Understanding and Using the Mechanistic Empirical Pavement Design Guide (MEPDG)

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Jim Mack, PE
CEMEX
jamesw.mack@cemex.com
## AGENDA

### My view on DARWin-ME / MEPDG

- Pavement Design Procedure
- Example – Monroe Bypass, Charlotte NC
  - Initial Costs Savings
  - Life Cycle Costs Savings
  - Stressing the Results
- Other issues
**DARWIN-ME / MECHANISTIC EMPIRICAL PAVEMENT DESIGN GUIDE**

New design procedure adopted by AASHTO in April 2011 as its Pavement Design Guide

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**DARWin-ME / MEPDG Facts**

State-of-the-practice design procedure based on advanced models & actual field data collected across the US

- New and rehabilitated pavements
- Calibrated with more than 2,400 asphalt and concrete pavement test sections across the U.S. and Canada, ranging in ages up to approximately 37 years

Uses mechanistic-empirical principles that account for:

- Traffic
- Climate
- Materials
- Proposed structure (layer thicknesses and features)

Provides performance estimates during the analysis period

- Criteria = IRI, cracked slabs, faulting, punchouts, crack spacing, load transfer, cumulative damage
- All other procedures (eg AASHTO 93) only provides thickness (no performance)

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**DARWin-ME / MEPDG Pavement Performance Curve**

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

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

**Blue Line** - The actual (most likely) level of distresses predicted

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1. MEPDG Overview & National Perspective, Federal Highway Administration, 88th Annual TRB meeting, January 2009
Pavements designs (thicknesses & features) are based on old design models

- Concrete is assumed to last the design life, without rehabilitation
- Asphalt is designed with rehabilitation activities in mind
  - Lower initial costs, but higher rehabilitation costs

LTPP and other data shows that most concrete pavements have carried many more loads than for which they were designed

- While increased performance is good, it comes at a cost that may be beyond the DOT’s budget

MEPDG designs uses newer models to match the pavement design life to the required performance life

- Reduces the initial costs
- without sacrificing life cycle costs
DARWIN-ME / MEPDG DESIGNS CAN DELIVER SUBSTANTIAL SAVINGS TO A PROJECT
DARWin-ME / MEPDG allows for design optimization

Optimization Opportunities
- Pavement Design
  - Thickness
  - Shoulders
  - Steel content
- Concrete Mix Design
- Base Design
- Soil Stabilization

Benefits to optimizing pavement design
- Decreased Concrete & Steel Requirements
- Decreased construction times (due to less materials)
- Decreased material delivery costs and cement and steel manufacturing requirements
  - fewer truck loads of concrete, cement/FA, aggregate, steel, etc
- Improved pavement sustainability due to lower material requirements

Optimizing can lower both the initial costs and life cycle costs of the project

Lower Initial and Long Term Cost

Initial Cost
Maintenance & Rehab (Real DR = 4%)

Asphalt
Original Concrete
MEPDG Concrete

$ M
$106.0
$92.7
$71.8
$85.4
$68.9
$79.3
$26.7

-10.2%
-47.7%
7.7%
-15.1%

Costs for 21 miles, 4 lanes & Shoulders. Initial costs include Pavement, base, and subgrade stabilization materials and labor
50 year LCCA: Concrete rehab schedule based on MEPDG. Asphalt rehab schedule are based on DOT standards.
UNDERSTANDING THAT IT PROVIDES BETTER DESIGNS, DARWIN-ME / MEPDG IS JUST A TOOL

Predicted Performance Curves & Pavement Designs

- Performance curves are estimates
  - It is not an exact answer
  - DARWIN-ME / MEPDG gives a distribution of what the actual performance could be
- There is no correct pavement design
  - There are many pavement designs that will work
  - MEPDG/DARWin-ME allows for comparisons and evaluation of different design features
- Performance estimates help determine the when and what rehabilitation activities to perform

Need to use with LCCA

- DARWin-ME/MEPDG should NOT be used by itself – needs to be combined with a LCCA
  - The user needs to develop a pavement design that meets the owner's budget
  - It is easy to develop designs to meet a given performance criteria.
  - Need to find the design that balances the initial costs, life cycle costs & performance

DARWIN-ME / MEPDG is a tool that helps identify and manage risks; and should be used with LCCA to quantify those risks
WHILE THE CONSENSUS IS THAT DARWIN-ME / MEPDG A BIG IMPROVEMENT OVER CURRENT DESIGN PROCESSES

There are many concerns with implementation

<table>
<thead>
<tr>
<th>Issues &amp; Concerns</th>
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<tbody>
<tr>
<td><strong>Too complicated</strong></td>
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<tr>
<td><strong>Too many inputs</strong></td>
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<tr>
<td>• Over 200 design variables</td>
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<tr>
<td>• Assembling the data required to run this program takes considerable time</td>
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<tr>
<td>• It requires too much training – minimum of one week, assuming the person being trained is an experienced pavement or materials engineer</td>
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<td>• Traffic Data is too voluminous and pavement engineers do not know what reasonable values are</td>
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<tr>
<td><strong>Material Properties</strong></td>
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<tr>
<td>• Many inputs are not commonly encountered by materials or pavement engineers</td>
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<td>• hydraulic conductivity, thermal conductivity, etc.</td>
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<td>• Does not handle some of the more common materials used by “my DOT”</td>
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<td>• Many values that have a significant impact on the design will not be known until during or after construction</td>
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<td>• Specification only defines the range of acceptable values for materials – not the actual value</td>
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<td>• Substantial testing of layer materials is required</td>
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<td>• Mix design is not known, construction month not known, etc.</td>
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<tr>
<td>• Concerns with the sensitivity of the inputs and the effects of different parameters on predicted distresses</td>
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<tr>
<td><strong>Calibration</strong></td>
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<tr>
<td>• It is not calibrated to local conditions – the performance models used are calibrated using limited national databases and does not take into account local materials, traffic, and environmental conditions.</td>
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<tr>
<td>• Calibration for the local materials and conditions in that state can cost $500,000 to $1,000,000 and may take six months to a year.</td>
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<tr>
<td><strong>Others</strong></td>
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<tr>
<td>• Only evaluates a proposed design – there is no real way to suggest layer types and thicknesses.</td>
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<tr>
<td>• Asphalt side is not ready</td>
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<tr>
<td>• Too Expensive</td>
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While these are a concern, I use inputs that are reasonable and address these impacts by doing a “Life Cycle Cost sensitivity analysis”
My view on DARWin-ME / MEPDG

Pavement Design Procedure

Example – Monroe Bypass, Charlotte NC

  Initial Costs Savings

  Life Cycle Costs Savings

  Stressing the Results

Other issues
OPTIMIZING DESIGN STARTS WITH THE STATE DOT PROCEDURE
And checks & refines designs with the AASHTO DARWin-ME / MEPDG

1. Determine Basic Design Parameters (traffic, soil conditions, etc)
   - Estimate the traffic (ESALS), subgrade k-values, etc
     • Estimate the load carrying capacity of the asphalt section
     • Estimate alternate pavement design costs

2. Determine Concrete Thickness
   - per DOT standards
   - per AASHTO 93
   - Develop rigid pavement designs for the roadway using the DOT’s Pavement Design Guide Procedure or 1993 AASHTO Design Procedure
     • Develop rigid pavement designs for the roadway using design inputs that may change due to job site specifics

3. Evaluate Concrete Performance
   - Use the AASHTO DARWin-ME / MEPDG to evaluate the life-cycle performance of each pavement design, develop life-cycle activity profiles

4. Develop Initial & Life Cycle Cost (Re-evaluate as needed)
   - Calculate the life-cycle costs over a 50-year analysis period
   - Evaluate the life cycle cost of the pavement designs & if needed, revise the design to develop a pavement section that has the best combination of low Initial Costs and low Life-Cycle Cost
**Concrete Pavement Preservation**

- A set of activities used early in the life of the pavement to repair isolated area of deteriorated pavement
  - Concrete Patching (% of pavement surface)
  - Diamond grinding (% of pavement surface)
    - Can be repeated up to 3 times
- Typical life is ~ 10 years

**Asphalt Overlays**

- 2” to 4+” asphalt overlay
  - May include milling of existing pavement surface
  - Can be repeated many times
- Typical life is ~ 10 years

<table>
<thead>
<tr>
<th>Activities</th>
<th>Cost Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Patching</td>
<td>Concrete Patch ≈ $2000 / patch</td>
</tr>
<tr>
<td>Diamond grinding</td>
<td>Diamond Grinding ≈ $3 – $4 / SY</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Asphalt Overlay ≈ $3.50 – $4.50/SY/in</td>
</tr>
<tr>
<td></td>
<td>Milling ≈ $1 – $4 / SY</td>
</tr>
</tbody>
</table>

Choice between CPP and AC overlay is based on cost and estimated performance.
LIFE-CYCLE COSTS ANALYSIS IS USED TO ASSESS THE TOTAL “COSTS OF OWNERSHIP” OVER THE LIFE OF AN ASSET

Nominal Expenditures by Pavement Type ($ M)

Asphalt | Concrete

M $

Nominal Expenses (current year costs inflated at 4%) are shown. The process was developed for concession groups who are as interested in determining their actual future cash expenditures as they were about the Net Present Value (NPV) of the pavement expenditures.

Life-cycle cost analysis (LCCA) is used to make better pavement investment decisions

- Evaluates the trade-offs between cost and performance

Initial costs
- Pavement, base, and subgrade stabilization materials and labor

Rehabilitation costs
- Timing & activities based on MEPDG/DARWIN-ME
- Also include
  - Other Incidental Costs such as striping, mobilization, etc. (20% of material costs)
  - Traffic Control (5% of material cost)
  - Engineering & Inspection (5% of material cost)

The decisions made today commit future resources (dollars & time) for maintenance & rehabilitation

Sample Costs for 21 miles, 3 lanes plus Shoulders. Initial Costs include Pavement, base, and subgrade stabilization materials and labor
FINAL DESIGN IS FOUND BY ITERATING FEATURES AND BALANCING INITIAL COSTS, LIFE CYCLE COSTS & PERFORMANCE
Use both Engineering and Economics

Engineering
• Develop the pavement layer thicknesses and features for:
  - a given traffic level
  - the environmental conditions of the project
  - The subgrade properties of the project.
• Develop different structures for different periods of time
• Estimate the predicted performance of each alternate

Economic
• Initial costs associated with each structure.
• Life cycle costs associated with the maintenance / rehabilitation costs of each alternate to keep the pavement performing during the analysis period
AGENDA

My view on DARWin-ME / MEPDG

Pavement Design Procedure

Example – Monroe Bypass, Charlotte NC

   Initial Costs Savings

   Life Cycle Costs Savings

   Stressing the Results

Other issues
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 ~ $520 M
  Project was let as Design-Build with alternate pavement designs (asphalt or concrete)
- Length is approximately 21 miles
- Estimated Traffic:
  - Yr 2015 – ADT = 35,600
  - Yr 2030 – ADT = 56,600
    - % Duals = 1%
    - TTST = 2%
    - Growth = 3.14%
  - 20-yr F-ESALS$^2$ = 7.74 M
  - 30-yr R-ESALS$^2$ = 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)
These are designs for Station 183+75 to Station 830+00 – largest portion of the Project. There were two other section with different designs. 

Costs include 3 lanes, 2 directions - Pavement, base, and subgrade stabilization materials and labor.

12.5” Conc Pvmnt = $44.39/SY:  AC Surface = $35.17/ton, AC Interm = $37.74/ton, AC Base = $38.56/ton, Liq AC = $503.21/ton

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Asphalt Design #1</th>
<th>Asphalt Design #2</th>
<th>Asphalt Design #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5” PCC Jointed w/ Dowels</td>
<td>3” Asphalt Surface (S12.5D PG 76-22)</td>
<td>3” Asphalt Surface (S12.5D PG 76-22)</td>
<td>3” Asphalt Surface (S12.5D PG 76-22)</td>
</tr>
<tr>
<td>3” PATB</td>
<td>4” Asphalt Inter. (I19.0D PG 70-22)</td>
<td>4” Asphalt Inter. (I19.0D PG 70-22)</td>
<td>4.0” Asphalt Inter. (I19.0D PG 70-22)</td>
</tr>
<tr>
<td>1.25” Sur Coarse (SF9.5A)</td>
<td>10.0” Asphalt Bases (B25.0C PG 64-22)</td>
<td>5.5” Asphalt Bases (B25.0C PG 64-22)</td>
<td>4.0” Asphalt Bases (B25.0C PG 64-22)</td>
</tr>
<tr>
<td>7” Cement Stab. SG or 8” Lime Stab. SG</td>
<td>7” Cement Stab. SG or 8” Lime Stab. SG</td>
<td>7” Cement Stab. SG or 8” Lime Stab. SG</td>
<td>8.0” Cement Treat Aggr Base</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Subgrade</td>
<td>Subgrade</td>
<td>Subgrade</td>
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Concrete has 3 Shoulder options
- 12.5” Asphalt
- 9.5” Concrete
- 8” RCC / 5.75” Agg Base

Initial Cost Comparison (21 Miles)

<table>
<thead>
<tr>
<th></th>
<th>Concrete</th>
<th>Asphalt 1</th>
<th>Asphalt 2</th>
<th>Asphalt 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$85.40</td>
<td>$85.31</td>
<td>$82.77</td>
<td>$79.32</td>
</tr>
</tbody>
</table>

$\Delta = 7.7\%$
STANDARD LCCA PROCEDURES USED BY NCDOT
SLIGHTLY FAVORS CONCRETE

Nominal Expenditures by Pavement Type ($ M)

- 11.0" Asphalt – Rehab: 2” Mill / 2” AC Overlay in years 10 and 20
- 12.5” JPCP – Rehab: Joint Seal in year 10 and 20

LCC Net Present Value ($ M)

Concrete
$9.02 M lower (10.2%)

$97.49
$88.47

Based on NCDOT Process - selection would be concrete
Question 1: is 7.7% saving now is worth more than 10.2% savings in 30 years?
Question 2: How accurate are the rehabilitation schedules?

Costs for 21 miles, 3 lanes plus Shoulders. Initial Costs include Pavement, base, and subgrade stabilization materials and labor
Rehabilitation costs –Activities based on NCDOT Schedules

$23.27
$34.44
$79.32
$85.40
$5.82
$3.93

Real DR=4%
MEPDG SHOWS NO STRUCTURAL REHABILITATION REQUIRED FOR 50+ YEARS
The Pavement Design Criteria is 30-year Design

Faulting and Cracking remain well below distress limits for 50 years
IRI INDICATES REHABILITATION NEEDED AT APPROXIMATELY YEAR 36
The Pavement Design Criteria is 30-year Design

While the design meets the performance requirements, there are opportunities to improve design

Potential Improvement Considerations

- Iterate Thickness
  - 11”, 10”, 9”, etc
- Removed Asphalt Base & replaced with 1” AC interlayer & 4” CTB
- Decreased joint spacing to 13 ft
  - Local Agg has high COTE
- Change shoulder type and decrease thickness

![Graph showing MEPDG Predicted Performance](image)

Note: MEPDG IRI Default limit – 172 in/mi. A value of 120 in/mi is used as trigger value for rehabilitation

Arrows indicate year of predicted 1st rehabilitation for that given pavement
MEPDG SHOWS OTHER CONCRETE SECTIONS MEET THE 30-YEAR DESIGN CRITERIA
Changing designs also changed the controlling distress

<table>
<thead>
<tr>
<th>Standard Concrete</th>
<th>MEPDG Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5” PCC Jointed w/ Dowels</td>
<td>9.5” PCC Jointed w/ Dowels 13-ft JS, Wid. Lane</td>
</tr>
<tr>
<td>3” PATB</td>
<td>1.25” Sur Coarse (SF9.5A)</td>
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<td>Subgrade</td>
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**MEPDG Predicted Performance**

**Predicted Cracking**

- 12.5” JPCP / 4.25” AC (JS=15ft) - 90% Rel
- 11.5” JPCP / 4.25” AC (JS=15ft) - 90% Rel
- 10.0” JPCP / 1.25” AC / 4” CTB / (JS=13 ft, Wid Lan) - 90% Rel
- 9.5” JPCP / 1.25” AC / 4” CTB (JS=13 ft, Wid Lan) - 90% Rel
- Distress Limit

9.5” Jointed Pavement with Widened Lanes & 13-ft joint spacing is a 42-Year design
OTHER DISTRESS SHOW THAT THE 9.5” JPCP WITH WIDENED LANES & 13-FT JOINT SPACING MEETS DESIGN CRITERIA

![Predicted Faulting Diagram]

![Predicted IRI Diagram]
THE OPTIMIZED PAVEMENT HAS BOTH LOWEST INITIAL COSTS & FUTURE REHABILITATION COSTS
LCCA Procedures based on MEPDG/DARWIN-ME

Nominal Expenditures by Pavement Type ($ M)

- 11.0” Asphalt – Rehab: 2” Mill / 2” AC Overlay in years 10 and 20
- 12.5” JPCP – Rehab: Patch & Grind in years 35 & 45
- 9.5” JPCP / 13’ JS – Rehab: Patch & Grind in years 40

LCC Net Present Value ($ M)

MEPDG Concrete
$34.22 M lower (47.7%)

$106.03
$92.72
$71.81

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 MEPDG (no salvage) – 3% Patch & 100% Grind in yr 35, 5% Patch & 100% Grind in yr 35
IN DETERMINING FINAL PAVEMENT SELECTION
Need to look at “Key Risk Factors” and “Stress the Results”

Key Risk Factors

Performance
• How do changes in “when” each rehabilitation activity occurs affect results?
  - MEPDG is new. How do I know pavement will last as long as predicted?

Traffic
• How does different designs respond to changes in traffic
  • Increase (how does it affect rehab cycles?)

Nominal expenditures by pavement type ($ M)

Life cycle cost analysis allows designer to consider variability with inputs and impact on performance
FOR OPTIMIZED CONCRETE NOT TO BE A GOOD CHOICE, PAVEMENT REHAB MUST START IN YEAR 10
(eg. Pavement Rehabilitation occurs 30 years earlier than predicted)

Nominal Expenditures by Pavement Type ($ M)

- 11.0” Asphalt – Rehab: 2” Mill / 2” AC Overlay in years 10 and 20
- 12.5” JPCP – Rehab: Patch & Grind in years 35 & 45
- 9.5” JPCP / 13’ JS – Rehab: Patch & Grind in years 40
- 9.5” JPCP / 13’ JS – Rehab: Patch & Grind in years 10 & 20
  AC Overlay in years 30 & 40

Initial Cost Savings are much greater than the risk of additional rehabilitations due to pavement underperforming

MEPDG Concrete
Approx same as Original Concrete
Still much lower than Original AC

LCC Net Present Value ($ M)

Initial Cost Savings are much greater than the risk of additional rehabilitations due to pavement underperforming
AGENDA

My view on DARWin-ME / MEPDG

Pavement Design Procedure

Example – Monroe Bypass, Charlotte NC

Initial Costs Savings

Life Cycle Costs Savings

Stressing the Results

Other issues
SPECIFIC ISSUES / USES INVESTIGATED WITH MEPDG/DARWin-ME

| Coefficient of Thermal Expansion (CoTE) | • Sensitivity of Designs to CoTE  
|                                       | • AASHTO TP-60 vs. AASHTO T-336 Values  
|                                       |   • Systematic error or shift due to using the wrong calibration coefficients for the COTE of the reference materials in the standard test procedure. |
| MEPDG IRI Results | • There are designs where I could not get IRI to meet design criteria  
|                   |   • Can not look at distress items as single, un-related items |
| Monthly Impacts | • Month of Construction is an input, but is unknown at the time of paving  
|                 |   • How big is this? |
| Improving Estimate of Rehabilitation Timing | • Rehab occurs when Reliability line hits pre-defined distress limits  
|                                           |   • Additional rehab timing can also be determined this way |

Project Sensitivity Analysis can help address risk of pavement underperforming
COTE IMPACTS JOINTED PAVEMENT CRACKING
Higher COTE Values increase cracking

CoTE Variations

Concrete mix CoTE values are a function of aggregate type
aggregate CoTE values are a function of the mineral type

Calculation of CoTE

\[ R^2 = 0.9859 \]

Siliceous River Gravel
Granite
Limestone

CoTE Impacts on JPCP Cracking

Cracking is due to the curling of the slab so the key design aspect is to be able to deal with the curling

Cote Cracking Graph: Courtesy of ACPA
CURLING EFFECT DUE TO CoTE CAN BE MITIGATED WITH THICKNESS OR JOINT SPACING
Shorter Joints decrease the moment arm for slab uplift

To convert from AASHTO T-336 CTE results to values that can be used MEPDG (TP-60), add 0.695 to AASHTO T336 results

Pavement = 15 ft jointed concrete pavement on 4” AC base on 12” limerock base. Subgrade =A-3 Soil.
20 Year Design with 2-Way AADTT = 15,000, 2 lanes in each direction, Climate = Orlando FL

TP-60 (MEPDG) CTE (x 10^-6 / °F)

AASHTO T336 CTE results (x 10^-6 / °F)

Limestone CTE range from LTPP Database = 4.7 to 6.1 (avg = 5.4)
Granite = 5.2 to 6.4 (avg = 5.8)
Basalt = 4.5 to 5.9 (avg = 5.2)
Quartzite = 5.5 to 6.9 (avg = 6.2)

Change in pavement thickness due to CTE variation
Joint Spacing = 14 ft
Joint Spacing = 12 ft
Joint Spacing = 15 ft

Issue is not how low CoTE is, but how to design pavements based on the CoTE value for your aggregates
FOR SOME GIVEN SOIL AND CLIMATIC CONDITIONS
IRI DESIGN CRITERIA CAN NOT BE MET …

Rochester MN Example

- 30 year Design life (40 year MEPDG Analysis)
- 2-way AADTT (Truck Traffic) = 3,100
  - Single Lane
  - Estimated ESALs = 52.17 M

- Design Features
  - Thickness - varies
  - 4” Crushed Stone (Granular) Base
  - 15-ft Joint Spacing
    - 1.5” Dowels for 10” or greater
    - 1.25” Dowels for less than 10”
  - Tied Concrete Shoulder
  - Limestone Aggregate
    - CoTE = 5.5 x 10^{-6} / °F)
  - CH Suggrade (High Plastic Clay)

No matter the concrete thickness, the 30 year IRI default criteria can not be met
… BUT MEPDG SHOWS CRACKING AND FAULTING LIMITS CAN BE MET WITH A 10-IN PAVEMENT …

**Question:** How does a 14” Pavement IRI increase if there is no faulting or cracking?
... FOR THESE CONDITIONS USE THE LOWEST CONCRETE THICKNESS FROM CRACKING & FAULTING

<table>
<thead>
<tr>
<th>Model</th>
<th>IRI = C1*(Crack) + C2*(Spall) + C3*(Fault) + C4*(Site Factor)</th>
</tr>
</thead>
</table>
| Site Factors | • Freezing index  
| | • Percentage of subgrade material passing the 0.075-mm sieve.  
| | • Relates to the potential for soil movements due to frost heaving and settlement |
| Discussion | • When fault and cracking are low, IRI distress level is being controlled by “Site Factors”  
| | • Site factors can not be altered by changing pavement designs |

Adding additional thickness to control IRI is costly and not warranted
CONSTRUCTION MONTH HAS SOME IMPACT ON MEPDG RESULTS

IRI Results

Eg - Texas Example

- January – PCC Zero-Stress = 65
- February = 70
- March = 79
- April = 91
- May = 101
- June = 107
- July = 112
- August = 112
- September = 106
- October = 92
- November = 80
- December = 80

I design pavements using the highest PCC Zero Stress Month (usually July or August)
CONSTRUCTION MONTH IMPACT ON MEPDG RESULTS
FOR CRACKING & FAULTING

For this particular case. Controlling distress can change

The highest PCC Zero Stress Month typically shows the worst performance

The diagram shows the predicted cracking and faulting for each month, indicating the impact of construction month on MEPDG results for cracking and faulting. Each line represents a specific month's predicted cracking or faulting over the years, with the Cracking Limit and Fault Limit marked on the graphs.
MEPDG PERFORMANCE CURVES SHOW WHEN TO DO REHABILITATION ACTIVITIES
Performance criteria is 20-year design

MEPDG Predicted Performance

**Standard Design**
- 8.0" PCC
  - Jointed w/ Dowels
  - Spacing = 15 ft
- 3.0" AC Base (SuperPave 19.0)
- 12" Graded Agg Base Course
- AASHTO Class A-7-5

**Optimized Design**
- 8.0" PCC
  - Jointed w/ Dowels
  - Spacing = 12 ft
- 6" Graded Agg Base Course
- AASHTO Class A-7-5

Note: Initial IRI = 70 in/mile

Optimized Pavement has same predicted IRI as the Standard Design
ADJUSTED PERFORMANCE CURVES TAKING INTO ACCOUNT REHABILITATION TIMING

Rehab Schedules

Original 8” JPCP / 3” AC / 12” Agg
CPP 1 = 24 Yrs
CPP 2 = 36 Yrs
CPP 3 = 45 Yrs
ACOL = 50 Yrs

Optimized 8” JPCP / 6” Agg – 12’ JS
CPP 1 = 23 Yrs
CPP 2 = 38 Yrs
CPP 3 = 50 Yrs

MEPDG Predicted Performance with Rehabs included

IRI Limit

- 8” JPCP / 3” AC /12” Agg - 15 JS (2.4 M ESALs)
- 8” JPCP / 3” AC /12” Agg - 15 JS (2.4 M ESALs) - 90% Reliability
- 8” JPCP / 6” Agg - 12 JS (2.4 M ESALs)
- 8” JPCP / 6” Agg - 12 JS (2.4 M ESALs) - 90% Reliability

Time between rehabilitation changes with designs and decreases due to increasing traffic
OTHER DISTRESS ALSO SHOW THAT THE 8” JPCP WITH SHORT JOINT SPACING PERFORMS BETTER

Predicted Faulting

Predicted Cracking

Distress Limit

Rehab Timing
SUMMARY

1. DARWin-ME / MEPDG can be used to lower concrete pavement’s initial cost
   - They will still have good long term performance
   - They still have “Low Cost of Ownership” and Low Life Cycle Cost

2. Designs should be developed using both Engineering & Economic Analysis balancing the initial costs and long term performance
   - Engineering
     - Determine concrete thickness and match rehabilitation schedules to the design using DARwin-ME / MEPDG predictions
   - Economic
     - Estimate initial and LCCA costs for each design

3. Adjust structures to meet the design, performance and cost requirements
   - Optimizing concrete pavements is more than just cutting thickness
   - Other “features” have a significant impact on performance & cost
     - Each design feature is a balance between performance and cost