Consideration of Preservation in Pavement Design and Analysis

June 27, 2016
Today’s Presenters

- **Moderator**
  Judith Corley-Lay, NCDOT

- **Findings of NCHRP 1-48**
  David Peshkin, Applied Pavement Technology

- **Texas DOT Approach to Pavement Design**
  Magdy Mikhail, TexDOT

- **NC Review of Report 810**
  Judith Corley-Lay, NCDOT
NCHRP is...

A state-driven national program

- The state DOTs, through AASHTO’s Standing Committee on Research...
  - Are core sponsors of NCHRP
  - Suggest research topics and select final projects
  - Help select investigators and guide their work through oversight panels
NCHRP delivers...

Practical, ready-to-use results

- Applied research aimed at state DOT practitioners
- Often become AASHTO standards, specifications, guides, manuals
- Can be directly applied across the spectrum of highway concerns: planning, design, construction, operation, maintenance, safety
A range of approaches and products

- Traditional NCHRP reports
- Syntheses of highway practice
- IDEA Program
- Domestic Scan Program
- Quick-Response Research for AASHTO
- Other products to foster implementation:
  - Research Results Digests
  - Legal Research Digests
  - Web-Only Documents and CD-ROMs
NCHRP Webinar Series

- Part of TRB’s larger webinar program
- Opportunity to interact with investigators and apply research findings.
Today’s First Presenter

• Findings of NCHRP 1-48

David Peshkin,

Applied Pavement Technology
Consideration of Preservation in Pavement Design and Analysis Procedures

NCHRP Project 1-48 / NCHRP Report 810
Presentation Summary

• Project overview
• Information sources for state of practice
  – Literature
  – Interviews
• Evaluation of test sections used in MEPDG
• Recommended procedures for incorporating pavement preservation into the MEPDG and associated steps
Project Overview

Background—

(1) The MEPDG is increasingly being used by agencies as the pavement design and analysis tool. (2) Most agencies have some sort of preservation program. (3) MEPDG models do not consider the effects of preservation.

Initial Project Objective—

Develop procedures for incorporating pavement preservation treatments into the MEPDG process.
Underlying Concept

Preventive Maintenance Treatments

Initial Performance Period
Literature Review

Sources
- NCHRP/TRB
- AASHTO
- FHWA

National research organizations

Preservation organizations

Industry organizations

Pavement preservation performance
Effects of preservation on pavement performance
MEPDG models
Agency calibration efforts
Literature Review Topics

- Techniques for analyzing performance of pavement preservation treatments
- MEPDG performance prediction models
- MEPDG evaluation and implementation activities, including local calibration
Interviews

Included SHAs and selected industry representatives

- Purpose: gather information from agencies with progressive preservation and MEPDG experience
- SHAs: Arizona, California, Indiana, Kansas, Maryland, Minnesota, Missouri, New Jersey, North Carolina, Ohio, Texas, Utah, Virginia, Washington
- Industries: NCPP, ACPA, ISSA, NAPA, AEMA
Interview Results—SHAs

- Preservation practices vary widely: half of respondents have dedicated funding, most programs are decentralized, little in common regarding treatment use, tracking performance inconsistent.

- MEPDG: two current users, two doing side-by-sides, the rest in various stages of implementation.

- Incorporating preservation: different ideas about how to do this, but no one is actually doing it; CalME includes the ability to do it (still prototype) [two approaches: reset certain distresses at time of treatment or adjust future material properties].
Interview Results—Industry

• Preservation: all have strong emphasis on preservation; little objective data on pavement life extension

• MEPDG: NCPP, AEMA, ISSA not very familiar; NAPA, ACPA very familiar, but from perspective of design, not preservation

• PP and the MEPDG: NAPA, ACPA thought it was a good idea, but would need an LTPP-type experiment to implement
Evaluation of MEPDG Test Sections—Overview

Wanted to answer the question: Did pavements used to develop or verify MEPDG models benefit from preservation?

• Identify pavement sections

• Extract maintenance history from LTPP database and other sources

• Organize information in tables

• Determine whether treatments may have affected MEPDG models
Evaluation of MEPDG Test Sections—Findings

• Table 3 (p. 12) summarizes sections used to develop and calibrate MEPDG performance prediction models.

• Table 4 (p. 13) summarizes potential influence of preservation on performance of sections and MEPDG model development and calibration.
Evaluation of MEPDG Test Sections—Findings (continued)

- Flexible pavement models (10): 2 NA; range from 2 to 67 percent [crack sealing, fog, slurry, seal coats]
- Rigid pavement models (9): 4 NA; range from 7 to 23 percent [joint resealing, crack sealing, PDR, FDR, a few instances of grinding/grooving]
Transition from Phase I to Phase II

• Phase I outcome: three approaches to consider effects of preservation in the MEPDG
  – Develop pavement preservation response models
  – Calibrate existing models for effect of preservation
  – Modify material properties to account for preservation effects

Identified data to fully develop these approaches and their availability within SHAs. Conclusion – sufficient data not readily available.
Phase II: Describe/Illustrate Approaches

1. Response models which consider effects of preservation in the MEPDG procedures (chapter 4).

2. Calibration of MEPDG models to account for preservation (chapter 5).

3. Modify material and pavement structural properties in MEPDG models to account for preservation effects (chapter 6).

- Assess feasibility
- Provide example
Approach 1—Response Models

• Create experimental matrix and construct test sections
• Test sections dictated by variables of interest to agency
• Include controls (based on MEPDG design)
Response Models Steps

- Pavement preservation treatment and strategy selection
- Experimental design
- Construct test sections/sites
- Monitor performance
- Develop performance models
- Calibrate/validate models
## Example Experimental Matrix

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Preservation Treatment</th>
<th>Flexible Pavement</th>
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<tbody>
<tr>
<td>Wet, hard freeze, spring thaw</td>
<td>(0) Untreated control</td>
<td>Site 1</td>
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<tr>
<td></td>
<td>(1a) Chip seal @ Year 4</td>
<td>Site 2</td>
</tr>
<tr>
<td></td>
<td>(1b) Chip seal @ Year 5</td>
<td>Site 3 (chip seals excluded)</td>
</tr>
<tr>
<td></td>
<td>(1c) Chip seal @ Year 6</td>
<td></td>
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<tr>
<td></td>
<td>(1d) Chip seal @ Year 7</td>
<td></td>
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<tr>
<td></td>
<td>(2a) Microsurface @ Year 4</td>
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<tr>
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<td>(2b) Microsurface @ Year 4</td>
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<td>(2c) Microsurface @ Year 4</td>
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<tr>
<td></td>
<td>(2d) Microsurface @ Year 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3a) Thin HMA Overlay @ Year 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3b) Thin HMA Overlay @ Year 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3c) Thin HMA Overlay @ Year 4</td>
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</table>
Approach 2—Calibrate MEPDG Models

• Systematic process to eliminate bias and minimize residual errors between observed or measured real world results and predicted (model) results

• Assumes existing models do not, or don’t adequately, account for preservation
Calibrate MEPDG Model Steps

1. Selected hierarchical input level
2. Develop experimental plan
3. Estimate sample size for specific models
4. Select roadway segments
5. Extract/evaluate distress and project data
6. Conduct field and forensic studies

1 From AASHTO Guide for Local Calibration
7. Assess local bias
8. Eliminate local bias of distress, IRI
9. Assess standard error of estimate (SEE)
10. Reduce SEE
11. Interpret results/evaluate adequacy of calibration parameters
Approach 3—Modify Material and Structural Properties

• “Corrected” distress (or life) to reflect effects of preservation
• Correction consists of altering MEPDG outputs
• Requires knowledge, understanding, or ability to estimate effect of preservation treatments or strategies on predicted distresses
**Model Modification Example**

- **Measured Total Rutting, in** vs **Predicted Total Rutting, in**

**Model Details:**

- Linear Regression model:
  \[ y = 0.4322x + 0.0265 \]
  - \( R^2 = 0.2977 \)

- **Hypothesis Testing:**
  - **H\(_0\):** \( \Sigma (y_{meas} - x_{pred}) = 0 \)
  - **T-test @10% significance level**
  - \( n = 197 \)
  - Avg Pred Total Rut = 0.166 in
  - Avg. Meas Total Rut = 0.098 in
  - Bias = -0.068 in
  - \( p\)-value = 0.000
  - Reject \( H_0 \) (\( p\)-value < 0.1)

- **Bias:** -0.068 in
  - \( p\)-value = 0.000
  - Reject \( H_0 \) (\( p\)-value < 0.1)
Steps to Modify Properties in MEPDG Models

1. Identify basic pavement structure and preservation treatment type
2. Identify preservation treatment timing
3. Identify baseline material properties of pavement structure and treatment
4. Quantify treatment effect on thickness
5. Identify effect on existing layer material properties and on moisture/thermal properties
Steps to Modify Properties in MEPDG Models (continued)

6. Identify treatment effect on pavement performance
7. Establish MEPDG model coefficients
8. Perform base pavement ME design analysis
9. Perform ME design analysis for preservation-treated design
NCHRP 1-48 Outcomes and Recommendations

- Growing experience with use of preservation
- Lack of agency documentation of impacts of preservation
- Recognition that preservation has ability to extend service life and delay need for subsequent structural treatments
- Acknowledgment that preservation is not a structural enhancement and MEPDG is a structural design process
- More data needed to support implementation of identified approaches.
Example Effect of Preservation

Predicted Distress or IRI

Age

Baseline Design

Preservation-Treated Design

Threshold for Service Life

Pavement Life Extension
Questions and Discussion
Texas Department of transportation approach to pavement design
# Table of Contents

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<td>Design Process</td>
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<td>3</td>
<td>Project Selection</td>
<td>38-41</td>
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<td>4</td>
<td>Flexible Pavement Database</td>
<td>42-45</td>
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<td>5</td>
<td>Summary</td>
<td>46</td>
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Flexible Pavement Design in Texas

- Decentralized design
  - Most designs done in-house, usually in Area Offices (100+)
  - Construction Division provides support and training

- Texas Network
  - Over 50% of network very thin surfaced asphalt pavements
  - Range of climates and soil support conditions

- Materials Information
  - Thickness designs completed 1 – 2 years before materials selection
  - Designs currently based on spec item number
Flexible Pavement Design in Texas

- **Traffic Data**
  - Based on 20 Year 18 Kip ESAL’s
  - Extensive Axle load Spectra data not available

- **Implementation Status**
  - Original FPS developed in the 1970’s
  - Current system implemented mid 1990’s
  - Training schools taught in-house and with University support
  - Experienced designers comfortable with results
Design Process

- Project Selection
  - PMIS
  - 4-year Plan
  - Key Staff recommendations

- Request Traffic Data

- Evaluation of Existing Structure
  - Records
  - Site visit
  - NDT
  - Sampling
Design Process

Design

On Line Pavement Design Guide
District SOP
Pavement Design Concept Conference
FPS 21
1993 AASHTO (DarWin 3.1)
TxCRCP-ME

Materials Selection
Standard & Special Specifications and Special Provisions
Special Guidelines/SOP

Design Review
Project Selection

- **PMIS**
  - Set of automated tools to help identify sections in most need of improvement
  - Present condition
  - Multi-year trends
  - Predictions of future performance

- **Staff Recommendations**
  - Maintenance and Area Engineers
  - District Pavement Engineer
  - Planning and Development
Request Traffic Data

- TP&P is the TxDOT “sole source”
- TP&P manages statewide traffic data collection (WIM, Classification, Counts)
- Critical Traffic input parameters include:
  - Beg & End ADT
  - % Trucks in the ADT
  - ATHWLD
  - Cumulative ESALs (20 or 30 yr)
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<th>Description of Location</th>
<th>Average Daily Traffic</th>
<th>Dir Dist %</th>
<th>K Factor</th>
<th>Percent Trucks</th>
<th>ATHWLD</th>
<th>Percent Tandem Axles in ATHWLD</th>
<th>Total Number of Equivalent 18k Single Axle Load Applications One Direction Expected for a 20 Year Period (2011 to 2031)</th>
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Evaluation

- Records
  - As-built drawings/plans
  - Maintenance
  - Soils Maps
- Site Visit
  - Drainage issues
  - Cross slope/crown
  - ROW issues
  - Distress Survey
Evaluation (cont.)

- NDT
  - Rut/Ride
  - Skid
  - Deflection
  - GPR
  - DCP

- Sampling
  - HMA Cores
  - Soil Borings
  - Auger/Trench (FDR samples)
Pavement Design

FWD Data → Modulus → FPS-19W(21) → HMA

Design Info → FPS-19W(21) → Base → Subgrade

Texas Triaxial Check (Rutting and Cracking)

Mechanistic Check (Rutting and Cracking)
Pavement Design

Pavement Properties

- Traffic
- Reliability
- Serviceability

FPS 21

Design Alternatives

- District SOP
- Material Testing
- Life-cycle Cost
- Initial Construction
- Funding Available
- User Delay

Consider Constructability and material characteristics
- Does the structure make sense??
Performance Curve

Initial Serviceability Index

Serviceability Index after Overlay

ACP Overlay

Performance Period 1

Performance Period 2

Minimum Serviceability Index

Length of Analysis Period

Min. Time to First Overlay

Min. Time Between Overlays

Time (years)

Serviceability Index

0 5 10 15 20 25 30

2 2.5 3 3.5 4 4.5 5
A Design Report is Required For:

- Structural changes > 500-ft long, including:
  - New Location Projects
  - Reconstruction Projects
  - Rehabilitation (3R) Projects
  - Unbonded Concrete Overlays

- Special Cases:
  - Document the Criteria and Rationale for the Strategy Selected
    - Bridge Approaches
    - Detours
    - Pavement Widening
    - HMA Overlays of Rigid Pavements
    - Bonded Rigid Overlays of Rigid Pavement
    - Thin Whitetopping of Flexible Pavement
The Design Report – Steps for Approval

- Key District Players Agree on General Pavement Format: Design Concept Conference

- Technical Review/Approval: District Pavement Engineer (License #)

- Final Approval: District Engineer w/Signature and Date (exception only for Metro Districts, value < $20M).

- Qualifier statement: “This document is released for the purpose of interim review and is not intended for bidding, construction, or permitting purposes.”
**FPS 21 – Design Types**

1. **Seal**
   - **Flex Base**
   - **Subgrade**

2. **AC**
   - **Flex Base**
   - **Subgrade**

3. **AC**
   - **ASB**
   - **Subgrade**

4. **AC**
   - **ASB**
   - **Flex Base**
   - **Subgrade**

5. **AC**
   - **Flex Base**
   - **Stab. SG**
   - **Subgrade**

6. **Overlay**
   - **AC**
   - **Base**
   - **Subgrade**

7. **HMA Base**
   - **RBL**
   - **Stab. SG**
   - **Subgrade**

8. **Use Existing Input File**

**User-defined; 4 to 7 Layers**
FPS 21 Strengths and Shortcomings

**Does:**

- Flexible Base Pavements
- Asphalt Stabilized Base Pavements
- Lightly Stabilized Base Pavements (<3% Stabilizer)
- Perpetual Pavements
- Overlay Thickness

**Does Not Do:**

- Heavily Stabilized Pavements
- Concrete
- Overlay on CTB or Concrete
Transition to M-E design
Future Direction

- Pavement Location
- FWD Modulus
- Max. and Min. Thickness
- Traffic

FPS 21

Lab Testing Data

TxME Check
Magdy Mikhail  
Director Pavement Preservation Branch  
Maintenance Division  
Texas Department of Transportation  

Phone : (512)832-7210  
E-mail: Magdy.Mikhail@txdot.gov
AN AGENCY LOOK AT CONSIDERING PRESERVATION IN PAVEMENT DESIGN

Judith Corley-Lay
June 27, 2016
Outline of Presentation

• Our review of Response Model approach
• Our review of Calibrating MEPDG models
• Our review of Modified Material and Structural properties in ME models
• So what can we do?
Response Models that consider effects of preservation.
Test Section Approach

• Would need test sections for full depth asphalt and aggregate base pavements.
• Regular aggregate and lightweight aggregate.
• Control section, single chip seal and double seal.
• With and without polymer modifications.
Test sections

• Also need to include thin lift overlays.
• 3 climatic zones
• 2-3 traffic levels
• Monitor for 7-10 years or longer
• Replicates???
Test Section issues

• Experimental design dictates treating pavements at different points in time. Difficult to maintain this schedule over time.

• Would also need to conduct similar process for rigid pavement preservation, although our history here is short.
Calibrating ME models to Account for Preservation
Local Calibration

• Goal is to eliminate bias and make predicted distresses better match measured distresses.
• May reduce scatter in the data
• Each distress has one or more coefficients that are modified during local calibration.
Local Calibration approach

• Must cover a range of distress levels for each distress type.
• Large number of test sections is required.
• Need 10 years of performance data- 4 years before treatment and 5 years after.
• May need field investigation to fill missing data.
Using modified material and structural properties in ME models
Must identify exact impact of each preservation treatment

- For example, microsurfacing may reduce rutting by ½ inch.
- Rejuvenator or fog seal will reduce the modulus of the asphalt surface. How long will the reduction be maintained?
- Treatment may change the pavement structure: milling or diamond grinding.
- Treatment may change moisture/temperature profile.
Drawback

• “A major drawback to this approach is the complexity of accurately defining the changes in properties resulting from the application of different preservation treatments at different times during the life of the pavement.”

• Some of this could be done through national research.
So what CAN we do?
NCDOT current view...

• We have performed 3 cycles of automated data collection that provide the necessary level of data accuracy and consistency.

• We do not yet have enough data to apply approach 2 (local calibration), but that approach will be feasible for us.

• We can identify test sections in preparation for using this approach.
Current view...

- NCDOT will be performing a local calibration in the coming six months.
- Since we have a long standing preservation program for flexible pavements, this local calibration may satisfy some of the method 2 requirements.
Conclusions
Consideration of Preservation in ME design

• Method 1 required years of consistency in applying treatments on a schedule.
• Method 2 requires local calibration, which NCDOT plans to do in the next 6 months.
• Method 3 requires carefully defining impacts of each preservation treatment on material properties, structure, distress levels, and moisture/temperature regime.
MY CONTACT INFORMATION:
JLAY@NCDOT.GOV

Thank you for your attention.
QUESTIONS?