State Experience with ME Pavement Design

(MEPDG Implementation at ADOT)

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MEPDG Implementation at ADOT

Outline

- Where we’ve come from
- Where we’re at now
- Where we’re going...
Where we’ve come from
New Pavement Design

- ADOT has used the AASHTO Design Guide for Pavements as its basis for designing new pavements since it was first issued as an “Interim” guide in 1961/2.
- Updates to the guide were made in 1972, 1981, 1986 and 1993.
Where we’ve come from

New Pavement Design – AASHO Road Test

- The AASHTO Design Guide is based on the AASHO Road Test from the late 1950’s
Consisted of six, two-lane loops constructed along the future alignment of Interstate 80 in Ottawa, Illinois.

The pavement structure within each loop was varied.

Each loop was loaded with a specific vehicle type and weight so that the interaction between vehicle loads and pavement structure could be investigated.

The outcome of this road test was a general equation which relates the loss in pavement serviceability to the pavement structure and load applications.
Where we’ve come from
New Pavement Design – AASHTO Design Guide

Design equation for Flexible pavements:

\[
\log_{10}(W_{18}) = Z_R \times S_O + 9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta\text{PSI}}{4.2 - 1.5}\right)}{1094} + 2.32 \times \log_{10}(M_R) - 8.07
\]
Where we’ve come from
New Pavement Design – AASHTO Design Guide

\[ SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 \]

Asphalt
Aggregate Subbase
Aggregate Base

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<th>SN Value</th>
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SN = 3.90
SN = 3.88
Where we’ve come from

New Pavement Design – AASHTO Design Guide

- The AASHTO Design Guide was used to design much of the original Interstate Highway System.
- Most of these pavements lasted the expected 20 years while carrying traffic volumes in excess of those predicted at the time of design.
- After nearly 6 decades since the completion of the AASHO Road Test, the design procedure continues to serve as the cornerstone for both PCC and HMA pavements.
Where we’ve come from

- ADOT’s “official” design methodology for new pavement is still the 1993 AASHTO Design Guide.
Where we’ve come from
New Pavement Design

- Despite it’s successful use over many decades, the procedure has many shortcomings.
Where we’ve come from

1993 Design Guide Shortcomings

- Only one soil type
- Only one climate
- AC thickness between one and six inches
- Limited traffic (1 Million Axle Load Cycles)
- Only one set of materials
- Can only predict ΔPSI
- Virtually every pavement design we conduct today using the 1993 AASHTO Guide is an EXTRAPOLATION!
Where we’ve come from
Pavement Rehabilitation

- ADOT has used the Structural Overlay Design for Arizona (SODA) method for pavement rehabilitation since the early 80’s
- The method was developed using regression analysis of 24 overlay projects constructed in the 1970’s
- Overlay thickness is a function of ESAL’s, pavement deflections, SVF, milling depth, and roughness
- Despite successful use for many years, it has many shortcomings
Where we’ve come from
SODA Shortcomings

- Materials quality, construction methods, etc. have changed considerably since the 1970’s
- The average overlay thickness for projects used to develop the method was approximately 2”
- Projects were overlayed only without any milling
- So, most pavement rehabilitation designs conducted using the SODA method is an EXTRAPOLATION!
Where we’re at now
Implementation of the MEPDG

- ADOT has been in the process of implementing the MEPDG since the late 90’s.
- Allows for a more accurate prediction of pavement performance over time (better decisions relative to life-cycle cost and cash flow).
  - Utilizes both mechanistic and empirical principles.
  - Accounts for variations in materials and construction.
  - Utilizes more representative inputs for climate and vehicle loading.
Where we’re at now

A Few Terms...

- Mechanistic – relationship supported by laws of mechanics.
- Empirical – relationship supported by experiment or observation.
- Mechanistic-Empirical Pavement Design Guide (MEPDG) - Pavement design methodology developed under NCHRP 1-37a.
- AASHTOWare Pavement ME Design – Pavement design software used to analyze and design pavements based on M-E principles developed under NCHRP 1-37a.
AASHTOWare Pavement ME
Overview

- State-of-the-practice tool for the design and analysis of new and rehabilitated pavements, based on mechanistic-empirical (ME) principles.
- Pavement ME calculates pavement response (stresses, strains, and deflections) and used those responses to compute incremental damage over time.
- Predicts multiple performance indicators and provides a direct tie between materials, structural design, construction, climate, and traffic.
Define the traffic, climate and materials property inputs
Select a trial design to analyze
Analyze the pavement response
Empirically relate pavement response to distress
Adjust predicted distresses for the specified design reliability
Compare predicted distress against design limits
Pavement ME

Inputs

- Design method incorporates a hierarchical approach for specifying all design inputs.
- Approach is based on the philosophy that the level of engineering effort exerted in determining design inputs should be commensurate with the relative importance, size and cost of the project.
- Three levels are provided in the NCHRP 1-37A procedure.
Pavement ME

Inputs (cont.)

- Level 1 – Provides the highest accuracy and lowest uncertainty. Typically requires project specific field or laboratory evaluation (e.g. FWD, triaxial testing).
- Level 2 – Provides an intermediate level of accuracy. Typically derived from a limited testing program or estimated via correlations, or agency specific database (e.g. $M_r$ estimated from R-values, ADOT Materials Libraries).
- Level 3 – Lowest level of accuracy.Derived from local or National default values (e.g. $M_r$ based on soil class).
## Performance Criteria

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<th>Unit</th>
<th>Limit</th>
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<tr>
<td>AC bottom-up fatigue cracking (percent)</td>
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<td>AC thermal cracking (ft/mile)</td>
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<td>Permanent deformation - total pavement (in.)</td>
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<td>AC total cracking - bottom up + reflective (percent)</td>
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## General Information

- **Design type:** Overlay
- **Pavement type:** AC over AC
- **Design live (years):**
- **Existing construction:** May 1962
- **Pavement construction:** June 2014
- **Traffic opening:** September 2014

### Layer Properties

- **Layer 1 Flexible:** 34 in. Marshall 416
- **Layer 2 Flexible:** 54 in. Marshall 416
- **Layer 3 Non-stabilized Base:** A-12
- **Layer 4 Subgrade:** A-14

### Additional Information

- **Project Name:** H8672 - I-15 (Sin MF 30%-Crk V2.0) RCTest
- **Approver:**
  - Date approved: 8/21/2013 5:59 AM
- **Date created:** 8/21/2013 5:59 AM
- **County:**
- **State:**
- **District:**
- **Direction of travel:**
- **From station (miles):**
- **To station (miles):**
- **Highway:**
- **Revision Number:** 0
- **User defined field 1:**
- **User defined field 2:**
- **User defined field 3:**
- **Item Locked?** False
Vehicle Class Distribution and Growth

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Monthly Adjustment

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Axles Per Truck

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Pavement ME
Implementation Efforts to Date

- Phase I – Development of Work Plan.
- Phase II – Characterization of Material (Binders, AC Mixtures, Unbound Materials).
- Phase III – Local Calibration of MEPDG, and Development of Performance Related Specifications
Pavement ME

Implementation Efforts to Date

- Calibrate and Validate the MEPDG, and accompanying software, for Arizona conditions.
- Develop an ADOT Users Guide for the MEPDG.
- Provide training in the use of the MEPDG
Pavement ME
Implementation Efforts to Date

- SPR-672: Development of a Traffic Data Input System in Arizona for the MEPDG. (ARA, 2009 - 2010)
- Developed default recommendations or Level 2/3 statewide traffic inputs for Arizona.
- Developed and action plan for future work to obtain Level 1 traffic inputs.
Pavement ME
Implementation Efforts to Date

- Since completing the local calibration in 2012, ADOT has been performing parallel designs on all major new construction and rehabilitation projects.
Design Example

- ESALS – 10,998,000
- R-value - 40
- SVF – 1.5
- Mr – 19,150 psi
- Reliability – 99%

- $SN_{\text{req}}$ – 4.31
- 7” AC over 9” AB
- $SN_{\text{des}}$ – 4.34
Design Example
US93 MP 116.3 – 119.7 (Pavement ME)
Design Example

US93 MP 116.3 – 119.7 (Pavement ME)
Design Example

US93 MP 116.3 – 119.7

- 1993 Design Guide indicates we need 7” AC over 9’ AB (SN = 4.34)
- Pavement ME indicates we need 9” AC over 11” AB (SN = 5.50)

What do we do???
In general, Pavement ME results for new flexible pavement have been more conservative than our 1993 Design Guide results.

We have had a number of 1993 Design Guide projects that have not met their 20-year design life.

We should be able to have significant confidence in our Pavement ME results due to the fact that we have performed a local calibration.

Performed a verification on an adjacent project constructed in 2008.
Design Example
Verification Project (US93)

- 2006 Pavement design, based on 93 AASHTO Design Guide, required 6” AC over 8” AB.
- Construction completed in 2008 (9-year old pavement).
- 2016 Photolog shows extensive alligator cracking including pumping of fines.
Design Example
Verification of Adjacent Project (US93 MP 119.8)
Design Example
Verification of Adjacent Project (US93 MP 120.9)
Pavement ME

Pavement ME Design Example

- In general, we are making final design recommendations based on Pavement ME results, unless there is good evidence to do otherwise.
- As is the case with the 1993 AASHTO Design Guide, and SODA, the AASHTOWare Pavement ME has it’s shortcomings.
Pavement ME Shortcomings

- Occasionally we get results that are counter to what experience tells us
- Composite (PCC + FC) pavement modeling questionable
- Significant investment to characterize materials, perform a local calibration and purchase the software
- Extensive training required
- Can easily become a “Black Box”
- Software changes on a regular basis
Where we’re going

- Continue to run parallel designs
- Continue to participate in Pavement ME training opportunities as well as User Group Meetings
- Consider future re-calibration of some or all of the models
- Construction of additional WIM stations
- Long term plan is to fully adopt the use of Pavement ME
Pavement ME

For Further Information

- SPR-672: Development of a Traffic Data Input System in Arizona for the MEPDG
- Training Webinars at http://me-design.com/MEDesign/Webinars.html
- Scott Weinland (602) 712-8131