Polymer- Modified Bridge Deck Waterproof Surface Mix

Pennsylvania Asphalt Pavement Association
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Ron Corun
Specialty Products Manager
Associated Asphalt
Requirements for an Asphalt Surface Mix For Bridges

• Mix designed to provide rut resistance
• Mix designed to provide extreme fatigue resistance – may experience much greater vertical movement than on a roadway
• Mix designed to achieve density without vibratory compaction
• Mix designed to have extremely low permeability - “water proof”
• Mix designed to have excellent workability
Requirements for an Asphalt Surface Mix For Bridges

• Challenge in the past to maintain rut resistance and extreme flexibility at the same time

• Industry has used Styrene-Butadiene-Styrene (SBS) polymers to modify asphalt for over 25 years
  • Styrene is a hard plastic material - provides stiffness
  • Butadiene is man-made rubber – provides flexibility
Requirements for an Asphalt Surface Mix For Bridges

• In the past, SBS dosage levels above 4% have created asphalt binders with poor workability

• New formulations of SBS polymer now allow dosages >7% with excellent workability

• Now possible to provide high levels of rut and fatigue resistance at the same time with high levels of SBS polymer modification

• Associated Asphalt formulated a highly modified asphalt to meet NJDOT specification for bridge deck applications – StellarFlex BD
Requirements for an Asphalt Surface Mix For Bridges

• NJDOT and Rutgers University developed a Bridge Deck Waterproof Surface Course (BDWSC) mix to utilize highly polymer-modified asphalt
  • 3/8” mix designed at 1% air voids to provide impermeable mix
  • Mixture rut test specification
  • Mixture fatigue cracking test specification
  • No specification for PG grade of asphalt binder – requires polymer modified binder that allows mix to pass rutting and fatigue test requirements
# Bridge Deck Water Proof Wearing Surface Course - Specifications

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>½”</td>
<td>100</td>
</tr>
<tr>
<td>3/8”</td>
<td>80-90</td>
</tr>
<tr>
<td>#4</td>
<td>55-85</td>
</tr>
<tr>
<td>#8</td>
<td>32-42</td>
</tr>
<tr>
<td>#16</td>
<td>20-30</td>
</tr>
<tr>
<td>#30</td>
<td>12-22</td>
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<tr>
<td>#50</td>
<td>7-16</td>
</tr>
<tr>
<td>#100</td>
<td>3-12</td>
</tr>
<tr>
<td>#200</td>
<td>2.0-6.0</td>
</tr>
</tbody>
</table>

Minimum Percent Asphalt Binder by Mass of Total Mix: 7.0
BDWSC Rut Testing

Asphalt Pavement Analyzer
AASHTO TP 63

- 100 lb. wheel load; 100 psi hose pressure
- Tested at 64°C for 8,000 loading cycles
- Measures rut depth
- NJDOT BDWSC specification rutting ≤ 3 mm
BDWSC Rut Testing

APA Rut Depth, mm

<table>
<thead>
<tr>
<th>BDWSC 1</th>
<th>BDWSC 2</th>
<th>BDWSC 3</th>
<th>BDWSC 4</th>
<th>BDWSC 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.27</td>
<td>2.89</td>
<td>1.31</td>
<td>2.74</td>
<td>2.36</td>
</tr>
</tbody>
</table>

NJDOT Spec Limit
BDWSC Fatigue Test

- Flexural Beam Fatigue Device, AASHTO T-321
  - Tests mix’s ability to withstand repeated bending which causes fatigue failure
  - Data = number of loading cycles to failure (loss of stiffness)
BDWSC Fatigue Test

- Beam Fatigue Test typically run at 900 μ-strain and 10 Hz (high deflection, slow moving vehicle)
- For additional vertical movement in bridge decks, test for BDWSC is run at 1500 μ-strain
- NJDOT requires > 100,000 cycles to failure
BDWSC Beam Fatigue

Beam Fatigue, Cycles to Failure

<table>
<thead>
<tr>
<th>BDWSC 1</th>
<th>BDWSC 2</th>
<th>BDWSC 3</th>
<th>BDWSC 4</th>
<th>BDWSC 5</th>
<th>9.5mm PG 76-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>444,000</td>
<td>488,000</td>
<td>508,000</td>
<td>314,000</td>
<td>696,200</td>
<td>5,400</td>
</tr>
</tbody>
</table>

NJDOT Spec Limit
BDWSC Permeability Test

• Falling Head Permeability Test
  • Most commonly used for asphalt
  • Can test 4 or 6” diameter cores
  • Rubber membrane forced on side of samples (15 psi) to prevent side leakage
BDWSC Permeability Testing

- BDWSC mixture was found to be “impermeable” – could not get water to flow through sample

Samples cored from 6-inch diameter gyratory sample
BDWSC Projects – NJ Route 87

• NJ Route 87 Absecon Inlet Bridge
• Paved in 2008 with BDWSC mix
• 2008 National Asphalt Pavement Association (NAPA) “Quality in Construction” award winner
BDWSC Projects – George Washington Bridge (GWB)

• GWB presents extreme challenge to asphalt mix
• Orthotropic steel deck – substantial vertical movement
• Most heavily trafficked bridge in the world – 108 million vehicles per year
• BDWSC mix performing well after seven years
BDWSC Projects – NYSDOT
Robert Moses Causeway
BDWSC Projects – NYSDOT
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Robert Moses Causeway
BDWSC Projects – NYSDOT
Robert Moses Causeway
Chesapeake Bay Bridge Tunnel

- PAPA member Allan Myers is currently repaving the 18 mile long Chesapeake Bay Bridge Tunnel with StellarFlex® Bridge Deck Binder
BDWSC Summary

• BDWSC binder and mix is very attractive product for bridge deck paving
  • Excellent workability
  • Liquid asphalt delivered to contractor ready-to-use
    • No additives at asphalt plant
    • Liquid asphalt is delivered and certified to meet requirements prior to use
  • Excellent rut resistance
  • Superior fatigue resistance
  • Excellent compactibility
  • Environmentally friendly
  • Economical
Questions?
StellarFlex FR® Binder For High Friction Chip Seals

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Specialty Products Manager
Associated Asphalt Partners, LLC
High Friction Surface Treatment (HFST)

• FHWA has been promoting HFST for safety

• HFST consists of epoxy binder and bauxite aggregate

• NJDOT placed sections of HFST in 2018 and experienced severe delamination of epoxy binder
NJDOT HFST Study

- NJDOT hired Rutgers University to investigate
- Major cause – epoxy expands and contracts at a much higher rate than asphalt pavement
- Causes tearing and cracking resulting in delamination
- Aged pavements are less able to withstand stresses
Crack @ HFST Terminus Due to Thermal Contraction
NJDOT HFST Study

• Delamination caused by thermal contraction stresses
NJDOT HFST Study

- Rutgers proposed to replace the epoxy with PG 88-22FR asphalt binder used by FAA (actually grades as a PG 94-22)
- NJDOT placed sections of High Friction Chip Seal (HFCS) using FR binder with bauxite aggregate and local trap rock aggregate in 2018
- Excellent performance after one year
NJDOT HFST Study

Bond Strength (psi)

- HFST with Epoxy: 145 psi
- HFCS with FR Binder: 130 psi

Source – Rutgers University Study
High Friction Chip Seal

- Chip seal installation contractor raves about FR binder as chip adhesive
  - Sprays easily
  - Excellent chip retention
  - No broken windshields
  - No bleeding
High Friction Chip Seal
High Friction Chip Seal
High Friction Chip Seal

NJ Route 68 - One year old HFCS With FR Binder
High Friction Chip Seal

- NJDOT measured initial skid number of SN = 70
HFCS Cost Compared to HFST

- PG 88-22FR Binder provides excellent performance at a lower cost
- Cost data courtesy NJDOT

Cost per Square Yard, $
Summary

• HFCS using PG 88-22FR asphalt binder eliminates HFST epoxy coefficient of expansion incompatibility – which is major cause of delamination

• HFCS application becomes a standard chip seal installation

• Comparable bond strength to epoxy

• Excellent performance to date

• Substantial cost savings
Questions?