M-E Design Implementation Meeting 1

September 17, 2002

Background:

M-E Design Concept:
1. Stress and strain calculated from material properties, loading, and environmental conditions.
   a. Calculated monthly/daily to include environment and loading influence
2. Strain accumulated to formulate damage function
3. Damage related to distress by transfer function

Distress Modeled:

Asphalt Pavements:
rutting (mean rut depth in wheel path)
fatigue cracking (unknown)
thermal cracking (crack width)

Rigid Pavements:
faulting (mean fault in wheel path)
cracking (% slabs cracked)

Material Properties:

Asphalt Pavements:
Dynamic Modulus, 10^5 psi
bitumen viscosity, 10^6 poise
loading frequency, Hz
air void content, %
effective bitumen content, % by volume
cumulative % retained on the 19 mm sieve
cumulative % retained on the 9.5 mm sieve
cumulative % retained on the 4.76 mm sieve
% passing the 0.075 mm sieve
Complex elastic modulus
Poisson’s Ratio

Rigid Pavements:
Modulus of rupture
Modulus of elasticity
Coefficient of thermal expansion
Poisson’s ratio

Unbound Materials:
Modulus of elasticity
Poisson’s ratio

Subgrade:
Resilient Modulus of Elasticity
Modulus of Elasticity of bedrock
Poisson’s ratio

Environmental Inputs:

- Average annual total precipitation
- Average annual daily mean air temperature
- Average annual daily maximum air temperature
- Average annual daily minimum air temperature
- Average annual absolute maximum air temperature
- Average annual absolute minimum air temperature
- Average annual number of days above 90°F
- Average annual number of days below 32°F
- Average annual number of wet days.
- Average annual Freezing Index (359.48 °F - days for Columbus)
- Average annual number of freeze thaw cycles
- Average annual wind speed.
- Average annual maximum wind gust speed
Traffic Loading Inputs:

- Load Spectra for single, tandem, tridem, and quad axles.
- Counts of number of axles within a series of load groups in a given time interval.
- Tire pressure

Procedure:

M-E process will allow for a three level approach (levels can be mixed and matched with data):

Level 1
- Will require the most accurate of data, thus reliability will effect the results the least of the three levels, and result in the most cost effective pavement sections.
- Models created for NCHRP 1-37a were not calibrated using Level 1 data. LTPP data is not level 1 data. In order to design at the level 1, ODOT would need to provide Level 1 data from Ohio, and then calibrate the models to that data.
- Level 1 data requires load spectra from the site, and the material properties for the future construction.

Level 2
- This will be ODOT’s standard level for design. It is the most practical.
- Level 2 data uses system averages. Likely would need material properties to be provided by state average or possibly regional average.
- We may use Level 1 loading where WIM sites exist, if Tech services can provide load spectra in a reasonable time frame.

Level 3
- Level 3 uses default values for everything. Where we have problems supplying data we can always resort to level 3.

Barriers to Implementation:

ODOT PCR is not sufficient to validate. Validation will need to be done using research projects. Much of this data is not easily accessible. If ODOT finds that the models are not valid for Ohio, calibration will need to be done.

Witczak Equation for Dynamic Modulus is not based on SMA mixes, open graded mixes, and PG binders which are rated for a $\Delta T^\circ > 100^\circ$ C. Thus mixes which use a PG 76 - 28 may need to be tested for Dynamic Modulus.

Needed Materials Testing Equipment:

Future Focus:
1. Collect PCR data to calibrate and validate models for Ohio only.
2. Collect material properties on a broader base of projects to assist in calibration and validation
3. Purchase AASHTO-WARE software once available to use for full implementation
4. Create material specification that require material properties that define performance.
NCHRP 1-32a Draft Final Report  
Dec. 31, 2002

Assume Dec. date.

Joint Task Force  
4 month review process

Assume sufficient condition data exists.

NCHRP 1-32a Final Report  
May 2003

Validate Models:  
DEL-23  
ERI/LOR-2  
ATH-50  
LOG-33  
ROS-23

Begin Level 2 Implementation  
August 2003  
CO / Interstate

AASHTO  
and  
NCHRP 1-37A

Level 2 implementation is not to be a design procedure but rather a design tool. ODOT design procedure will continue to be AASHTO '93, but with AASHTO '02 as a design check.

Collect data for future calibration.
M-E Design Implementation 10 Year Timeline

Assume AASHTO 2007 is released July 2003

Spring 2004
Begin PCR collection to match AASHTO 02

Continue to collect Material Properties

Purchase AASHTO-WARE software 2004
$10,000

Continue to perform pavement design using combination of AASHTO 93 and 0?

Create Performance specifications that require material properties that define performance.

Calibrate AASHTO M-E models for Ohio 2010

Implement AASHTO 2007 network-wide with more confidence and higher reliability. 2011
M-E Design Implementation Plan
October 1, 2002

DECEMBER 31, 2002
NCHRP 1-37a Draft Final Report released.
- Begin review process (Task Force)
- Compile data needs for level 2 design: materials, traffic, environment
- Begin validation\(^1\) of models using DEL-23, ERI/LOR-2, ATH-50, LOG-33, ROS-23
- Begin collection of material property data by: research $\^2$, test lab $\$, and contractor support$\$.

FEBRUARY 1, 2003
NCHRP 1-39\(^3\) Final Report released (due date expected Feb 2003)
- Coordinate with Tech Services to ensure this software can be used with NCHRP 1-37a, as well as ODOT’s data collection methods.

MARCH 1, 2003
- Begin new PCR methodology to conform to AASHTO '02 model.
- Begin retrofit of PCR data collection.
- Revise PCR distress definition and thresholds
- Revise software for field personnel to begin new collection standards

MAY 31, 2003
NCHRP 1-37a Final Report released.

JULY 1, 2003
AASHTO 2002 Guide is released with the accompanied software ($10,000)$\(^4\).

OCTOBER 1, 2003
- Begin level 2 implementation\(^5\) for the Priority System- Major Rehab. and New AASHTO '93 for a design procedure and AASHTO '02 for a design check

2010
- Calibration of mechanistic design guide: material properties that have been collected for past 7-1/2 years, condition data that has been collected since spring 2003, and latest models available. Create performance specifications that require material properties that can be related to performance. Implement the M-E approach on a higher level, by not only design, but also construction, and PMS.

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\(^1\)Assumes the performance data exists in the research documents of these projects. Impossible to know until the guide is released.

\(^2\)$ Costs to implement are unknown.

\(^3\)$Traffic Data Collection Analysis and Forecasting for M-E pavement design.

\(^4\)$This is a major assumption on timing and cost. As long as 1-39 and 1-37a work together the level 2 implementation can still proceed.

\(^5\)$Assumes the initial validation was successful, axle spectra data can be loaded using 1-39, and sufficient material properties can be obtained for level 2. It is possible that Ohio performance would not validate the models. If this is the case we would need to calibrate the models.
Assumptions:
1-37a draft publish date: this date has changed numerous times and will likely be pushed again
Model validation:
- Thermal cracking model may not be able to be validated, since none of our research locations have thermal cracking.
- Only Del-23 has the entire list of data needed to validate. Some of the other sections have data for only concrete, and some for only asphalt. The thicker sections have not deteriorated sufficiently to provide distress data for validation. More time will necessary.
- Not a good mix of North and South for both concrete and asphalt.
Costs are not yet determined. Much of the cost data needed is dependent on the tests to be done. Many of these tests are being revised. May not know until the guide is released.