Maximizing Pavement Life

Considerations for Pavement Design and Construction

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Asphalt Institute

Madison, Wisconsin
Nov. 27th, 2018

Pavement Design Reminders

- Binder Type
- Pavement Thickness
- Lift Thickness & Mix Type

Prevent Thermal Cracking

- Use PG -34 Binders on New Construction
- 25 year old SHRP recommendation

Binder Type

WisDOT Binder regions

Iowa HIPRO Thin Lifts

Utilizing 58-28 E(+) % Recovery >90%

November 27, 2018 Madison, WI
On overlays

Consider high performance binders on overlays
- Reduced rutting
- Reduced cracking
- Better crack seal performance
- Maintain existing crack resistance

PG 64-22 modified, no rutting  PG 67-22 unmodified, 15mm rut

Better Joint Performance

I-29 Project
- Orig. 1962 PCC
- 1999 - 3” HMA
- 2004 – 1.5” SMA
  - PG 70-28
- 2004 – Saw/Seal
- 2009 – Sealed secondary cracks

But what does it cost?

2016 DOT Ave. Unit Bid Prices

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Total Quantity</th>
<th>Average Bid Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 58-28</td>
<td>Ton</td>
<td>15,547.30</td>
<td>$433.74</td>
</tr>
<tr>
<td>PG 58-34</td>
<td>Ton</td>
<td>125,661.00</td>
<td>$485.86</td>
</tr>
<tr>
<td>PG 64-22</td>
<td>Ton</td>
<td>519.60</td>
<td>$470.63</td>
</tr>
<tr>
<td>PG 64-28</td>
<td>Ton</td>
<td>182,175.80</td>
<td>$457.38</td>
</tr>
<tr>
<td>PG 64-34</td>
<td>Ton</td>
<td>61,502.20</td>
<td>$499.15</td>
</tr>
</tbody>
</table>

Highest to Lowest Difference = $65.41/ binder ton @ 6% Binder = $3.92 / ton of mix

Simple county overlay

10 mile overlay, No milling

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Units</th>
<th>Unit Price</th>
<th>Amount</th>
<th>% of Project Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG64-28</td>
<td>1,575.50</td>
<td>Ton</td>
<td>$462.07</td>
<td>$727,991.29</td>
<td>48.5%</td>
</tr>
<tr>
<td>Class E Mix</td>
<td>25,627.20</td>
<td>Ton</td>
<td>$22.82</td>
<td>$584,812.70</td>
<td>39.0%</td>
</tr>
<tr>
<td>Tot. Mix Cost</td>
<td></td>
<td></td>
<td></td>
<td>$1,312,803.99</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Assuming a $65.41 binder cost increase,

<table>
<thead>
<tr>
<th>Binder cost increase</th>
<th>Expected Service Needed Increase in Life (Years)</th>
<th></th>
<th>Project cost increase</th>
<th>Expected Service Needed Increase in Life (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.2%</td>
<td>15</td>
<td>1.0</td>
<td>6.9%</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Complicated Interstate overlay

20 + mile overlay, underdrains etc.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Units</th>
<th>Unit Price</th>
<th>Amount</th>
<th>% of Project Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG64-28</td>
<td>1,823.80</td>
<td>Ton</td>
<td>$400.00</td>
<td>$729,520.00</td>
<td>3%</td>
</tr>
<tr>
<td>PG64-34</td>
<td>11,152.60</td>
<td>Ton</td>
<td>$430.00</td>
<td>$4,795,618.00</td>
<td>21%</td>
</tr>
<tr>
<td>Tot Project Cost</td>
<td></td>
<td></td>
<td></td>
<td>$22,565,024.00</td>
<td></td>
</tr>
</tbody>
</table>

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<th>Project cost increase</th>
<th>Expected Service Needed Increase in Life (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.4%</td>
<td>15</td>
<td>0.6</td>
<td>3.8%</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Smaller Urban / Grading

1 mile 3-Lane, grading, C&G, sidewalks, lighting and new asphalt surface

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Units</th>
<th>Unit Price</th>
<th>Amount</th>
<th>% of Project Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG58-28</td>
<td>447.70</td>
<td>Ton</td>
<td>$730.00</td>
<td>$326,821.00</td>
<td>9.3%</td>
</tr>
<tr>
<td>Class HR</td>
<td>9,518.50</td>
<td>Ton</td>
<td>$33.00</td>
<td>$314,110.50</td>
<td>8.9%</td>
</tr>
<tr>
<td>Tot Mix Cost</td>
<td></td>
<td></td>
<td></td>
<td>$640,931.50</td>
<td>18.2%</td>
</tr>
<tr>
<td>Tot Project Cost</td>
<td></td>
<td></td>
<td></td>
<td>$3,521,707.00</td>
<td></td>
</tr>
</tbody>
</table>

Assuming a $65.41 binder mix cost increase,

<table>
<thead>
<tr>
<th>Binder cost increase</th>
<th>Expected Service Needed Increase in Life (Years)</th>
<th></th>
<th>Project cost increase</th>
<th>Expected Service Needed Increase in Life (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0%</td>
<td>15</td>
<td>0.12</td>
<td>0.8%</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LTPP Studies

Quantifying the Effects of PMA for Reducing Pavement Distress

This study (published in Feb 2005) used national field data to determine enhanced service life of pavements containing polymer modified binders versus conventional binders. The data is from a variety of climates and traffic volumes within North America.

Summary of Expected Increase in Service Life, Years, Based on M-E Damage Based Analysis

<table>
<thead>
<tr>
<th>Site Factor</th>
<th>Condition Description</th>
<th>Added Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>Non-expansive, coarse soils</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Expansive and plastic soils (PI&gt;35)</td>
<td>2-5</td>
</tr>
<tr>
<td></td>
<td>Frost Susceptible in cold climate</td>
<td>2-5</td>
</tr>
<tr>
<td>Water Table &amp; Drainage</td>
<td>Deep</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Shallow; adequate</td>
<td>5-8</td>
</tr>
<tr>
<td></td>
<td>Shallow; inadequate</td>
<td>0-2</td>
</tr>
<tr>
<td>Existing Pavement Condition</td>
<td>HMA Good</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Poor-extensive cracking</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td>PCC Good</td>
<td>3-6</td>
</tr>
<tr>
<td></td>
<td>Poor-faulting &amp; cracking</td>
<td>0-2</td>
</tr>
</tbody>
</table>

Assumptions: Unmodified sections designed for 20 yr. life. Also, PMA in top 4 inches.

Continued:

Summary of Expected Increase in Service Life, Yrs

<table>
<thead>
<tr>
<th>Site Factor</th>
<th>Condition Description</th>
<th>Added Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate; Temp. Fluctuations</td>
<td>Hot Extremes</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Hot</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>2-5</td>
</tr>
<tr>
<td></td>
<td>Cold</td>
<td>3-6</td>
</tr>
<tr>
<td>Traffic, Truck Volumes</td>
<td>Low</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Intersections</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Thoroughfares</td>
<td>3-6</td>
</tr>
<tr>
<td></td>
<td>Heavy Loads</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>5-10</td>
</tr>
</tbody>
</table>

Assumptions: Unmodified sections designed for 20 yr. life. Also, PMA in top 4 inches.

Recycled Binders

NCHRP Project D9-12

NCHRP REPORT 452 - Results
- Blending occurs at higher RAP contents. At low RAP contents, effects are not significant.
- Results from all phases support concept of a tiered system.
- Mix ETG recommendations were largely confirmed.

NCHRP 9-12 Recommendations

RAP mixtures should be able to perform at least as well as virgin mixes.

<table>
<thead>
<tr>
<th>ACTION</th>
<th>RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change in Binder Grade</td>
<td>15% or less</td>
</tr>
<tr>
<td>One Grade Lower</td>
<td>16 - 25%</td>
</tr>
<tr>
<td>Use Blending Charts</td>
<td>&gt;25%</td>
</tr>
</tbody>
</table>

Adopted in AASHTO M323
Superpave Volumetric Mix Design
Acknowledgement

- Project 0992-14-06 Critical Factors Affecting Asphalt Durability
  - Evaluate changes to the composition of asphalt mixtures that WisDOT should consider to improve durability
    - Resistance to load associated cracking
    - Resistance to aging
  
  [Link to report](http://wisconsindot.gov/documents2/research/14-06-revised-final-report.pdf)

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Effect of Recycled Binder

<table>
<thead>
<tr>
<th>No Grade Change</th>
<th>AASHTO M 323 Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBE</td>
<td>Low Grade</td>
</tr>
<tr>
<td>10.5</td>
<td>-28</td>
</tr>
<tr>
<td>10.5</td>
<td>-28</td>
</tr>
<tr>
<td>10.5</td>
<td>-28</td>
</tr>
<tr>
<td>10.5</td>
<td>-28</td>
</tr>
<tr>
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<td>-28</td>
</tr>
<tr>
<td>10.5</td>
<td>-28</td>
</tr>
<tr>
<td>10.5</td>
<td>-28</td>
</tr>
</tbody>
</table>

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**Illinois SCB (Flexibility Index)**

SI = Stiffness Index
Slope @ 50% of Peak Load
AI - Aging Index

\[ SI = \frac{\text{Energy/Peak Slope}}{\text{Resistance to cracking increases with increasing FI}} \]

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The Experiment

- Structure:
  - 10 Lanes (10 Mixes)
  - Built in 2013

- Materials:
  - 2 Binder Grades
  - RAP/RAS
  - 2 WMA Technologies
  - 3 ABR contents

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**Project #1:**
High RAP (RAS) + WMA Accelerated Pavement Test

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**Lanes Completed**

- Lane 1
- Lane 2
- Lane 3
- Lane 4
- Lane 5
- Lane 6
- Lane 7
- Lane 8
- Lane 9
- Lane 10

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**November 27, 2018**
**Madison, WI**
Moderation is the key

Thickness Design

Design - Section 2

Pavement Design

MEPDG (AASHTO 2000)

AASHTO has been developing MEPDG for high volume roads, but a gap has developed for local roads and lower volume roads.

What Is PaveXpress?

A free, online tool to help you create simplified pavement designs using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

- Accessible via the web and mobile devices
- Free — no cost to use
- Based on AASHTO pavement design equations
- User-friendly
- Share, save, and print project designs
- Interactive help and resource links

www.PaveXpressDesign.com

Perpetual Pavement Design Software

PerRoad is uses the mechanistic-empirical design philosophy. The program couples layered elastic analysis with a statistical analysis procedure (Monte Carlo simulation) to estimate stresses and strains within a pavement. In order to predict the strains which would prove detrimental for fatigue cracking or structural rutting.

www.asphaltroads.org/perpetual-pavement
What does a P. P. look like?

Ya But, Ya But Does Asphalt Really Last?

65+ years old!!

55+ years old!!

How it looks today

Died, after 1 Overlay, at the age of 51!!

$5.8M

$34M
Lift Thickness and Mix Type

Design - Section 3

Recommended Lift Thickness

Mix Type

NMAS grading is different than older “Topsize” Grading

Old Rule of Thumb - Minimum lift thickness = 2x Topsize

NMAS - Minimum compacted thickness
✓ 4 times nominal aggregate size
✓ 3 times nominal aggregate size for fine graded mixtures

• Thicker lifts are easier to compact
• Cool slower providing longer compaction time

Minimum ------------ NOT MAXIMUM !

Specified Mix Gradations

Field Tolerances
Coarse, intermediate, and fine gradations. No differences in rutting performance!

Courtesy of NCAT