OPTIMIZING DESIGN USING AASHTO PAVEMENT ME

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OUTLINE

1. AASHTO Pavement ME

2. How to Establish Inputs

3. Optimize the Design
New Pavement
- Asphalt Concrete (AC)
- Jointed Plain Concrete Pavement (JPCP)
- Continuously Reinforced Concrete Pavement (CRCP)
- Semi-Rigid Pavement

Overlays
- AC over AC (w/ & w/o seal coat/interlayer)
- AC over Semi-Rigid
- AC over JPCP (w/ & w/o fracture)
- AC over CRCP
- Bonded PCC over JPCP
- Bonded PCC over CRCP
- Unbound PCC over JPCP
- Unbound PCC over CRCP
- JPCP over AC
- CRCP over AC
- SJPCP over AC

Restoration
- JPCP Restoration

PAVEMENT ME IS THE MOST ADVANCED DESIGN PROCEDURE
Covers a wide range of applications, including nearly all new & rehabilitation options
Can account of new and diverse materials and various failure mechanisms

Most Recent Version 2.3.1 (Revision 66, as of Oct 2016)
Available from AASHTO
http://www.aashtoware.org/Pavement/Pages/default.aspx
Individual License Cost = $5,500 / year
Site License Costs = $22,000 to $44,000 / year
PAVEMENT ME PROVIDES PERFORMANCE ESTIMATES
All other procedures (e.g. StreetPave) only provide thickness

Pavement ME Performance Curve

Design life is when the Blue Reliability curve hits red threshold values

Red Line - Defined Distress Limit. When major rehabilitation is needed (i.e. patching & DG or overlay).

Black Dashed Line - The actual (most likely) level of distresses predicted

Blue Dotted Line - The predicted distresses at the given reliability level (i.e. 90%). Designs are based on when this line hits the defined distress limit

Design life is when the Blue Reliability curve hits red Predefined Distress level

Pavement ME Concrete Distresses Predicted

Bottom up & Top Down Cracking (JPCP Only)

Faulting (JPCP Only)

Punchout (CRCP Only)

• International Roughness index (IRI) – Smoothness

Other precursors to distresses
• Cumulative damage → Cracking
• Load transfer → Faulting (JPCP) or punchouts (CRCP)
• Crack Spacing → Punchouts
OUTLINE

1. AASHTO Pavement ME

2. How to Establish Inputs

3. Optimize the Design
PAVEMENT ME CONTAINS OVER 200 INPUT VARIABLES
broken down into five basic categories (most can use default values)

Design Categories

1. General information
   • Site/project Identification
   • Analysis parameters

2. Traffic

3. Climate

4. Design features
   • Layer definition & material properties
   • Drainage & surface properties

5. Calibration

Inputs are based on a Hierarchical levels (Level 1, 2 or 3)

<table>
<thead>
<tr>
<th>Level</th>
<th>Input Values</th>
<th>Knowledge of Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Segment or Project Specific Data (AVC, WIM, vehicle counts, soil properties, concrete and other material properties, etc)</td>
<td>Good</td>
</tr>
<tr>
<td>2</td>
<td>Regional/Statewide Data</td>
<td>Fair</td>
</tr>
<tr>
<td>3</td>
<td>National Data, Educated Guess based on local experience</td>
<td>Poor</td>
</tr>
</tbody>
</table>

It also helps knowing which inputs are the most sensitive/important and the difference between design variables and semi-constants
KEY TRAFFIC INPUTS ARE TRUCK TRAFFIC, GROWTH RATE AND TTC GROUPS

- Truck traffic on the design lane
- Vehicle Config - good default
- Axle spectrum - already grouped
- Annual growth rate
- Monthly and hourly distr. - good default
THREE OPTIONS FOR CLIMATIC INPUTS

1. Drop-down options for major US and Canadian cities

**Hourly climatic parameters**
OPTION 2. WEATHER FILES FOR 2514 LTPP PROJECTS
From LTTP InfoPave (US and Canada only)
OPTION 3. MAKE WEATHER FILES BASED ON NASA MERRA DATA
Also from LTTP InfoPave (available soon worldwide)

Select Location in ~30 mile × ~40 mile grids

Download No-gap hourly Precipitation, Temperature, Wind, Sunshine, & Relative humidity since 1979

Fill the data in Pavement ME
ONLY THREE SENSITIVE INPUTS FOR PCC LAYER
Thickness, CTE and Strength

Density, Poisson’s-semi-constants
Thermal properties-semi-constants
Shrinkage-good defaults

Stiffness-correlations
Typical unbound materials are provided in groups; the only user inputs are thickness and resilient modulus.

Coefficient of earth pressure, Poisson’s-semi-constants

Gradation, Atterberg limits, hydraulic properties—good defaults or insensitive
PAVEMENT ME ALSO ACCOUNT FOR MANY DESIGN FEATURES

Design features:
- Joint spacing
- Dowels
- Widen lanes
- Shoulder type
- Sealant type

These are not design features, but inherent property of the material or construction:
- Base friction
- Base erodibility

Semi-constants:
- Built-in gradient
- Surface shortwave absorptivity

There is no such thing as one-size-fits-all design. Each project is unique.
PAVEMENT ME ALLOWS AGENCIES TO DEVELOP AND USE LOCAL CALIBRATION COEFFICIENTS

You can save your local calibration coefficients as default or restore the national as default at one click.
LOCAL CALIBRATION RESULT IN $\frac{1}{2}$-IN OR LESS DIFFERENCE IN REQUIRED THICKNESS vs. NATIONAL CALIBRATION

However, using Pavement ME result in ~2-3 in thinner JPCPs when compared to the AASHTO 93 guide.
THREE NATIONAL CALIBRATIONS FOR NEW JPCP SO FAR
Most JPCP designs have been done using the 2nd Calibration

Cal. 1 (NCHRP 1-37)
- Models updated
- Cal. database expanded

Cal. 2 (NCHRP 1-40D)
- Models updated
- Cal. database expanded

Cal. 2.5 (NCHRP 20-07 Task 288)
- To correct CTE testing

Cal. 3 (NCHRP 20-07 Task 327)
- To validate Task 288

MEPDG 0.7
2004

MEPDG 1.0 - Pavement ME 2.1
2007

Pavement ME 2.2
August, 2015
Impact of New Global Calibration

• Version 2.2 new global calibration for JPCP and CRCP should not result in significantly different designs on average since the same field sections with the same performance trends were used.
• Of course, some designs will be a little thicker and some thinner due to variations involved.
15-25 PAGES OF REPORT SUMMARIZES ALL THE INPUTS AND OUTPUTS
Many more intermediate outputs are also available for in-depth analysis
OUTLINE

1. AASHTO Pavement ME
2. How to Establish Inputs
3. Optimize the Design
Many pavement designs will meet the design criteria
- Pavement-ME predicts what the actual performance could be
- Allows for comparisons and evaluation of different design features / thickness
- Performance estimates help determine the “when” and “what” rehabilitation activities to perform

Pavement-ME is for 50 years to give long term performance for each design
- Pavement design must the “design criteria” (eg less than 10% cracking at year 30)

Combining Performance Results with the LCCA finds the design that best balances the initial costs, life cycle costs and performance.
COMBINING PAVMENT ME AND LCCA INTO THE DESIGN PROCESS
finds the optimum design in terms of initial, long-term cost and performance

Slide: Courtesy of MIT Concrete Sustainability Hub
COMBINING PAVEMENT ME AND LCCA INTO THE DESIGN PROCESS
finds the optimum design in terms of initial, long-term cost and performance

Develop Pavement Structure
Layers Traffic Climate

Analyze Using ME Design Principles

Develop “Life-cycle Schedule of Activities”

Evaluate LCCA / LCA

Adequate Performance
COMBINING PAVEMENT ME AND LCCA INTO THE DESIGN PROCESS finds the optimum design in terms of initial, long-term cost and performance

Develop Pavement Structure
Layers Traffic Climate

10.0” JPCP w/ 1.25” Dia Dowels
6.0” Agg Subbse
Subgrade

Analyze Using ME Design Principles

Develop “Life-cycle Schedule of Activities”

Evaluate LCCA / LCA

Adequate Performance

N
COMBINING PAVEMENT ME AND LCCA INTO THE DESIGN PROCESS finds the optimum design in terms of initial, long-term cost and performance.
COMBINING PAVEMENT ME AND LCCA INTO THE DESIGN PROCESS finds the optimum design in terms of initial, long-term cost and performance.

- Improves performance
- Lowers cost
- Lowers environmental impacts

Designing pavements in an iterative procedure provides a Feedback Loop.
MONROE PARKWAY IS NEW ROAD NEAR CHARLOTTE NC
From US 74 at I-485 in eastern Mecklenburg County to US 74 near the Town of Marshville

- Project owner: North Carolina Turnpike Authority (NCTA)

- Preliminary cost estimate ~ $520 M
  Project was let as Design-Build with alternate pavement designs (asphalt or concrete)

- Length is approximately 21 miles

- Estimated Traffic:¹
  - Yr 2015 – ADT = 35,600
  - Yr 2030 –ADT = 56,600
    - % Duals = 1 % TTST = 2%
    - Growth = 3.14%
  - 20-yr F-ESALS² = 7.74 M
  - 30-yr R-ESALS² = 18.0 M

¹. NCTA – Proposed Monroe Connector/Bypass Preliminary Traffic and Revenue Study – 2009 Update
². F-ESALS based on Dual TF = 0.35, TTST TF = 1.15, Lane Distribution Factor = 0.8 (3 lanes / direction)
   R-ESALS based on Dual TF = 0.3, TTST TF = 1.6, Lane Distribution Factor = 0.8 (3 lanes / direction)
9.5" Jointed Pavement with Widened Lanes & 13-ft joint spacing is a 42-Year design.
THE ORIGINAL CONCRETE PAVEMENT HAS HIGHER INITIAL COST
BUT LOWER LIFE CYCLE COST
Makes pavement type selection difficult

Nominal Expenditures by Pavement Type ($ M)

<table>
<thead>
<tr>
<th>Year</th>
<th>Original Concrete</th>
<th>Difference vs AC</th>
<th>11.0” Asphalt</th>
<th>12.5&quot; JPCP</th>
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<tbody>
<tr>
<td>0</td>
<td>$85.40</td>
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<td>$79.32</td>
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Real DR=4%

LCC Net Present Value ($ M)

- Original Concrete $13.3 M lower (12.5%)
- 11.0” Asphalt
- 12.5” JPCP

Costs for 21 miles, 3 lanes plus Shoulders. Initial Costs include Pavement, base, and subgrade stabilization materials and labor
Rehabilitation costs – AC Activities based on NCDOT Schedules with same activities continued throughout 50 year analysis
Concrete activities based on Pavement-ME (no salvage) – 3% Patch & 100% Grind in yr 35, 5% Patch & 100% Grind in yr 35
THE OPTIMIZED PAVEMENT HAS BOTH LOWEST INITIAL COSTS & FUTURE REHABILITATION COSTS

<table>
<thead>
<tr>
<th>Year</th>
<th>11.0” Asphalt – Rehab: 2” Mill / 2” AC Overlay in years 10 and 20</th>
<th>12.5” JPCP – Rehab: Patch &amp; Grind in years 35 &amp; 45</th>
<th>9.5” JPCP / 13’ JS – Rehab: Patch &amp; Grind in years 40</th>
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<tbody>
<tr>
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<td>$79.32</td>
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Nominal Expenditures by Pavement Type ($ M)

<table>
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<tr>
<th>Pavement-ME Concrete</th>
<th>$10.41 M lower (15.1%)</th>
</tr>
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</table>

LCC Net Present Value ($ M)

| Pavement-ME Concrete | $34.22 M lower (47.7%) |

 Costs for 21 miles, 3 lanes plus Shoulders. Initial Costs include Pavement, base, and subgrade stabilization materials and labor
Rehabilitation costs – AC Activities based on NCDOT Schedules with same activities continued throughout 50 year analysis
Concrete activities based on Pavement-ME (no salvage) – 3% Patch & 100% Grind in yr 35, 5% Patch & 100% Grind in yr 35
SUMMARY

1 Pavement ME is a powerful tool for pavement performance prediction
   • Covers a wide range of applications
   • Determines when and how the pavement will fail
   • No longer just a thickness design procedure

2 For design, Pavement ME only needs a handful of important and necessary inputs
   • Three levels of input determination
   • Many inputs are semi-constants
   • Even more inputs are not sensitive
   • Be aware which are the design variables

3 Combine Pavement ME and LCCA to find the optimum design
   • No one-size-fits-all design. Each project is unique.
   • Use Pavement ME to generate many feasible designs
   • Use LCCA to decide the final design