High Polymer, Thick Lift, Low Void Pavement

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Utah State Asphalt Engineer

62nd Annual Idaho Asphalt Conference
October 27, 2022

Highly-Modified, Thick-Lift Demonstration Project in Utah

Rocky Mountain Asphalt User Producer Group Meeting
October 13, 2021
Past Experience With Highly Modified and/or Thick Lifts

- South Carolina
  - Limited information on the mix
  - Believed to be highly modified
  - Single-lift at 7.9 inch
  - Consistent densities ~95%
- NCAT
  - South Carolina sponsored
  - Highly Modified
  - 5.75-inch, 12.5 mm mixture
  - Consistent densities through the lift of ~95%
  - Great performance

- Utah
  - Past laboratory work
    - Hamburg driven
    - Typical 12.5 mm mix
    - Multiple samples up to 6.8% binder
    - 40,000 passes
    - No Hamburg failures (<10 mm)
  - Two secondary highways
    - Simply substituted binder into the mix design
    - Constructed in 2017
    - Typical lift thicknesses
    - Excellent performance

The Binder Specification

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
<th>ASTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Shear Rheometer, AASHTO T 315</td>
<td>@ 76°C, G*, kPa</td>
<td>1.30 Min.</td>
</tr>
<tr>
<td>Rotary Viscosimeter, AASHTO T 316</td>
<td>@ 150°C, θ, degrees</td>
<td>3.0 Min.</td>
</tr>
<tr>
<td>Fluoroscan, AASHTO T 314</td>
<td>@ 76°C, θ, degrees</td>
<td>2.5 Min.</td>
</tr>
<tr>
<td>Flash Point, AASHTO T 48</td>
<td>°C</td>
<td>59 Min.</td>
</tr>
<tr>
<td>RTFO Residue, AASHTO T 249</td>
<td>@ 76°C, G*, kPa</td>
<td>4.0 Min.</td>
</tr>
<tr>
<td>Elastic Recovery, AASHTO T 301 mod (a)</td>
<td>%</td>
<td>3.0 Min.</td>
</tr>
<tr>
<td>PAV Residue, 20 hours, 40°C, AASHTO R 28</td>
<td>@ 40°C, G, MPa</td>
<td>6.8 Min.</td>
</tr>
<tr>
<td>Bending Beam Rheometer, AASHTO T 313</td>
<td>@ -25°C, S, MPa</td>
<td>1.0 Min.</td>
</tr>
<tr>
<td>Delta Tc from additional BBR test,</td>
<td>@ -30°C</td>
<td>2.20 Min.</td>
</tr>
<tr>
<td>NDT M 074/45</td>
<td></td>
<td>260 Min.</td>
</tr>
</tbody>
</table>

(a) Modify paragraph 4.5 as follows: Stop the ductilometer after 20 cm has been reached and within 2 seconds. Sever the specimen at its center with a pair of scissors.
Highly Modified Asphalt Materials

WASHTO Conference
April 4, 2016
Salt Lake City, Utah

AASHO Road Test
Ottawa, Illinois Constructed 1956-58
Hamburg Test  
Showing load cell output
**Hamburg Test Data**

<table>
<thead>
<tr>
<th>Mix Design</th>
<th>%AC</th>
<th>Air Voids/Rut. Voids</th>
<th>20,000</th>
<th>+(20,000 + 20 lb)</th>
<th>Total Rut, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab 1</td>
<td>4.8</td>
<td>7.3/7.2</td>
<td>2.32</td>
<td>4.64</td>
<td>6.95</td>
</tr>
<tr>
<td>Slab 2</td>
<td>4.8</td>
<td>7.8/7.8</td>
<td>2.6</td>
<td>4.14</td>
<td>6.71</td>
</tr>
<tr>
<td>Slab 1</td>
<td>5.8</td>
<td>5.5/4.7</td>
<td>2.17</td>
<td>3.86</td>
<td>5.03</td>
</tr>
<tr>
<td>Slab 2</td>
<td>5.8</td>
<td>5.9/5.9</td>
<td>3.26</td>
<td>5.75</td>
<td>9.01</td>
</tr>
<tr>
<td>Slab 1</td>
<td>6.8</td>
<td>3.8/3.0</td>
<td>5</td>
<td>5.16</td>
<td>7.13</td>
</tr>
<tr>
<td>Slab 2</td>
<td>6.8</td>
<td>3.9/3.7</td>
<td>5.82</td>
<td>7.19</td>
<td>8.05</td>
</tr>
<tr>
<td>Slab 1 Low Va</td>
<td>6.8</td>
<td>2.5/1.8</td>
<td>3.8</td>
<td>6.05</td>
<td>9.91</td>
</tr>
<tr>
<td>Slab 2 Low Va</td>
<td>6.8</td>
<td>2.9/2.2</td>
<td>3.06</td>
<td>5.89</td>
<td>6.15</td>
</tr>
</tbody>
</table>

**Hamburg Test**

- **Mix Design**: PG 70E-34
- **Air Void Under Wheel**: +20K with +20 lb 20K passes

**Air Void Under Wheel**: mm rut or % air voids

*9*  
*10*
Hamburg Test Data

<table>
<thead>
<tr>
<th>Mix Design</th>
<th>%AC</th>
<th>Air Voids/Rut Voids</th>
<th>20K</th>
<th>+ (20,000 + 20 lb)</th>
<th>Total Rut, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab 1</td>
<td>4.8</td>
<td>7.4/7.1</td>
<td>3.13</td>
<td>2.43</td>
<td>5.56</td>
</tr>
<tr>
<td>Slab 2</td>
<td>4.8</td>
<td>7.6/7.7</td>
<td>3.15</td>
<td>2.43</td>
<td>5.56</td>
</tr>
<tr>
<td>Slab 1</td>
<td>5.8</td>
<td>5.8/5.0</td>
<td>3.19</td>
<td>2.43</td>
<td>5.62</td>
</tr>
<tr>
<td>Slab 2</td>
<td>5.8</td>
<td>5.7/5.8</td>
<td>3.21</td>
<td>2.43</td>
<td>5.64</td>
</tr>
<tr>
<td>Slab 1</td>
<td>6.8</td>
<td>3.6/3.2</td>
<td>3.16</td>
<td>2.43</td>
<td>5.39</td>
</tr>
<tr>
<td>Slab 2</td>
<td>6.8</td>
<td>3.6/3.3</td>
<td>3.16</td>
<td>2.43</td>
<td>5.39</td>
</tr>
<tr>
<td>Slab 1 Low Va</td>
<td>6.8</td>
<td>3.5/3.0</td>
<td>3.11</td>
<td>2.43</td>
<td>5.51</td>
</tr>
<tr>
<td>Slab 2 Low Va</td>
<td>6.8</td>
<td>3.5/3.1</td>
<td>3.11</td>
<td>2.43</td>
<td>5.51</td>
</tr>
</tbody>
</table>
Project Location

- Port of Entry on I-80 Near Wendover, UT
- High Truck Volume (51%), AADT 7,900
- 2-2.5 Million ESALs/year
- Very Hot in the Summer
- LTPPBind = PG64-28 (98% reliability)

Project Scope

- Mill and Inlay 6.0 Inches of PCC
- ~330 Ton Project
- Highly Modified Binder
- Dense-Graded Mixture
- Construct in a Single Lift
- ~2-Hour One-Way Haul
Notable Design Requirements

• PG 76-34
  ◦ 110-degree useful temperature interval!
  ◦ Highly modified
• Mix Design Requirements
  ◦ 50 gyrations
  ◦ 12.5 mm NMAS
  ◦ 1.0 – 1.5% air voids
  ◦ VMA 15.0 – 17.0
  ◦ VFA 90 – 95%
  ◦ 0.3% maximum draindown
  ◦ 15% RAP maximum

• Proprietary PG 76-34 from Peak/Idaho Asphalt

Mix Design Properties

• 1% Air Voids (0.1% at 75 gyrations)
• VMA = 15.3
• VFA = 93.3%
• 6% Total Asphalt
  ◦ 5.33% Virgin
  ◦ 0.67% RAP Binder
• 0% Naturals
• Incorporated Evotherm as a Compaction Aid

Superpave Specimens
Hamburg Wheel Tracking Requirements

• Slab Air Voids $\rightarrow$ 3.5 – 4.5% (6.5 – 7.5%)
• Water Bath Temperature
  ◦ 50°C – first 20,000 passes
  ◦ 54°C – second 20,000 passes
• Wheel Loading = 158 pounds
• Maximum Rut Depth at 20,000 Passes = 7.0 mm (10.0 mm)
• Maximum Rut Depth at 40,000 Passes = 10.0 mm

• Approximately 3.9 mm after 20,000 Passes
• Approximately 6.1 mm after 40,000 Passes

Hamburg Graphs

First 20,000 Passes

Second 20,000 Passes – same specimen
Key Players

Howard Anderson, UDOT
Craig Fabrizio, Staker Parsons

Test Strip Construction

• At Staker-Parson’s Beck Street Facility
• Aggregate base vs. Portland cement concrete
• Virtually no haul vs. 2+ hours
Test Strip Construction
Test Strip Lessons Learned

- Density of 97% or more was easily achieved
- Regular rolling equipment and procedures followed
- Feeding while placing such a large volume of mix was achieved
- Mix was stable even with roller overhang
- No significant issues encountered

Western Section Coming Off I-80
Eastern Section Off the Scale

Paving Operations
### Time vs. Temperature

A graph showing the relationship between time and temperature.

### Density Results

<table>
<thead>
<tr>
<th>Core</th>
<th>Total Thickness</th>
<th>Top Half Density</th>
<th>Bottom Half Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.27 inches</td>
<td>97.9%</td>
<td>98.0%</td>
</tr>
<tr>
<td>2</td>
<td>6.27 inches</td>
<td>97.8%</td>
<td>94.4%</td>
</tr>
<tr>
<td>3</td>
<td>6.1 Inches</td>
<td>97.2%</td>
<td>92.8%</td>
</tr>
<tr>
<td>4</td>
<td>6.1 Inches</td>
<td>97.3%</td>
<td>97.6%</td>
</tr>
</tbody>
</table>
Lessons Learned

- Highly modified asphalt can be successfully constructed even with a 2+ hour haul
- High densities were easily achieved
- Initial performance has been spectacular
**Early Post Traffic Performance**

- Exceptional early performance
  - 17 days of 100+°F since opening to traffic
  - Nearly 500,000 commercial trucks
  - No discernable movement

**Skid Testing Results**

- British Pendulum Test (AASHTO T-278)
- Existing Pavement
  - 41 average skid number
- New Pavement
  - 53 average skid number
UDOT is experimenting with a unique asphalt paving method that, if successful, will significantly enhance traffic impacts during construction and increase the life and durability of the pavement.

The new method requires a highly granulated asphalt binder - 90 percent of the binder comes from pricing the mixture at the same temperature as the paving mix, and the other 10 percent is from the actual mix of the asphalt. The asphalt is then placed at a high temperature, which allows it to be laid on the road at a lower temperature. The binder provides the strength and durability of the asphalt, and the asphalt provides the flexibility and smoothness of the pavement.

The test site for this new paving method is being conducted at UDOT’s new international airport in Draper. The project, funded by the Governor’s Office, costs $30 million.
• This picture and the following were taken June 23, 2022.
• Surface is dirty with PCC dust. No visible distress, or cracking or rutting.
The POE Weigh Scales have been rebuilt

Cost Considerations:

- First project was $150 per ton. This is with a small quantity, long haul and an experimental feature.
- Expect costs to end up similar to SMA or less with experience.
  - The aggregate gradation is cheaper than SMA
  - Binder content is less than SMA, but more expensive
  - No mineral filler
  - No fibers to add
  - QC and QA testing is less than SMA
  - Production is higher
  - The cost for high polymer binder is expected to come down a little with experience
Other Benefits:

- UDOT and the Contractor also have time savings
  - One lift to pave, compact and test
  - Savings in traffic control costs
  - User costs are reduced
  - No tack coat needed
  - Stronger more durable pavement - density, binder grade, content
  - Real potential to expand paving season

Further Discussion:

- Maintenance of Traffic:
  - Cool down time is expected to be one day longer
  - The edge will be thicker, protect from traffic
  - Shorter construction time may be safer for workers and public

- Smoothness
  - One less opportunity to improve the ride
  - A high density material can be ground
  - Can add surface coarse

- Higher volume of material to produce and truck
PCCP Test Section on I-15

• This same mix (2216 tons) was placed on all 5 lanes of I-15 northbound near parish lane in early May of this year. Average density of 97.3%, Ave thickness of 2.97 inches. Ave binder 5.94%, Ave VMA 15.7

• This 3 inch lift was placed directly over very poor PCCP that had only crack sealing done prior to the overlay.

• The PG 76-34 low void mix was placed near also new 3 inch PG 64-34 Superpave mix (1347 tons) for comparison.

• We have excellent performance so far.

Future UDOT Usage

• PG 76-34 Low Void Mix
  ◦ Multiple thin-lift installations around Salt Lake City, bids close this week. Bridge decks are being planned.
  ◦ 13 mile project on SR 196 to I-80 just came in yesterday at $103/mix ton.

• Thick Lift, PG 76-34 Low Void Mix
  ◦ Potential 6 inch lift placed on PCCP on I-15
  ◦ I-15 Ramps and SR 6 Intersection

https://www.visitsaltlake.com/
Acknowledgments

• Lonnie Marchant, Clinton Martin, Robert Stewart, Region 2
• Dave Johnson, Asphalt Institute
• Clark Allen, Dave Thomas, Mike Evans, Central Labs
• Reed Ryan, UAPA

What do you see?
Questions or Comments: