Implementing Mechanistic-Empirical Pavement Design and DARWin-ME

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Overview

- Summarize information contained in the FHWA white paper titled “Implementing the DARWin-ME: Pavement Design Software to Support the MEPDG”
  - Brief overview of the application and use of the MEPDG
  - Snapshot of activities nationwide related to MEPDG implementation
  - Summary of benefits in using DARWin-ME Software

- Summarize information from three State DOT case studies (MO, IN & MT)

- Steps to successful implementation
Outline

- Introduction & DARWin-METM Benefits
- Implementation Activities & Steps
- Calibration & Validation
- Implementation Studies/Efforts
- Lessons Learned from Implementation & Recommendations
- Planning for the Future
MEPDG & DARWin-ME History

MEPDG history:
- Work product of NCHRP projects 1-37A and 1-40D
- Nearly a decade of development at cost > $10M
- Covers 17 pavement design situations—new & rehab
- Adopted as AASHTO’s Interim Pavement Design Guide in 2008

MEPDG related software:
- Base software: Freeware, available through Transportation Research Board until 2012
- DARWin-ME: Production-level software in support of AASHTO’s MEPDG
What is DARWin-ME?

A tool to provide the transportation community with a production level, state-of-the-art software tool for the design of new and rehabilitated pavement structures consistent with AASHTO’s Interim MEPDG.
What is DARWin-ME?

DARWin-ME calculates pavement responses to predict pavement distresses and smoothness loss overtime for both HMA & PCC surfaced pavements through the use of transfer functions.
Why Implement the MEPDG?

Pavement Design Practice as of 2007

Factors Leading to MEPDG Development

- Current AASHTO Guide:
  - Produces conservative designs for high truck volume roadways
  - Cannot handle rehabilitation adequately
  - Cannot adequately consider all modern design features, materials, loadings
  - Is thickness-centric
How can DARWin-ME Help?

- Evaluate design features and strategies for optimizing design other than thickness.
- Designs based on agency-established performance criteria which can be tracked during the use phase.
- Output can be used in life cycle cost analyses and performance related specifications.
- Ability to consider newer materials.
- Considers interaction between materials, structure, construction parameters, climate, and traffic.
How can DARWin-ME Help?

- It has the ability to quantify additional damage caused by unique truck loading configurations or increased truck weights.
- It can consider unique design features and strategies, not just pavement thickness.
- It determines the most cost-effective strategies.
- The designs are based on agency-established performance criteria which are measured through the life cycle of the pavement.
- Its output can be used in life-cycle cost analyses and performance related specifications, as well as in establishing warranties.
Snapshot of MEPDG Implementation Activities

- No plans to implement in Short Term: 13.5%
- R & D Activities, Only: 28.8%
- Will Implement, but in Preliminary Stages: 23.1%
- Preparing Input Libraries: 15.4%
- Completing Validation or Local Calibration: 11.5%
- Using MEPDG on Periodic Basis: 7.7%
Summary of DARWin-ME Deployment

Data Gathered from 42 State Highway Agencies

- R&D in progress or Completed with Unknown Deployment Timeframe: 10
- R&D Completed or not Initiated and no Plans for Deployment: 4
- R&D Ongoing with MEPDG (Deployment after 5 years): 2
- MEPDG Fully or Partially Deployment (Possible other R&D ongoing): 7
- Nearing Deployment (Expected Deployment within 1 year): 2
- R&D Ongoing with MEPDG (Deployment Possible within 2 years): 6
- R&D Ongoing with MEPDG (Deployment Possible in 2-5 years): 11
Implementation Approaches, Activities & Steps
Approaches to Implementation

Category 1:

- Less time and effort for implementation, focus on developing and measuring key inputs and performing limited verification or sensitivity studies.
- It includes validation efforts using data from readily available pavement sections to ensure that the transfer functions predict reasonable distress levels.

Most agencies are in this category.
Approaches to Implementation

Category 2:

- Extensive effort & time to complete a full local calibration of the MEPDG as part of the implementation process.
- This involves activities for creating more comprehensive input libraries for traffic, materials, and climate inputs; creating design automation tools such as data libraries for MEPDG-specific input files; and conducting extensive field and laboratory testing activities.
Key Steps of an Implementation Program

Critical Steps/Elements:

1. A champion to lead the implementation effort and program.
2. Develop a roadmap to success.
3. Complete concurrent designs.
4. Establish communication lines – input parameters.
Communications

Planning, Traffic

Research

Materials

Construction

Geotechnical

Need to know what data is needed and how is that data obtained & used?
Key Steps of an Implementation Program

Critical Steps/Elements:

5. Participate in & establish training programs.
6. Build libraries for common input parameters.
7. Conduct local/regional validation/calibration studies.
8. Provide funding/support personnel.
Calibration and Validation
Local Validation-Calibration of Transfer Functions

How close is close enough?
A difficult & case-specific issue to address!
Preparing a Calibration-Validation Plan

1. Adequate sample size
2. Forensic investigation of sites
3. Analyses of performance data
4. Quantify error components
Validation-Calibration

- In summary – it is your choice and an engineering decision
- Regional validation-calibration efforts are encouraged as a minimum
Examples of Implementation Studies & Efforts
**Implementation Effort Snapshot—Fall 2010**

No data available: DE, ND, TN, WV; *NETC = New Eng. Trans. Consortium

- **D** = MEPDG Deployment (either partial or full)
- **R** = Research ongoing
- **Plan** = Formal implementation plan developed

**Definitions:**
- **V** = Model Verification Studies
- **I(tcm)** = Input characterization
- **C** = Calibration completed

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[Map showing implementation status across the United States with symbols indicating various statuses such as D, R, Plan, and V, I(tcm), C, D for each state.]
Selected Studies & Efforts Related to Implementation

Formal Implementation Plan for Implementing MEPDG
- Alabama, Arizona, Arkansas, Colorado, Iowa, Maryland, Mississippi, Montana, North Carolina, Utah

Sensitivity Studies
- NCHRP project 1-47, Arkansas, Maryland, Michigan, Nebraska, Texas
Selected Studies & Efforts Related to Implementation

Material Input Libraries

**HMA**

**PCC**
- Arkansas, Colorado, Florida, Indiana, Iowa, Pennsylvania, Wisconsin

**Unbound Materials**
- Florida, Indiana, Kentucky, Louisiana, Mississippi, Missouri, Montana, New Jersey, Oklahoma, Virginia
Selected Studies & Efforts Related to Implementation

Traffic – Determination of Regional/Local Input Libraries

- Alabama, Arizona, Arkansas, California, Indiana, Michigan, Mississippi, North Carolina, Virginia

Validation-Calibration; Determination of Local Calibration Factors

- Arizona, Arkansas, Colorado, Mississippi, Missouri, Montana, Utah
Lessons Learned from Implementation & Recommendations
Case Study Document

- Indiana
- Missouri
- Montana

Lessons Learned: Impact & issues of Implementation from these agencies.
Lessons Learned from Implementation: What has been the Impact?

- Thinner pavements for higher volume roadways
Lessons Learned from Implementation: What has been the Impact?

- Ability to use construction specification values in design and understand effect of changing specification
- Minimum layer thickness from MEPDG considered reasonable based on historical performance data
- Preventive maintenance is cost effective in extending pavement service life
- Savings in initial construction costs
Lessons Learned from Implementation: What were the issues?

- Expect more time to be spent on design
- Input values need to be scrutinized & checked – they are different than what has historically been used
- Distress definitions/measurements were difficult to deal with at the beginning
- Preventive maintenance activities make it difficult for calibrating the MEPDG
- Local calibration is complicated – it is more than just number crunching
Recommendations from Selected Agencies

- Appoint a champion or leader for using and implementing the MEPDG
- Prepare a step-by-step procedure to run the software
- Make sure that the agency’s pavement design manual is updated to be consistent with MEPDG
- Tie the material specifications to the material inputs
- Start building the traffic & materials libraries & then think about local calibration
Recommendations from Selected Agencies

- Lack of coordination and communication between divisions within an agency can be a real challenge
  - Coordination and communication are critical and must be emphasized.
- Reviewing designs is important
  - Make sure all inputs are checked!
- Focus on application for design and not analysis
Recommendations from Selected Agencies

- Do not expect to start using the MEPDG for design right away
  - Use of the MEPDG requires training in different areas
  - Plan on increasing the designer’s knowledge of pavement design and material characterization
  - Use of the MEPDG requires a basic knowledge of pavements and materials characterization
Recommendations from Selected Agencies

- For agencies that permit consultants to complete the designs:
  - Plan on a lot of time for checking and reviewing the inputs for errors and mistakes
  - Consultants should be required to take training prior to using the MEPDG
- Designate in-house staff for troubleshooting the software and be available for answering questions with the software and hardware
Recommendations from Selected Agencies

- Agencies need to consider as part of implementation and adoption of the MEPDG its use as related to construction.
- The training demonstrations that FHWA put together were worthwhile.
  - These demonstrations had more immediate benefit to States that were not very familiar with M-E based methods.
Recommendations from Selected Agencies

- The process, including local calibration, is complicated. Understand the inputs and their importance related to the distresses predicted by the MEPDG.

- Durability, non-load related distresses, and construction defects are important but not considered by the MEPDG.
Planning for the Future
Planning for Future Updates

1. Maintain calibration-validation database along with the input libraries.
2. Periodically monitor test sections & input parameters & update database.
3. Verify local calibration or agency specific factors for future DARWin-ME versions.
Previous & On-Going Studies

- Calibration Documents:
  - NCHRP Digest 283, December 2003; Jackknife Testing – An Experimental Approach to Refine Model Calibration and Validation

- FHWA sponsored projects:
  - Use of PMS data for local calibration
  - Traffic Input Workshops, ongoing
  - PREP-ME Pooled Fund Project - TPF-5(242)
  - Use of deflection basin data in the MEPDG & backcalculation of layer moduli
Questions

- www.trb.org/mepdg
- www.fhwa.dot.gov/pavement

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