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

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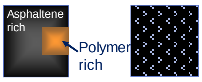
Introduction

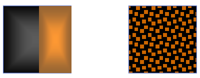
- Concept of highly modified asphalt
- Two high SBS sections in monitored field trials at NCAT, USA
- Rutting data comparison section N7
  - APA and AMPT data
  - Finite Element Modelling and actual rut depths at NCAT
- Successful rehabilitation of failed pavement on weak subgrade
- Summary / conclusions

Concept of Highly Modified Asphalt (HiMA)

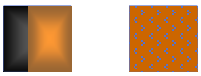
Before mixing **After mixing**



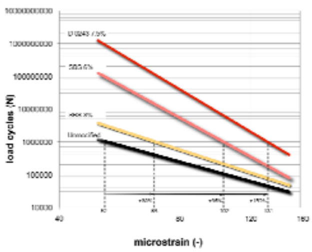
2.5% SBS - Continuous asphaltene rich phase



5 % SBS - Co-continuous asphaltene and polymer rich phases



7.5% SBS – Continuous polymer rich phase



TU Delft, standard base course mix with 4.6% binder. Full sine loading in 4 point bending (20° C, 8 Hz)

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)

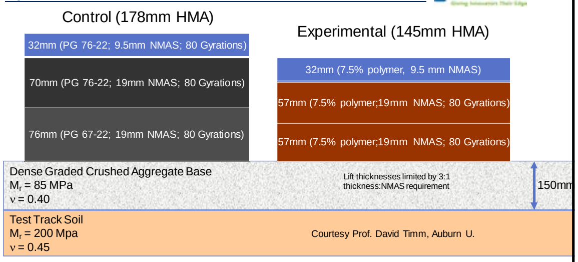
Objective
Evaluate in situ structural characteristics of highly modified asphalt pavement relative to reference section

Two sections
1. Full depth highly modified asphalt (N7)
   - 7.5% SBS in all layers
   - 20% reduced pavement thickness
2. Highly modified overlay (N8)
   - 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

Update section N7



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

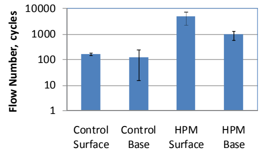
Rutting comparison mixtures section N7

- Asphalt Pavement Analyzer (APA) – AASHTO TP63-09
  - Test temperature 64° C
  - 8000 cycles

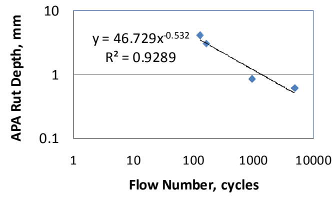
Mixture	Average Rut Depth, mm	StDev, mm	Rate of Secondary Rutting, mm/1000 cycles
Control – Surface	3.07	0.58	0.140
Control – Base	4.15	1.33	0.116
HiMA – Surface	0.62	0.32	0.0267
HiMA – Base	0.86	0.20	0.0280

- Asphalt Mixture Performance Tester (AMPT)
  - Test temperature 59.5° C
  - Flow number as rutting indicator

(no. of cycles at 10% axial strain)

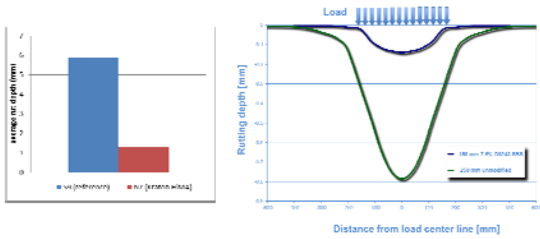


Rutting comparison mixtures section N7

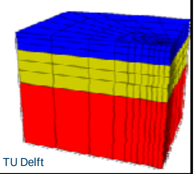


- Rutting predictions with APA and AMPT provide same relative result
- HiMA mixes provide significant improvement in rutting resistance

Measured rut depths versus Finite Element Model

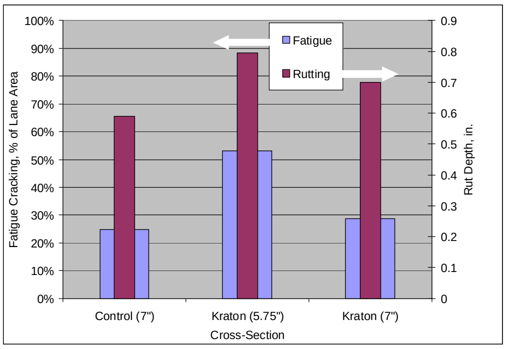


- Relative rutting in actual NCAT sections very similar to rutting in modelled pavements at TU Delft
- 4.5 - 5x less rutting in high SBS pavements



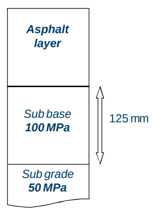
TU Delft

Conventional design for N7 using stiffness data



Conventional modelling 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 – 8 Hz: **8900 MPa**
Fatigue equation:

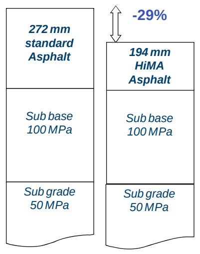
$$N = 6.10^{11}x^{-3.36}$$

Polymer modified mix:
Stiffness at 20° C – 8 Hz: **8100 MPa**
Fatigue equation:

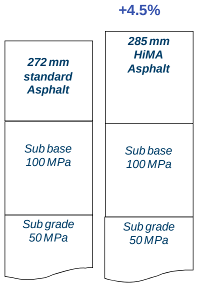
$$N = 9.10^{18}x^{-6.17}$$

What difference does fatigue make for the design?

The importance of taking into account fatigue



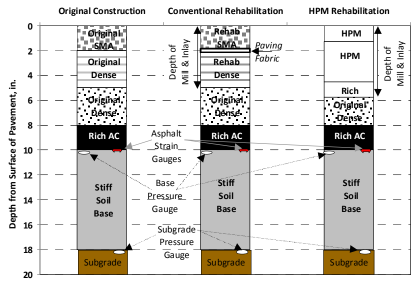
Fatigue line HiMA included;
HiMA asphalt allows 29% thickness reduction despite slightly lower stiffness



Fatigue line unmodified asphalt applied for both mixes:
HiMA 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)



2006 2009 2010

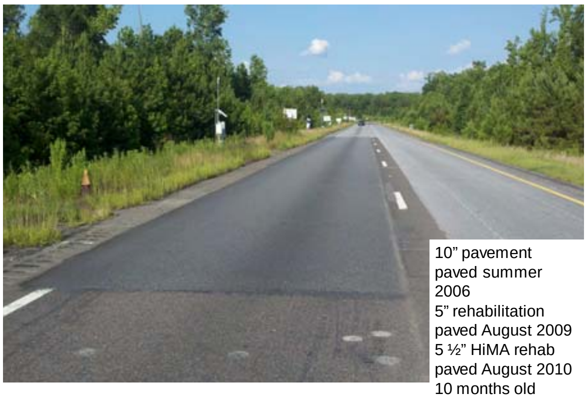
Original construction severely distressed after 10 million ESALs

Rehab with paving fabric failed after 4.0 million ESALs

Rehab with paving fabric after 4.0 million ESALs

10" pavement paved summer 2006
5" rehabilitation paved August 2009
10 months old

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

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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