inputs not currently measured/tracked
- "Levels" of inputs
 - Level 3: I don't know much about the input...
 - Level 2: I know "some" about the input...
 - Level 1: I know a lot about the input...
- Typical Approaches
 - catalogs/libraries
 - correlations

Asphalt Materials Properties



Parameter	Level 1	Level 2	Level 3
Dynamic Modulus, E*	Lab: simple performance test	Mix volumetric properties	Mix volumetric properties
Tensile strength & Creep compliance	Lab: indirect tension test	Lab: IDT at 1 temperature	Default data calculated



Level: 1

Asphalt material type: Asphalt concrete

Layer thickness (in): 4

Options - At Short Term Aging - RTFD

Superpave binder test data

Conventional binder test data

Temperature (°F)	Angular frequency = 10 rad/sec	G' (Pa)	Delta (°)
40		1.79E7	37.4
55		4.98e6	46.9
77		8.14e5	56.5
113		4.1e4	66

Superpave binder test

Level: 3

Asphalt material type: Asphalt concrete

Layer thickness (in): 4

Options

Superpave binder grading

Conventional viscosity grade

Conventional penetration grade

High Temp (°C)	Low Temp (°C)						
	-10	-16	-22	-28	-34	-40	-46
46							
52							
58							
64							
70							
76							
82							

Superpave binder grade

Level: 3

Asphalt material type: Asphalt concrete

Layer thickness (in): 4

General Properties

Reference temperature (°F): 70

Poisson's Ratio

Poisson's ratio: 0.3

As Built Hot Mix

Effective binder content (%): 8.6

Air voids (%): 7

Total unit weight (pcf): 148

Thermal Properties

Thermal conductivity asphalt (BTU/hr-R-F): 0.67

Heat capacity asphalt (BTU/lb-F): 0.23

Level: 1

Asphalt material type: Asphalt concrete

Layer thickness (in): 4

Dynamic Modulus Table

Temperature (°F)	Mixture E' (psi)			
	0.1	1	10	25
10	1807698	2214499	2509367	2598853
40	789187	1227495	1654832	1734659
70	226939	440246	781182	957396
100	49488	107164	232124	324039
130	16160	32519	68538	105721

Import/export already-created Dynamic modulus data

SEAUPG 2005 Conference - Nashville, TN

Asphalt Material Properties

Level: 3

Asphalt material type: Asphalt concrete

Layer thickness (in): 4

Aggregate Gradation

Cumulative % Retained 3/4 inch sieve: 0

Cumulative % Retained 3/8 inch sieve: 11

Cumulative % Retained #4 sieve: 46

% Passing #200 sieve: 2.5

Levels 2 & 3 Input aggregate gradation

Thermal Cracking

Level 1
Level 2
Level 3

Average tensile strength at 14 °F (psi): 444

Creep test duration (sec): 100

Import/export already-created thermal cracking files

Loading Time sec	Creep Compliance (1/psi)		
	Low Temp (°F)	Mid Temp (°F)	High Temp (°F)
-4	14	32	
1	2.827e-007	4.137e-007	5.309e-007
2	2.965e-007	4.206e-007	6.205e-007
5	3.309e-007	5.34e-007	7.791e-007
10	3.378e-007	5.86e-007	8.756e-007
20	3.654e-007	6.481e-007	1.049e-006
50	3.792e-007	7.996e-007	1.358e-006
100	3.999e-007	9.101e-007	1.696e-006

Input or default coefficient of thermal contraction

Compute mix coefficient of thermal contraction:

Mixture VMA (%):

Aggregate coefficient of thermal contraction:

Mix coefficient of thermal contraction (mm/mm/°C): 1.3e-005

For Level 1, Tensile Strength and Creep Compliance at three temperatures are needed to determine thermal cracking

Thermal Cracking - Level 2

Level 2

Level 1
Level 2
Level 3

Average tensile strength at 14 °F (psi): 444

Creep test duration (sec): 100

Input tensile strength and creep compliance data at one temperature

Loading Time sec	Creep Compliance (1/psi)		
	Mid Temp (°F)	14	
1	4.137e-007		
2	4.206e-007		
5	5.24e-007		
10	5.86e-007		
20	6.481e-007		
50	7.996e-007		
100	9.101e-007		

Thermal Cracking - Level 3

Level 3

Level 1
Level 2
Level 3

Average tensile strength at 14 °F (psi): 438.88

Creep test duration (sec): 100

Level 3 Tensile Strength and Creep Compliance default values will be generated as a function of volumetric properties and binder type

Loading Time sec	Creep Compliance (1/psi)		
	Low Temp (°F)	Mid Temp (°F)	High Temp (°F)
-4	14	32	
1	2.84235e-007	3.88755e-007	5.31713e-007
2	3.14314e-007	4.54281e-007	6.88031e-007
5	3.59017e-007	5.58147e-007	9.67326e-007
10	3.97011e-007	6.52223e-007	1.25171e-006
20	4.39026e-007	7.62155e-007	1.6197e-006
50	5.01466e-007	9.36415e-007	2.27719e-006
100	5.54534e-007	1.09425e-006	2.94666e-006

MEPDG: Pavement Responses

- Ties to materials inputs
- Typical Approach: **Sensitivity Analysis**
 - Identifies "critical" inputs
 - "Where do I need to spend my money?"
 - Provides an assessment of the suitability of using default values
 - Allows designers to focus on topics most affecting design
 - Gives designers tools to affect one distress without affecting others

MEPDG: Local Calibration

- This is where the "empirical" of M-E comes in...
- Compare predicted distress versus real life
- Adjust distress prediction models to "fit"
 - Current calibration is *national*
- Typical Approach
 - Start with LTPP sections
 - Add existing sections (PMS??)
 - Plan new sections
 - DATA QUALITY IS KEY
- This could be a long-term effort!!!

To Sum Up...



- Materials and traffic inputs have gotten intense
 - Catalog and document past & future testing efforts
- Pavement responses must be understood
 - Sensitivity analyses – R – us
- Make it real – but make sure it's complete
 - Local calibration makes the MEPDG work for you

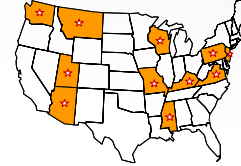
A final thought: you are not alone!



- FHWA Design Guide Implementation Team (DGIT)



- Lead States



- Technology Transfer

THANK YOU

QUESTIONS?

