Accelerated loading test results of two NCAT sections with highly modified asphalt

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Introduction

- Concept of highly modified asphalt
- Two high SBS sections in monitored field trials at NCAT, USA
- Rutting data comparison section N7
- APA and AMPT data
- Finite Element Modeling and actual rut depths at NCAT
- Successful rehabilitation of failed pavement on weak subgrade

Summary / conclusions

Concept of Highly Modified Asphalt (HiMA)

<table>
<thead>
<tr>
<th>Before mixing</th>
<th>After mixing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5% SBS - Continuous asphaltene rich phase</td>
<td></td>
</tr>
<tr>
<td>5% SBS - Co-continuous asphaltene and polymer rich phases</td>
<td></td>
</tr>
<tr>
<td>7.5% SBS – Continuous polymer rich phase</td>
<td></td>
</tr>
</tbody>
</table>

Making it possible with current equipment

Challenges:
- Hard base bitumens (40-60 pen, C320, C600)
- High SBS content
- Storage stability

Issues solved by adapting design of the polymer

Kraton D0243
- Provides a low viscosity, even in hard bitumens at elevated SBS content
- Provides compatibility
- Provides storage stable PMBs with most base bitumens

Opportunities with highly modified asphalt (HiMA)

1. Base/binder course layer thickness reduction
   - Life cycle impact reduction
   - Up front Cost Savings and eco impact

2. Perpetual pavement at standard thickness
   - High modulus, fatigue resistant, full depth asphalt pavements

3. Reinforced binder/wearing course for pavement rehabilitation
   - Better performance without making pavement thicker

Kraton™ Polymers’ new SBS grade D0243 enables high SBS content with current equipment

National Center for Asphalt Technology (NCAT)

Objective

Evaluate in situ structural characteristics of highly modified asphalt pavement relative to reference section

Two sections
1. Full depth highly modified asphalt (NT)
   - 7.5% SBS in all layers
   - 20% reduced pavement thickness
2. Highly modified overlay (NB)
   - 14.5 cm inlay over cracked pavement

3 year cycle of construction and testing

Unique opportunity to evaluate structural responses against wide range of materials and pavement structures
Rutting:

- S9 (control) = 5.9 mm
- N7 (HiMA) = 1.3 mm

No cracking in either section

Previous experience with thin sections led to fatigue failure within one year

Test Track Soil

Mr = 200 Mpa  
\( \mu = 0.45 \)

Dense Graded Crushed Aggregate Base

Mr = 85 MPa  
\( \mu = 0.40 \)

150mm  
76mm (PG 67-22; 19mm NMAS; 80 Gyrations)

70mm (PG 76-22; 19mm NMAS; 80 Gyrations)

32mm (PG 76-22; 9.5mm NMAS; 80 Gyrations)

Control (178mm HMA)

57mm (7.5% polymer; 19mm NMAS; 80 Gyrations)

57mm (7.5% polymer; 19mm NMAS; 80 Gyrations)

32mm (7.5% polymer; 9.5 mm NMAS)

Experimental (145mm HMA)

Asphalt Pavement Analyzer (APA) – AASHTO TP63-09

Test temperature 64°C  
8000 cycles

Asphalt Mixture Performance Tester (AMPT)

Test temperature 59.5°C  
Flow number as rutting indicator (no. of cycles at 10% axial strain)

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Average Rut Depth, mm</th>
<th>StDev, mm</th>
<th>Rate of Secondary Rutting, mm/1000 cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control – Surface</td>
<td>3.07</td>
<td>0.58</td>
<td>0.140</td>
</tr>
<tr>
<td>Control – Base</td>
<td>4.15</td>
<td>1.33</td>
<td>0.116</td>
</tr>
<tr>
<td>HiMA – Surface</td>
<td>0.62</td>
<td>0.32</td>
<td>0.0267</td>
</tr>
<tr>
<td>HiMA – Base</td>
<td>0.86</td>
<td>0.20</td>
<td>0.0280</td>
</tr>
</tbody>
</table>

Relative rutting in actual NCAT sections very similar to rutting in modelled pavements at TU Delft

4.5 - 5x less rutting in high SBS pavements

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Conventional design indicates highly modified pavements have more rutting due to reduced stiffness……….test results show the opposite

Design calculations

- Shell Pavement Design Manual
- Melbourne climate
- 10 million ESALs

Standard asphalt mix:

Stiffness at 20°C – 9 hr: 950 MPa

Fatigue equation:

\( N = 6.10^{11} x^{0.3} \)

Polymer modified mix:

Stiffness at 20°C – 9 hr: 8100 MPa

Fatigue equation:

\( N = 9.10^{11} x^{0.17} \)

What difference does fatigue make for the design?
The importance of taking into account fatigue

Fatigue line HMA included; HMA asphalt allows 29% thickness reduction despite slightly lower stiffness.

Fatigue line unmodified asphalt applied for both mixes; HMA pavement would be thicker due to lower stiffness.

Rehabilitation of failed pavement with high SBS mix

2006 Perpetual design study Oklahoma DoT at NCAT
Soft subgrade with stiff top 8 inches (lime stabilization)

Original

2006 Construction severely distressed after 10 million ESALs

Renovation

2009 Pavement originally

2010 Rehabilitation

High SBS modified mill & inlay after 4.2 million ESALs

10" pavement paved summer 2006
5" rehabilitation paved August 2009
5 ½" HiMA rehab paved August 2010
10 months old

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Concluding remarks

- Full depth high SBS modified section N7 at NCAT shows continued good rutting results
- Asphalt Pavement Analyzer and Asphalt Mixture Performance Tester predict same relative rutting differences between reference and high SBS mixes
- Actual rutting data matches predicted rutting performance based on Finite Element Modelling from TU Delft
- Excellent rutting performance could not be predicted with traditional pavement design models
- Need for better models!
- High SBS modified mill and inlay shows no damage after 4.2 million ESALs whilst previous rehab failed

Concluding remarks

- NCAT section N7 has no cracking until date despite 20% thickness reduction
- Lab testing confirms superior performance of high SBS mixes to prevent rutting and cracking
- Thinner, more cost effective asphalt pavements are possible now without jeopardizing performance
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