Polymer- Modified Bridge Deck Waterproof Surface Mix

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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
Rosphalt for Bridge Decks

- Rosphalt is a powdered additive
  - Combination of polymer and ground tire rubber
  - Must be added at asphalt mix plant (2.25% by weight of mix)
    - May be added through a pneumatic device (shown at left)
    - Requires additional personnel to load and operate device
Rosphalt for Bridge Decks

• Rosphalt requires extremely high mix temperatures (> 400°F)
  • Needed to allow some blending of additive and asphalt inside asphalt mix plant
  • Needed to provided mix workability
  • Needed to permit proper compaction

• High temperatures cause excessive fumes
  • Every 10°F increase in mix temperature doubles fume emissions

• Rosphalt LT (Low Temperature) product does not perform as well as high temperature version
  • Reduced blending in plant
  • Minimal reduction in mix temperature because of workability (Recommended mix temperature 374°F)
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
What is SBS Polymer?

Poly-styrene

Poly-butadiene

Disposable fork

Rubber Band
StellarFlex SBS Modified Asphalt

- Artist’s rendition of SBS polymer molecules
  - Large blocks of styrene connected by rubbery cords of butadiene
- StellarFlex production process disperses SBS completely in asphalt
StellarFlex Production Process

- Add SBS polymer to asphalt
- Mill polymer into fine particles with a Siefer mill
  - Pump and grinder in one machine
  - Sharp teeth
  - Clearances of .001”
  - Requires 200 hp motor
  - Processed at high temperatures (>380°F)
StellarFlex SP Production Process

• Add cross-linking additive
• Cure PMA in a tank with heat and constant agitation
• Curing process may take two days
• Monitor slides for total fluorescence
• Associated Asphalt’s laboratory tests properties and certifies PG properties before selling the asphalt
StellarFlex During Curing
Fully Cured StellarFlex Asphalt
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 (HiMA) to meet NJDOT specification for bridge deck applications – StellarFlex HiMA
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>
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<tbody>
<tr>
<td>½”</td>
<td>100</td>
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<tr>
<td>3/8”</td>
<td>80-90</td>
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<tr>
<td>#4</td>
<td>55-85</td>
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<tr>
<td>#100</td>
<td>3-12</td>
</tr>
<tr>
<td>#200</td>
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</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

NJDOT Spec Limit

<table>
<thead>
<tr>
<th></th>
<th>BDWSC 1</th>
<th>BDWSC 2</th>
<th>BDWSC 3</th>
<th>BDWSC 4</th>
<th>BDWSC 5</th>
<th>Rosphalt 1</th>
<th>Rosphalt 2</th>
<th>Rosphalt 3</th>
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</thead>
<tbody>
<tr>
<td>Value</td>
<td>1.27</td>
<td>2.89</td>
<td>1.31</td>
<td>2.74</td>
<td>2.36</td>
<td>1.64</td>
<td>1.35</td>
<td>1.45</td>
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</table>
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

NJDOT Spec Limit

BDWSC 1: 444,000
BDWSC 2: 488,000
BDWSC 3: 508,000
BDWSC 4: 314,000
BDWSC 5: 696,200
Rosphalt-1: 212,000
Rosphalt-2: 167,000
Rosphalt-3: 160,000
Rosphalt LT

Flexural Beam Fatigue, Cycles to failure

- Rosphalt LT: 20,277 cycles
- StellarFlex HiMA: 635,910 cycles (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 – NYSDOT
Robert Moses Causeway

![Image of a temperature gauge reading 303.6°F](image-url)
BDWSC Projects – NYSDOT
Robert Moses Causeway
BDWSC Summary

• BDWSC binder and mix is very attractive alternative to Rosphalt
  • Excellent workability at much lower temperatures
  • 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
  • Equivalent rut resistance
  • Much better fatigue resistance
  • Excellent compactibility
  • Less expensive
Questions?