Historical Review and Construction of Durable SMA Pavement in Chicago, IL

1st International Conference on Stone Matrix Asphalt (SMA)
Atlanta, Georgia
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Thornton-Warrenville - Joliet, Illinois
Greetings from Chicago
Chicago Area Expressways

Extensive railroad networks, high volume truck traffic
Region One, Chicago Metro Area

- 1,422 Bridges
- 2,793 Miles of Highways
- 218 Interstate Miles
- 80 Million miles/day
SMA is the mix of choice for the Chicagoland area expressways

- Mainline pavement as an overlay
- On bridge decks as an overlay
- Superb performance as a full depth HMA pavement
SO WHY **SMA**?

**STRONG**

Stone on Stone Contact

**DURABLE**

Rich in Mortar Binder

**COST EFFECTIVE**

Longer Service Life

AASHTO-M325, 2008.
Started with a 12.5 mm Mix

<table>
<thead>
<tr>
<th>SIEVE</th>
<th>Limits % PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>19MM</td>
<td>100</td>
</tr>
<tr>
<td>12.5MM</td>
<td>90-100</td>
</tr>
<tr>
<td>9.5MM</td>
<td>75 MAX</td>
</tr>
<tr>
<td>4.75MM</td>
<td>20-28</td>
</tr>
<tr>
<td>2.36MM</td>
<td>16-24</td>
</tr>
<tr>
<td>600mM</td>
<td>12-16</td>
</tr>
<tr>
<td>300mM</td>
<td>12-15</td>
</tr>
<tr>
<td>75mM</td>
<td>8-10</td>
</tr>
</tbody>
</table>

AASHTO-M325, 2008.
Aggregate

- **FA**
  - 100% Manufactured sand
  - FAA (method A) 45 MIN
  - Soundness loss 15 % MAX
  - Absorption 2 % MAX

- **CA**
  - LA abrasion 30 % MAX
  - Soundness loss 15 % MAX
  - F&E
    - 3 TO 1 20 % MAX
    - 5 TO 1 5 % MAX
  - Absorption 2 % MAX
Design criteria:

- $N_{\text{des}}$ 80 Gyrations
- Poly AC 6.0 % Typical Content
- VMA 17 % Min
- VTM 3.5%
- In-Pace Density 94% of MTD
- HW 6 mm Max 20 K Passes
- DRAIN DOWN 0.3 % MAX
Other mix requirements:

**ASPHALT CEMENT**

- Polymer Asphalt Cement
- SBS/SBR PG 76-28
- Mixing Production Temperature
- 325 – 325 F (150 C -160 C)

**MINERAL FILLER**

- Mineral filler shall be free from organic impurities and have a PI ≤ 4

**STABILIZER ADDITIVE**

- CELLULOSE @ 0.3% OF MIX WEIGHT
- MINERAL FIBER @ 0.4 % OF MIX WEIGHT
Critical to an SMA mix design:

- Voids in the Coarse Aggregates (VCA) is the volume between the coarse aggregate particles. $\text{VCA}_{(DRC)}$

- The VCA of the CA fraction is determined by compacting the stone with the dry rodded technique according to T19.

- The SMA mixture must have a coarse aggregate skeleton with stone-on-stone contact. $\text{VCA}_{(MIX)}$

Photo courtesy of Karol Kowalski and Adam Rudy
Purdue University, Via Web Search
Critical to an SMA mix design:

\[ VCA_{(MIX)} < VCA_{(DRC)} \]

However...

\[ VCA_{(MIX)} > VCA_{(DRC)} \]

- An adjustment to the aggregate blend is in order, and
- Accomplished by an increase in the coarse aggregate fraction of the aggregate blend
A typical Structural Overlay for an interstate is 4.75” to 5.0” (120 mm to 127 mm):

A 2” (50 mm) inlay has also been placed.
- Keeps the paver stops at a minimum
- Keeps mat temperature uniform
- Uniform mat temp will improve mat density
- Paving pace should be slow & consistent
- Ensure that the placemen hourly rate is slightly less than production rate
- Don’t out-run the breakdown rollers
- Slow paver down, but NEVER stop
- Maintain multiple trucks at the MTD

Night-time Paving or off peak hours, is very common and often times required
Properly Ballast Rollers

Should maintain a close rolling distance to the paver
Early on, steel plates used as additional weight

Later on, 3 wheel static rollers, regained wider use to help productivity
Later on, 3 wheel static rollers regained wider use to help productivity
Design criteria:

- $N_{des}$: 80 Gyrations
- Poly AC: 6.0 % Typical Content
- VMA: 17 % Min
- VTM: 3.5%
- In-Pace Density: 94% of MTD
- HW: 6 mm Max 20 K Passes
- DRAIN DOWN: 0.3 % MAX
Hamburg Wheel data for SMA and dense graded mixes

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th># of Samples</th>
<th>Average Center Lane Density</th>
<th>Center Lane Rut 20,000 Passes</th>
<th>Average Wheel Lane Density</th>
<th>Wheel Lane Rut 20,000 Passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>12</td>
<td>94.5%</td>
<td>3.5</td>
<td>94.4%</td>
<td>3.7</td>
</tr>
<tr>
<td>N-70</td>
<td>14</td>
<td>94.4%</td>
<td>8.9</td>
<td>94.7%</td>
<td>8.2</td>
</tr>
</tbody>
</table>
A laboratory test results using a gyratory compactor is shown in the figure below.

The dense asphalt concrete mixture (DAC13), required 25 gyrations to obtain 96% of designed MTD density, while an SMA 13 required 50 gyrations.

The lab results indicated that twice the compaction energy is necessary for the SMA compaction compared to ordinary dense asphalt mixture.
Field compaction of SMA mix in Japan using a VTW & VPT Rollers:

The purpose was to compare the effect of the combination of the VTW roller and the VPT roller.

- The compacted layer thickness was 40 mm.
- There were three pavement sections.
- The same paver model was used a VOGEL super 2100.
- The VTW roller was used in the Break Down.
- The VPT roller was used in the intermediate position behind the VTW.
- The Vibratory tandem (VT) roller was used for finishing compaction as static roller (no vibration).

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<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 mm</td>
<td>100</td>
</tr>
<tr>
<td>13.2 mm</td>
<td>99.8</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>47.5</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>32.8</td>
</tr>
<tr>
<td>600 um</td>
<td>24.1</td>
</tr>
<tr>
<td>300 um</td>
<td>16.8</td>
</tr>
<tr>
<td>150 um</td>
<td>12.7</td>
</tr>
<tr>
<td>75 um</td>
<td>10.6</td>
</tr>
<tr>
<td>Binder content (%)</td>
<td>6.4</td>
</tr>
<tr>
<td>Asphalt binder type (penetration)</td>
<td>60/80</td>
</tr>
</tbody>
</table>

Mix design data of the SMA mixture.
The rolling patterns used are shown in the table below:

- The breakdown roller for each section was a VTW roller in static mode in section 1.

- In the case of VTW roller sections, all passes of the VTW were made in oscillatory vibration mode.

- The second roller for each section was a VPT roller. Amplitude setting number 1 was used in section 1, amplitude setting 2 in section 2 and amplitude setting 4 in section 3.

- The finish roller for each section was the VT roller. All passes of this roller were static mode.

- Each roller traveled at 3 km/h and all the rollers compacted from cold side 200 mm (8 in) away from longitudinal joint.
## Rolling Patterns and Percent of TMD

<table>
<thead>
<tr>
<th>Section No.</th>
<th>Rolling Process</th>
<th>Roller Type (Model)</th>
<th>Roller Mass (kg)</th>
<th>Operating Speed (km/h)</th>
<th>Number of Rolling Passes (pass)</th>
<th>Vibration Mode</th>
<th>Average Percent of TMD(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Breakdown</td>
<td>STW (MW700)</td>
<td>8730</td>
<td>3</td>
<td>8</td>
<td>Static</td>
<td>93.9</td>
</tr>
<tr>
<td></td>
<td>Second</td>
<td>VPT (GE750)</td>
<td>9100</td>
<td>3</td>
<td>8</td>
<td>Vib.1st Amp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finsh</td>
<td>VT (SW650)</td>
<td>7100</td>
<td>3</td>
<td>8</td>
<td>Static</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Breakdown</td>
<td>VTW (MW700)</td>
<td>8730</td>
<td>3</td>
<td>8</td>
<td>Oscillation</td>
<td>94.7</td>
</tr>
<tr>
<td></td>
<td>Second</td>
<td>VPT (GE750)</td>
<td>9100</td>
<td>3</td>
<td>8</td>
<td>Vib.2nd Amp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finsh</td>
<td>VT (SW650)</td>
<td>7100</td>
<td>3</td>
<td>8</td>
<td>Static</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Breakdown</td>
<td>VTW (MW700)</td>
<td>8730</td>
<td>3</td>
<td>8</td>
<td>Oscillation</td>
<td>95.3</td>
</tr>
<tr>
<td></td>
<td>Second</td>
<td>VPT (GE750)</td>
<td>9100</td>
<td>3</td>
<td>8</td>
<td>Vib.4th Amp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finsh</td>
<td>VT (SW650)</td>
<td>7100</td>
<td>3</td>
<td>8</td>
<td>Static</td>
<td></td>
</tr>
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Using SMA in full depth application

11” of SMA was placed back in 1997 on this route which is the gate to a major quarry.
New North Avenue Bridge over Chicago River

Designed for Latex Concrete Wearing Surface

Built in December 13, 2007 With SMA as a Wearing Surface
Overlays on existing structures
Overlays on existing structures
For an improved bond of the overlay to the bridge deck surface, consider the following:

- Hydro scarification of the surface
- Heavier application rate of tack coat
Inside view of multi-jet rotating blasting head

Recommended Water pressure range
30 K to 35 K PSI

Milled surface  ★  Hydro scarified surface

Surface texture achieved after Hydro scarification
Statewide:
- Over 140,745 miles

IDOT:
- 16,000 miles of highways
- 7,741 bridges
- 2,182 miles of Interstate Routes

This is the 3rd largest in the Nation!!
To Recap:
For the Chicago Metro Region

1,422 Bridges
2,793 Miles of Highways
218 Interstate Miles
80 Million miles/day
High volume interstate traffic

Heavy, concentrated loading
For the last 20+ years under the most demanding traffic conditions in the Chicagoland area, **SMA** has been the mix of choice.

With its stone-on stone-contact and asphalt rich mortar, an SMA mixture will provide the needed strength and durability to meet the challenges of heavy traffic conditions.
Questions?
Thank you

Questions

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