Data Needs for Calibrating the MEPDG: Texas Experience

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Original Research Goal

- To develop a sustainable flexible pavement database to be used for the development, validation, and calibration of pavement design methods.
  - Project level vs. Network level
- Keep it manageable. Many lessons learned from LTPP and previous Texas database.
- Initially consisting of 64 sections
  - 50/50 “old” versus “new”
Necessary Research Phases

- **Phase 1: Planning**
  - Assess current situation, concurrent efforts, existing databases, potential role of other popular databases such as LTPP

- **Phase 2: Data Collection**
  - Realistic data needs, define elements, database architecture, data collection, database population

- **Phase 3: Initial Implementation**
  - Recommendations for the “Maintenance and Management of the TFPD”
Initial Experiment
Design and Data Collection
Experiment Design

- Pavement type (3 levels)
  - Hot-mix asphalt surface on top of hot-mix asphalt base
  - Hot-mix asphalt surface on top of untreated granular base
  - Surface treatment on top of untreated granular base

- Traffic levels (2 levels)
  - Heavier traffic
  - Lighter traffic
Experiment Design

- Environmental conditions (5 levels)
  - Wet-warm
  - Wet-cold
  - Dry-warm
  - Dry-cold
  - Mixed

- Section replicates (2 levels)
  - Whenever available replicates will be included
Experiment Design

- Proposed Experimental Design
  - 3 Pavem. x 2 Traf. x 5 Env. x 2 Reps. = 60

- Actual Experiment
  - 53 LTPP Sections (“Old”).
  - 73 TXFLEX Sections (“New”).
  - 24 FHWA “Fabric Underseal” Sections.
  - 32 Experimental Sections (Geogrids).
  - 12 Additional LTPP calibration sections.

- Access website
  - http://pavements.ce.utexas.edu
“Old Sections”
“New Sections”
Performance Data Collection

- **FWD**

- **Roughness**
  - IRI data to be collected once a year
  - RWP, LWP and Average ($\mu$, $\sigma$)

- **Rutting**
  - To be collected once a year
  - Use wireline method
  - RWP, LWP and Average ($\mu$, $\sigma$)

- **Cracking**
  - VCrack system to be collect once a year
  - Digital data are summarized every 10’ by 3’
  - Specific statistics are to be determined: long. and trans. cracks, # of cracks, crack length
Local, Regional and State Default Calibration
Calibration Approach

- Accuracy and Calibration Levels
  - Level 1: site specific
  - Level 2: regional
  - Level 3: state defaults

- Optimal calibration for Levels 2 and 3
  - Joint calibration

- Sub-optimal calibration
  - Individual calibration + average
**AC Rutting Transfer Function**

\[ \varepsilon_p = k_z \beta_{r_1} 10^{k_1 T} \beta_{r_2} N^{k_3 \beta_{r_3}} \]

where,

\( \varepsilon_p \) = plastic strain (in/in)
\( \varepsilon_r \) = resilient strain (in/in)
\( T \) = layer temperature (°F)
\( N \) = number of load repetitions
\( \beta_{r_1}, \beta_{r_2}, \beta_{r_3} \) = calibration coefficients
Soil Rutting Transfer Function

\[ \delta = \beta_s k_1 \varepsilon_v \left( \frac{\varepsilon_0}{\varepsilon_r} \right) \exp \left( -\frac{\rho}{N} \right)^\beta \]

where,
\( \delta \) = layer permanent deformation
\( \varepsilon_v \) = average vertical strain (in/in)
\( \varepsilon_r \) = resilient strain (in/in)
\( N \) = number of load repetitions
\( k_1, \varepsilon_0, \beta, \rho \) = material properties
\( \beta_s \) = calibration coefficient
**Calibration Approach**

- Initialize with all betas = 1.0
- Calculate SSE (observations vs. un-calibrated)
- Modify the betas and recalculate SSE
- Continue until SSE is minimized
SPS Sections used in Local Calibration

- El Paso (48-L300)
- Abilene (48-D300)
- Brownwood (48-Q300)
- Tyler (48-G300)
- Pharr (48-0100)
Example: El Paso

- Location: US-62, El Paso
- Sections: 48-L310, 48-L320 & 48-L330
- Lat: 31.8 N; Long: 106.26 W

<table>
<thead>
<tr>
<th>SECTION_ID</th>
<th>Construction Date</th>
<th>Subgrade (Silty Sand)</th>
<th>Base (Crushed Stone)</th>
<th>Surface Course (Asphalt Concrete)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48-L310-3</td>
<td>April, 1991</td>
<td>Semi-infinite</td>
<td>8.4”</td>
<td>3.1”</td>
</tr>
<tr>
<td>48-L320-3</td>
<td>September, 1990</td>
<td>Semi-infinite</td>
<td>8.4”</td>
<td>2.3”</td>
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<tr>
<td>48-L330-2</td>
<td>September, 1990</td>
<td>Semi-infinite</td>
<td>8.8”</td>
<td>2.0”</td>
</tr>
</tbody>
</table>
Traffic in El Paso

Vehicle Class Distribution

(in %)
Approach for Local Calibration of the AC Rutting Model in the MEPDG

- Distress predictions are more sensitive to the $\beta_{r3}$ and less to the $\beta_{r1}$.
- Step chosen for $\beta_{r1} = 0.1$
- Step chosen for $\beta_{r3} = 0.002$
- $\beta_{r2}$ left as the default 1
- $\beta_{sl}$ fixed based on research by Von Quintus et al.
- “Brute-force”
Calibration Results: Brownwood

\[ \beta_{r1} = 1.40, \beta_{r3} = 0.78 \]
Calibrated vs. Uncalibrated Distress Predictions for El Paso

Permanent Deformation Distress Predictions

Rut Depth (in inches)

Survey Date

Section: 48-L310
Calibrated vs. Uncalibrated Distress Predictions for El Paso (contd.)

Section: 48-L320
Recommended Calibration Parameters for El Paso

- AC Rutting
  - $\beta_{r1} = 2.00$
  - $\beta_{r2} = 1.00$
  - $\beta_{r3} = 0.866$

- Subgrade Rutting
  - $\beta_{s1}$ (Granular Soil) = 0.3
Interim MEPDG Rutting Model Calibration for Texas

- β₁ = 2.45, β₃ = 0.908, βₕ₁ = 0.3
- β₁ = 2.39, β₃ = 0.78, βₕ₁ = 0.5
- β₁ = 2.0, β₃ = 0.866, βₕ₁ = 0.3
- β₁ = 3.55, β₃ = 0.862, βₕ₁ = 0.7
- β₁ = 2.39, β₃ = 0.856, βₕ₁ = 0.5
- B₁ = 2.55, β₃ = 0.864, βₕ₁ = 0.7
What is next?

- Five Year Data Collection Plan
  - 100 new sections fully characterized
  - M-E PDG
  - FPS mechanistic checks
  - TxDOT M-E Approach
    - AC: Overlay tester, Hamburg Wheel
    - Granular: Triaxial

- Database Management Plan
Conclusions

- Initial calibrations was accomplished but this process will require more data points to get better fittings (• More sections + longer times.
- The iterative process used for the calibration is time consuming and may require the development of a more streamlined process.
- For improved accuracy, the data for the calibration of the MEPDG should be collected at project level data (as opposed to network).
Recommendation

- TxDOT: It is recommended that other state DOTs use project level databases for calibration (rather than PMS).
- If these databases are not available, they should consider the establishment of a project level database as soon as possible and make it available to other DOTs.
  - http://pavements.ce.utexas.edu