SMA Success Stories

December 12, 2018

Cynthia Williams - Illinois Tollway
Deputy Chief of Program Implementation
About The Tollway

Part of a dynamic transportation network
- Connects to regional transit network
- Supports three international airports
- Part of one of the nation’s largest interstate systems

Five roadways
294-mile system across 12 counties
Serves more than 1.6 million vehicles a day
# 2018 Asphalt Paving Program

323,151 tons of SMA

<table>
<thead>
<tr>
<th>Item</th>
<th>Depth, inch</th>
<th>Layer Description</th>
<th>Tons</th>
<th>$/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>Stone matrix WMA surface friction course, IL-12.5, N80 (135 Lb/SY/In)</td>
<td>204,771</td>
<td>$81.02</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Stone matrix WMA binder course, IL-12.5, N80 (114 Lb/SY/In)</td>
<td>118,380</td>
<td>$87.07</td>
</tr>
<tr>
<td>3</td>
<td>Var</td>
<td>Polymerized WMA binder course (112 Lb/SY/In)</td>
<td>93,782</td>
<td>$80.09</td>
</tr>
<tr>
<td>4</td>
<td>Var</td>
<td>WMA surface course (112 Lb/SY/In)</td>
<td>100,596</td>
<td>$93.87</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>WMA stabilized subbase (112 Lb/SY/In)</td>
<td>120,291</td>
<td>$76.90</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Full-depth WMA shoulder</td>
<td>235,688</td>
<td>$67.26</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>Full-depth WMA shoulder</td>
<td>74,901</td>
<td>$72.18</td>
</tr>
<tr>
<td>8</td>
<td>10.25</td>
<td>Full-depth WMA lane pavement</td>
<td>51,171</td>
<td>$81.07</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>Full-depth WMA lane pavement</td>
<td>13,126</td>
<td>$74.18</td>
</tr>
</tbody>
</table>

912,625 tons
Stone-matrix asphalt (SMA) used for all mainline overlays

2008 to 2009 – Full-depth asphalt on the Jane Addams Memorial Tollway (I-90) in Rockford area

2015 – Reagan Memorial Tollway (I-88) rehabilitation

2018 – Veterans Memorial Tollway (I-355) overlay

2018 – I-88 rehabilitation

Seven asphalt producers
### Cost Savings

<table>
<thead>
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</tbody>
</table>
Cost Savings – Created By Innovations

Innovations to date
- Asphalt binder replacement
- Ground tire rubber
- Rejuvenators
Asphalt Binder Replacement

- This table was introduced into Tollway specifications in 2009 – and was for SMA mixes only
- The intent was to incentivize fractionalization of RAP and use of RAS

<table>
<thead>
<tr>
<th>Reclaimed Material</th>
<th>Binder Replacement %</th>
<th>Asphalt Binder Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category I FRAP only</td>
<td>0 -20</td>
<td>SBS PG 76-22</td>
</tr>
<tr>
<td>Category I FRAP only or</td>
<td>21 - 30</td>
<td>SBS PG 70-28</td>
</tr>
<tr>
<td>with RAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category I FRAP &amp; RAS</td>
<td>31 - 50</td>
<td>SBS PG 64-34</td>
</tr>
</tbody>
</table>
Asphalt Binder Replacement Now

<table>
<thead>
<tr>
<th>Reclaimed asphalt material (as allowed in Tollway Tables 7 &amp; 8)</th>
<th>RAP$^1$/FRAP/RAS</th>
<th>FRAP only or with RAS</th>
<th>Category 1 FRAP with RAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABR</td>
<td>0-17%</td>
<td>18-33%</td>
<td>34-50%$^2$</td>
</tr>
<tr>
<td>Allowable Mix Options</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMA and IL-4.75</td>
<td>SBS 70-28 GTR PG 70-28 PG 58-28 10% Dry GTR</td>
<td>SBS 64-34 GTR PG 64-34 PG 52-342$^3$ 10% Dry GTR</td>
<td></td>
</tr>
<tr>
<td>Binder and surface course</td>
<td>PG 58-28</td>
<td>PG 52-34$^3$</td>
<td></td>
</tr>
<tr>
<td>Asphalt stabilized subbase</td>
<td>PG 58-28$^4$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^1$/ RAP not allowed in SMA
$^2$/ Allowed up to 60 percent ABR on N50 IL 19.0mm binder
$^3$/ PG 46-34 shall be considered an equivalent to PG 52-34
$^4$/ Allowed up to 65 percent ABR on asphalt stabilized subbase
Tollway’s Approach To Equivalent Performance: 
*Balanced Mix Design*

**Rutting**
Hamburg @ 20,000 passes
SMA < 6.0mm

**Contractor Options**
- Warm mix
- ABR
- PG binder grade
- SBS polymer
- GTR (terminal and dry process)

...and now,
Rejuvenators are coming soon...

**Cracking**
DCT
SMA ≥ 600 J/m²
Binder Testing - PG Grading

Proposed Specification

Final grade of the extracted binder

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulders</td>
<td>PG 64-22</td>
</tr>
<tr>
<td>Mainline</td>
<td>PG 70-22</td>
</tr>
<tr>
<td>High volume</td>
<td>PG 76-22</td>
</tr>
</tbody>
</table>

Recovered binders - Next step in performance testing
The Future Of Balanced Mix Design

Where we are going…. you won’t need volumetrics!

Resultant Binder Testing

Resistant to rutting and cracking for a specific temperature range /traffic level

DCT

Hamburg
A Look At What Got Us Here
The Tollway’s Innovation Evolution

• Warm mix asphalt
• Use of aggregates
• Requirements for recycled materials
• Contractor options
• Performance testing
• RESULT: SMA mixes that are durable and affordable
SHOULDER

The Tollway’s Sandbox
The History Of WMA

1995 Preliminary lab experiments
1997 German Bitumen Forum
2000 Euroasphalt & Eurobitume Congress
2002 NAPA European Scan Tour
2004 First public demonstration in U.S.
2005 WMA Technical Working Group
2007 AASHTO FHWA International Scan Tour
2008 First U.S. International Conference
2010 FHWA emphasizes as part of EDC
2012 Tollway mandates all HMA to be WMA
2015 Chicago Department of Transportation does too!
NCHRP Projects funded as a result of WMA-related efforts:

<table>
<thead>
<tr>
<th>Project Code</th>
<th>Project Title</th>
<th>Total Cost</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-43</td>
<td>Mix Design Practices for WMA</td>
<td>$350,000</td>
<td></td>
</tr>
<tr>
<td>9-47</td>
<td>Engineering Properties, Performance, and Field Performance of WMA Technologies</td>
<td>$250,000</td>
<td>completed</td>
</tr>
<tr>
<td>9-47A</td>
<td>Properties of Foamed Asphalt for Warm Mix Asphalt Applications</td>
<td>$800,000</td>
<td>Nov 2014</td>
</tr>
<tr>
<td>9-49A</td>
<td>Short- and Long-Term Aging of Asphalt Mixtures for Performance Testing and Prediction</td>
<td>$800,000</td>
<td>May 2016</td>
</tr>
<tr>
<td>9-52</td>
<td>Recycled Asphalt Shingles in Asphalt Mixtures with WMA Technologies</td>
<td>$600,000</td>
<td>Sept 2016</td>
</tr>
<tr>
<td>9-53</td>
<td>Properties of Foamed Asphalt for Warm Mix Asphalt Applications</td>
<td>$700,000</td>
<td>Dec 2014</td>
</tr>
<tr>
<td>9-54</td>
<td>Long-Term Aging of Asphalt Mixtures for Performance Testing and Prediction</td>
<td>$800,000</td>
<td></td>
</tr>
<tr>
<td>9-55</td>
<td>Effects of Recycling Agents on Asphalt Mixtures w/High RAS &amp; RAP Binder Ratios</td>
<td>$1,500,000</td>
<td>July 2017 est.</td>
</tr>
</tbody>
</table>

Total: $7,522,501

TRB continues to spend a lot of money on WMA research.
The Most Important Research We Need To Know

Reduced Oxidation with a chemical WMA

Virgin AC  | After Paving  | 2 Years Later

Pen

Hot Mix
Warm Mix
New WMA Specification For 2019

**Contractor options**

- 0-20 RAP – can use foaming
- Any FRAP, RAS or >20 percent RAP – chemical foaming required

**Cold weather**

- Chemical foaming only when beyond temperature specifications
- Increase 50 percent additive from mix design target

<table>
<thead>
<tr>
<th>Minimum Ambient Air Temperature (In shade)</th>
<th>WMA Binder Course</th>
<th>WMA Surface Course</th>
<th>WMA IL-4.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>32°F and Rising</td>
<td>32°F and Rising</td>
<td>40°F and Rising</td>
<td>50°F and Rising</td>
</tr>
</tbody>
</table>
Coarse Aggregate For Tollway SMA

Friction surface SMA
- High-traffic pavements and curves
- Coarse aggregate: quartzite, granite, diabase/trap rock, crushed steel slag

Binder SMA and surface SMA
- Coarse aggregate: typically crushed gravel (also surface aggregates)
- 2008 friction evaluation – acceptable for tangents
Coarse Aggregates For Tollway SMA

• Friction aggregates – Non-Illinois sources, except slag
• Crushed gravel – Southern Wisconsin and Northern Illinois
• 2015 – Evaluated local crushed gravel and dolomite sources
• 2018 – Implemented aggregate testing, including coarse FRAP
Local Aggregates For Tollway SMA

2015 evaluation approach

• Identify potential sources
• Aggregate breakdown
  • Micro-Deval testing

Category I & II FRAP

• Extract using the analyzer
• Run through the Micro Deval
Micro-Deval Of Coarse Aggregates and FRAP

AASHTO T327

• Aggregate breakdown (percent loss) in presence of water
• Good identifier of pavement performance
• “Mini” L.A. Abrasion
• Repeatable test
• Some agencies use in lieu of soundness
Speciﬁcation – Coarse Aggregate For SMA

L.A. Abrasion – Less than 28 percent loss

Micro-Deval loss

• Single source: less than 12 percent
• Coarse aggregates: design weighted average < 9.5 percent (includes coarse FRAP) – A-OK, proceed with mix design
• If design weighted average 9.5 to 11.9 percent
  • Conduct mix design – optimum AC at 3.5 percent air voids
  • Air voids at optimum AC and $N_{225} \geq 2.0$ percent
How Does This Compare?

**NCHRP 557 (aggregate tests for HMA)**
- Micro-Deval: Max loss of 15 recommended

**AASHTO T327 (Micro-Deval for coarse aggregate)**
- 17-18 for HMA surface course (max 21 for lower courses)

**AASHTO M325 (standard for SMA)**
- Max L.A. Abrasion = 30
- Higher values have been successful
2018 SMA Mix Designs

- Four contracts
- Seven producers
- 323,151 tons of SMA
- 5 “local” sources used
- Micro Deval = 7.7 to 11.6
- 17 of 18 SMA designs used
  coarse FRAP

Good Quality RAP
Quality sources

• Tollway requires documentation of the RAP source
• Tollway mainline RAP is separated from shoulder or IDOT mixes

RAP and FRAP production

• RAP/FRAP stockpiles must be tested at a required interval
• All gradation and percent AC must be within a tolerance of mix design JMF targets
Reclaimed Material Processing

Allowable sources and minimum quality for RAP and FRAP stockpiles
### SMA mixes

- Only category I FRAP
- RAS is an option to use instead of fibers
- Terminal or dry process GTR is an option

### Reclaimed Asphalt Material

<table>
<thead>
<tr>
<th>Allowable Mix Options</th>
<th>RAP(^1)/FRAP/RAS</th>
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<td>SBS 70-28</td>
<td>GTR PG 70-28</td>
<td>SBS 64-34</td>
</tr>
<tr>
<td></td>
<td>PG 58-28</td>
<td>10% Dry GTR</td>
<td>GTR PG 64-34</td>
</tr>
<tr>
<td>Binder &amp; Surface Course</td>
<td>PG 58-28</td>
<td></td>
<td>PG 52-34(^3)</td>
</tr>
<tr>
<td>Asphalt Stabilized Subbase</td>
<td>PG 58-28(^4)</td>
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</tr>
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1/ RAP not allowed in SMA  
2/ Allowed up to 60% ABR on N50 IL 19.0mm Binder  
3/ PG 46-34 shall be considered an equivalent to PG 52-34  
4/ Allowed up to 65% ABR on Asphalt Stabilized Subbase
### Performance Testing

#### Hamburg

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th># Wheel Passes</th>
<th>Maximum Rut Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>20,000</td>
<td>6 mm</td>
</tr>
</tbody>
</table>

#### DCT

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th>Minimum Fracture Energy (Tested at -12°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA – Friction Surface</td>
<td>700 J/m²</td>
</tr>
<tr>
<td>SMA – Surface</td>
<td>650 J/m²</td>
</tr>
<tr>
<td>SMA – Binder</td>
<td>600 J/m²</td>
</tr>
</tbody>
</table>
### N80 IL 12.5 REC SMA - Performance

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Tollway Mix #</th>
<th>Mixture Description</th>
<th>ABR</th>
<th>Modification</th>
<th>DCT</th>
<th>Hamburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plote</td>
<td>90WMA 1841</td>
<td>Binder</td>
<td>50.1</td>
<td>PG 46-34 +10% ECR (dry process)</td>
<td>652 J/m²</td>
<td>-1.83 mm @20,000</td>
</tr>
<tr>
<td>Curran</td>
<td>90WMA 1833</td>
<td>Surface</td>
<td>37.1</td>
<td>PG 46-34 +10% ECR (dry process)</td>
<td>1510 J/m²</td>
<td>-5.92 mm @20,000</td>
</tr>
<tr>
<td>Geneva</td>
<td>90WMA 1839</td>
<td>Friction surface</td>
<td>25.8</td>
<td>PG 58-28 +12 GTR (terminal)</td>
<td>967 J/m²</td>
<td>-4.61 mm @20,000</td>
</tr>
<tr>
<td>Rock Road</td>
<td>90WMA 1824</td>
<td>Friction surface</td>
<td>37.6</td>
<td>SBS PG 64-34</td>
<td>904 J/m²</td>
<td>-3.36 mm @20,000</td>
</tr>
</tbody>
</table>
Recovered PG Grade Of The Mix

Extraction, recovery and grading of each individual design

This is the ONLY way to know the final PG grade in the pavement

Factors that will affect PG grade

• ABR
• Source of RAS/FRAP
• Virgin binder
• Rejuvenator, warm-mix additive or modifier
Recovered Binders

Next step in performance testing

Proposed new specification on recovered binders

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</tr>
<tr>
<td>High volume</td>
<td>PG 76-22</td>
</tr>
</tbody>
</table>

What’s the real PG in the road?
# N80 IL 12.5 REC SMA – Recovered Grading

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<th>Recovered Grading</th>
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</thead>
<tbody>
<tr>
<td>Plote</td>
<td>90WMA 1841</td>
<td>Binder</td>
<td>50.1</td>
<td>PG 46-34 +10% ECR (dry process)</td>
<td>PG 72.5-24.9</td>
</tr>
<tr>
<td>Curran</td>
<td>90WMA 1833</td>
<td>Surface</td>
<td>37.1</td>
<td>PG 46-34 +10% ECR (dry process)</td>
<td>PG 70.2 -23.1</td>
</tr>
<tr>
<td>Geneva</td>
<td>90WMA 1839</td>
<td>Friction surface</td>
<td>25.8</td>
<td>PG 58-28 +12 GTR (terminal)</td>
<td>PG 73.2-28.9</td>
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<tr>
<td>Rock Road</td>
<td>90WMA 1824</td>
<td>Friction surface</td>
<td>37.6</td>
<td>SBS PG 64-34</td>
<td>PG 78.9-30.2</td>
</tr>
</tbody>
</table>
SMA – Not Only For Roadways Anymore
The Mile Long Bridge

Laundry list *(also a mile long)*

- Overlay could not be more than 25 lbs./sf
- Patches of all material types
- Significant MOT restraints
- Had to be completed on a weekend
- And lastly...

*Winter is Coming*
The Plan

1. Start with longitudinal joint sealer to seal the deck from water infiltration
2. Pave with 9.5mm SMA over the top using

<table>
<thead>
<tr>
<th>Material Contractor</th>
<th>Tollway Mix Number</th>
<th>Mixture Description</th>
<th>ABR</th>
<th>AC</th>
<th>DCT</th>
<th>Hamburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-Five</td>
<td>90WMA453K</td>
<td>Friction surface</td>
<td>19.9</td>
<td>SBS 70-28</td>
<td>904 J/m²</td>
<td>-3.69mm @20,000</td>
</tr>
</tbody>
</table>
Success!!
Continued Success!!

An alternative to concrete overlays
Can be used by local agencies
Tollway Research Opportunities

Research Reports, Approved Materials And CCDD Facilities Lists

Research Request for Proposals
There are no active RRFPs at this time

Research Reports (links)
- Evaluation of Field-Produced Hot Mix Asphalt (HMA) Mixtures with Fractionated Recycled Asphalt Pavement (RAP)
- Short-Term Performance of Modified Stone Matrix Asphalt (SMA) Produced with Warm Mix Additives
- Texturing of Concrete Pavements, NCHRP Report 634
- Fractionated Reclaimed Asphalt Pavement (FRAP) as a Coarse Aggregate Replacement in a Ternary Blended Concrete Pavement
- Flexural Capacity of Rigid Pavement Concrete Slabs with Recycled Aggregates
- Concrete with Steel Furnace Slag and Fractionated Reclaimed Asphalt Pavement

Research Reports (pdf)
- High-Performance Concrete for Bridge Decks - Final Report (pdf)
- Laboratory Investigation of Illinois Tollway SMA Mixtures with Varied Levels of Asphalt Binder Replacement
THANK YOU