Mechanistic-Empirical Pavement Design Oversight Committee

Kickoff Meeting
Construction Field Services
June 18, 2012

Mike Eacker
Outline

• What Is ME?
• Why Adopt ME?
• Work Completed To Date
• Current Work
• Goals Of The Committee
• Proposed Subcommittees
• Q&A/Discussion
What Is ME?
What Is ME?

- Mechanistic-Empirical pavement design (ME) is the latest generation of pavement design methodology
- Not a new concept
- Theory of mechanics – pavement response (stresses/strains) to applied load
- Empirical observations used to calibrate the mechanistic models
What Is ME?

- NCHRP Project 1-37A began 1998
- 1-37A completed 2004
- Version 1.0 of the software (MEPDG) delivered 2007 – AASHTO interim design method
- Version 2.0 of the software (DARWin-ME) delivered 2011 – AASHTO standard design method
- 27 states, 6 Canadian provinces, several others are licensing DARWin-ME (as of Jan. 2012)
What Is ME?

- Climate
- Structure & Materials
- Traffic
- Mechanistic Analysis
- EICM
- Transfer Functions
- Predicted Performance
What Is ME?

- Mechanistic models used to calculate pavement response (stresses and strains) with each passing axle load
- Response is converted to distress through transfer functions
- Incremental damage approach is used to sum damage over time
- Distresses (performance) predicted over time
Questions?
Why Adopt ME?
Why Adopt ME?

- Current design method, AASHTO 1993, based on AASHO Road Test from 1958-1960
Why Adopt ME?

- **AASHO Road Test**
  - 1950’s trucks, loads, tires, tire pressures
  - 1950’s test methods
  - Local materials (Ottawa, Illinois)
  - Local weather conditions
  - Local drainage conditions
  - Single Subgrade type
  - Limited traffic (~1.1 million applied ESAL’s)
Why Adopt ME?

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<td>Performance Parameters</td>
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<td>Output</td>
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Why Adopt ME?

- Axle Load Spectra comes from WIM information

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Why Adopt ME?

- Examples of new inputs that affect pavement performance, but are not in current method:
  - Tire pressures
  - Hourly traffic distribution
  - Location specific climate data
  - Concrete coeff. of thermal expansion
  - HMA dynamic modulus
  - Plasticity Index, gradation, etc. of base, subbase, subgrade materials
Why Adopt ME?

Michigan weather stations embedded in DARWin-ME
Why Adopt ME?

Predicted Asphalt Mid-Quintile Sub-layer Modulus

One year time frame

Modulus (psi)

Pavement Ages (date)

AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC2(4) h = 1 in
AC2(5) h = 1.5 in
AC3(6) h = 4 in
AC3(7) h = 2.5 in
Why Adopt ME?

- ME distresses match up closely with our PMS data:
  - Concrete distresses predicted: % slabs cracked, faulting, IRI
  - HMA distresses predicted: transverse cracking, longitudinal cracking, % fatigue cracking, rutting, IRI
- Present Serviceability Index has not been measured
Why Adopt ME?

- Can see the effect of many more materials properties on a pavement’s performance
- Can evaluate the effects of proposed changes to designs/materials during specification development or construction
- Significant changes in pavement materials and traffic can be investigated/quantified
- Changes in materials properties with time (aging, etc.) are incorporated
- Hierarchical input structure allows for customization of the quality of the inputs depending on resources required and project importance
Why Adopt ME?

- Damage being output over time provides possibility of planning future work
Questions?
Work Completed To Date
Work Completed To Date

• “Evaluation of the 1-37A Design Process for New and Rehabilitated JPCP and HMA Pavements”
  – Sensitivity of the inputs
  – Comparison of in-service pavement performance with ME predicted performance
  • Michigan LTPP sections, 5 JPCP projects, 5 HMA projects
  – Reasonableness of model results
Work Completed To Date

- “Characterization of Truck Traffic in Michigan for the New Mechanistic Empirical Pavement Design Guide”
  - Sensitivity of traffic inputs
  - Used TrafLoad software
  - Used data from all permanent traffic recorders (WIM and classification sites)
  - Looked at one week per month vs. full data set – very little difference
Work Completed To Date

• “Characterization of Truck Traffic…” (cont.)
  – Grouped the WIM’s into cluster of similar characteristics for most of the traffic inputs
  – Recommended input levels for each of the traffic inputs
  – Developed method for coming up with traffic inputs for areas not represented by a WIM
Work Completed To Date

• “Quantifying Coefficient of Thermal Expansion Values for Typical Hydraulic Cement Concrete Paving Mixtures”
  – Utilized eight different aggregate geologies typically used in Michigan
  – Recommend CTE values for different aggregate types
Work Completed To Date

• “Pavement Subgrade MR Design Values for Michigan’s Seasonal Changes”
  – Used soil maps to break the state into zones of different subgrade types
  – Used FWD and samples collected to obtain resilient modulus values
  – Developed equations to calculate modulus from other soil parameters (dry unit weight, % passing #200 sieve, etc.)
  – Recommended modulus values for each of the subgrade types
Work Completed To Date

• “Backcalculation of Unbound Granular Layer Moduli”
  – Used FWD data to backcalculate resilient modulus values of base and subbase layers
  – Recommended modulus values for different base types, subbase, and both as one layer

Questions?
Current Work

• “Preparation for Implementation of the Mechanistic-Empirical Pavement Design Guide in Michigan”
  – Part 1 – HMA Characterization
  • Test many different HMA mixes from around the state
  • Try to decide how to categorize the different mixes into typical inputs
  • Use Artificial Neural Networks to build a model to predict the dynamic modulus master curve
  • 70+ total samples will be collected representing 40+ different HMA mixes
Current Work

• “Preparation for Implementation…” (cont.)
  – Part 2 – Evaluate Rehab Designs
    • Evaluate whether ME rehab designs give reasonable results
    • Sensitivity of rehab specific inputs
    • Compare in-service pavement performance with ME predicted performance – typically at least 10 projects for each fix type
Current Work

- “Preparation for Implementation…” (cont.)
  - Part 3 – Calibration and Validation
    - Evaluation of our PMS readiness to support ME
    - Compare in-service pavement performance with ME predicted performance
    - Adjust calibration factors as needed
    - Check the adjusted calibration factors on a different set of pavements
    - Recommend database needs
Current Work

• Example of calibration factor adjustment – ME over predicting
Current Work

- **PrepME pooled fund project**
  - PrepME is a software tool for preparing and housing inputs for ME
  - Started as a tool for converting WIM data into applicable traffic inputs
  - Expanded to include climatic and materials inputs, including a database structure for storage
Current Work

• Implementation Plan
  – Review MDOT ME research reports
  – Learn from states already implementing
  – Literature review (anything ME related)

– ME oversight committee
  – Decide on reliability levels *
  – Decide on performance thresholds *
  – Develop acceptance protocol for designs *
Current Work

- Implementation Plan (cont.)
  - Run designs, run designs, run designs
  - Catalog all inputs
  - Decide which inputs are default and which are in-play as well as input level *
  - Review climatic data that came with the software
  - Investigate rehab designs
  - Calibration and validation
  - Where does the initial cross-section come from? *
Current Work

• Implementation Plan (cont.)
  – What should be in the output file
  – Organization of design files
  – Transition plan *
  – Overall design process *
  – Get the server version of DARWin-ME set up
  – Develop user’s manual
  – Conduct training class
Current Work

- Implementation Plan (cont.)
  - Develop research ideas *
  - Determine equipment needs *
  - Keep stakeholders updated

Questions?
Goals Of The Committee
Goals Of The Committee

Facilitate the implementation of ME as MDOT’s standard design method
Goals Of The Committee

• Facilitate business process changes for pavement design
  – Who provides the traffic data and how?
  – Which designs are central office and which are not?
  – etc.

• Decisions on equipment
  – CTE test
  – HMA dynamic modulus test
  – etc.
Goals Of The Committee

• Help with decisions on design criteria
  – Distress thresholds
  – Reliability levels,
  – etc.

• Decisions on input values
  – Time to 50% shrinkage (PCC)
  – 20 year/28 day PCC compressive strength ratio
  – HMA effective binder content
  – % air voids
  – etc.
Goals Of The Committee

• Expand department knowledge of the software and the impacts of different inputs and design decisions
• Explore research needs
• Facilitate industry participation
• Decide on and oversee subcommittees, including membership
Questions?
Proposed Subcommittees
Proposed Subcommittees

- Proposed Subcommittees
  - Traffic
  - HMA
  - Concrete
Proposed Subcommittees

- Subcommittee goals
  - Learn the materials/traffic inputs and their impacts in the software
  - Recommend equipment
  - Facilitate testing
  - Make recommendations on input values
Proposed Subcommittees

• Meeting Frequency
  – Oversight – every two to three months
  – Subcommittees – every four to six weeks
  – As we progress and subcommittees complete their work, Oversight committee will likely meet more often
Questions?