HIMA
HIGHLY MODIFIED ASPHALT FOR THINNER AND LONGER LASTING PAVEMENT

Willem Vonk

Kraton
Giving Innovators Their Edge

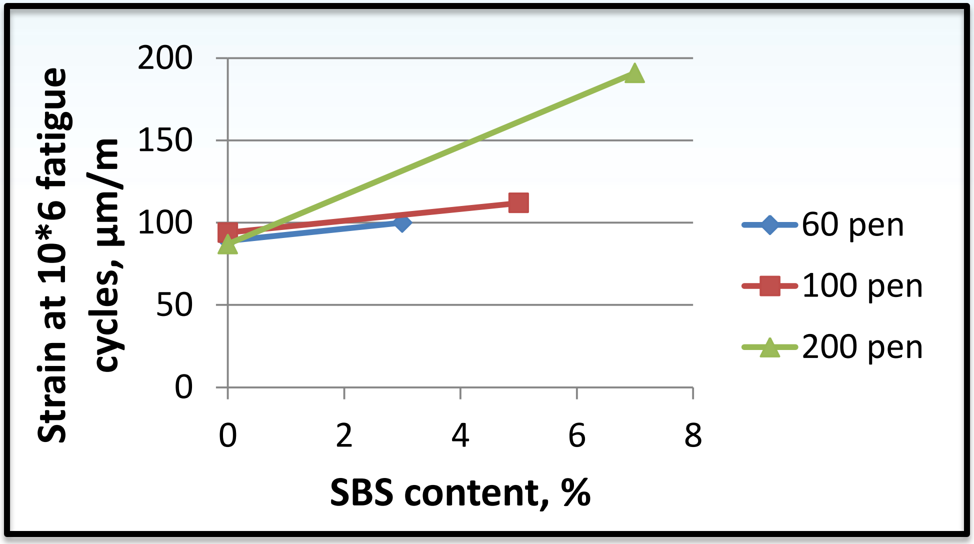
Outline

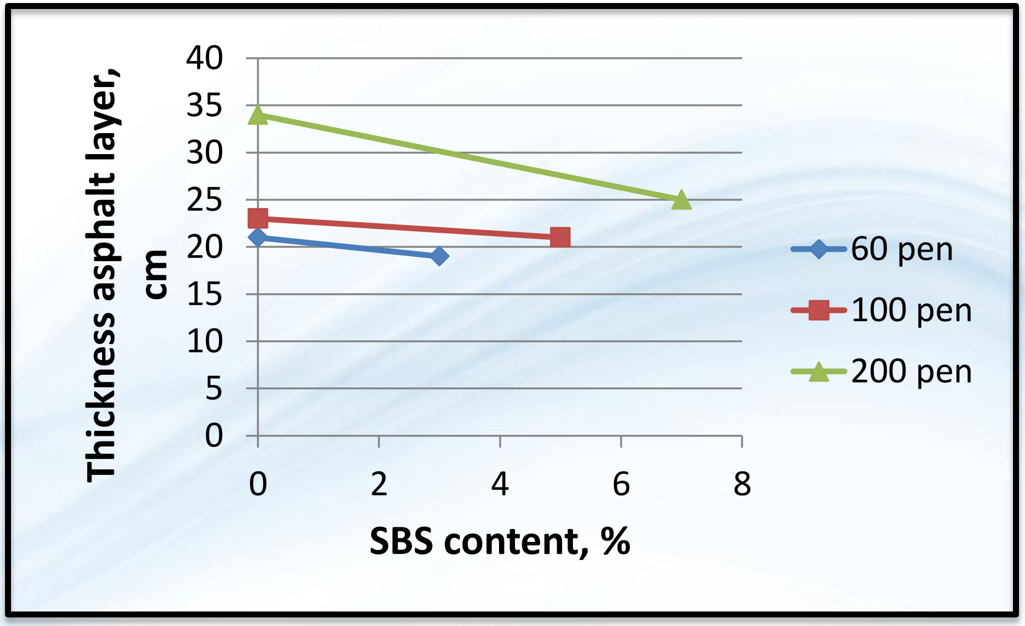
- Key elements of the superior modified asphalt mixes concept
- Demonstrating the concept
  - Polymer design
  - Comparing structures using Finite Element Modeling
  - Asphalt mix fatigue
  - Full scale trial at NCAT
- Design examples
- Trials and commercial applications
- Concluding remarks

Pavement design principles

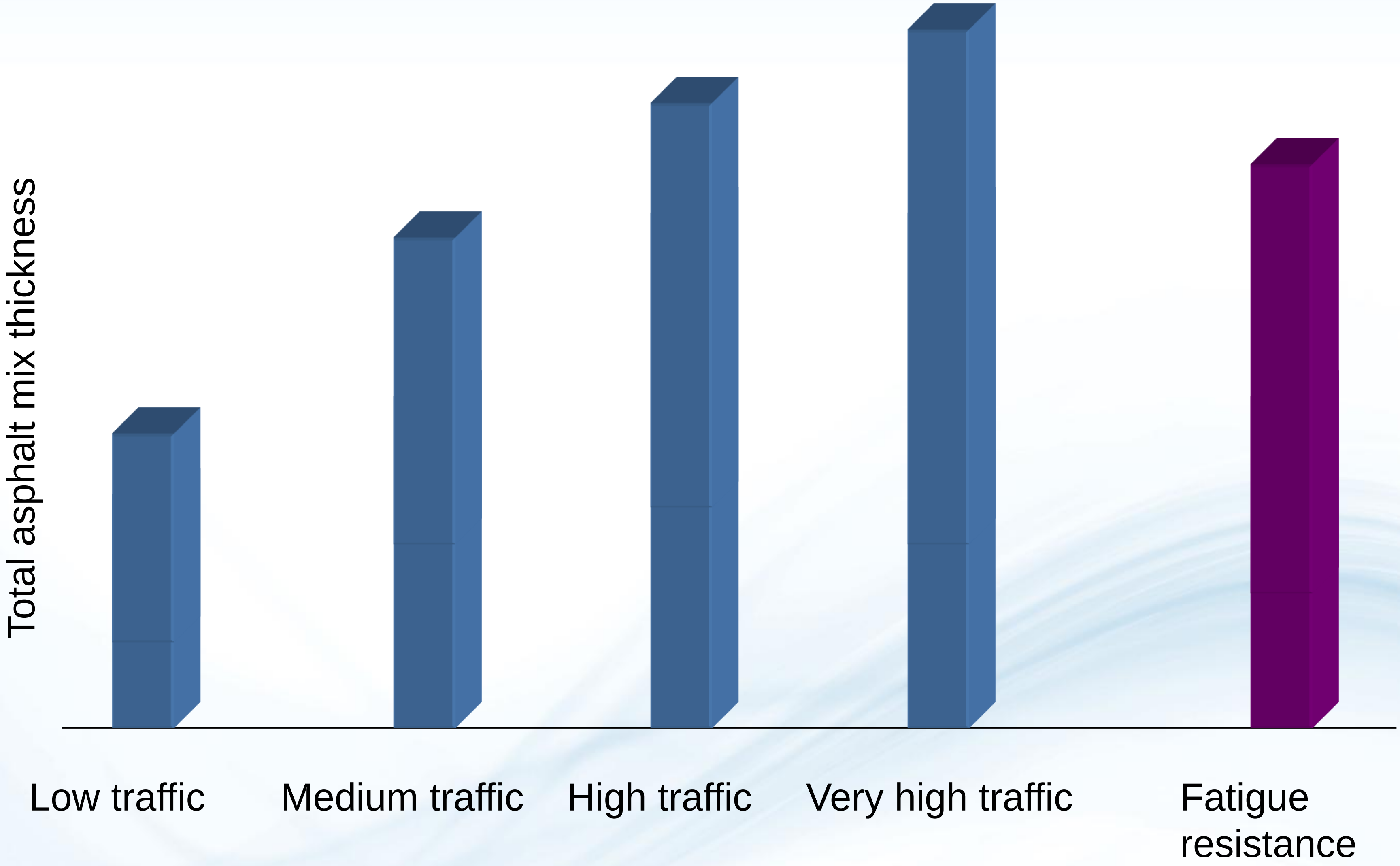
- In M-E pavement design approach, the pavement is idealized as a layered structure (generally assumed as elastic for simplicity in analysis) consisting of three to four horizontal layers made up of bituminous surfacing, base, sub-base and the subgrade. Each layer is characterized by its elastic modulus, Poisson's ratio and the thickness.
- How to deal with asphalt mixes that have superior fatigue performance as a result of improved binder properties?
- Kielce 1998: Jan Lijzenga of Shell: Pavement design with modified binders by means of the Shell Pavement Design computer program for Windows.
- Model calculations can be made once the fatigue equation has been established (fatigue test method is of utmost importance!!).

Calculations from the Shell Kielce Reference



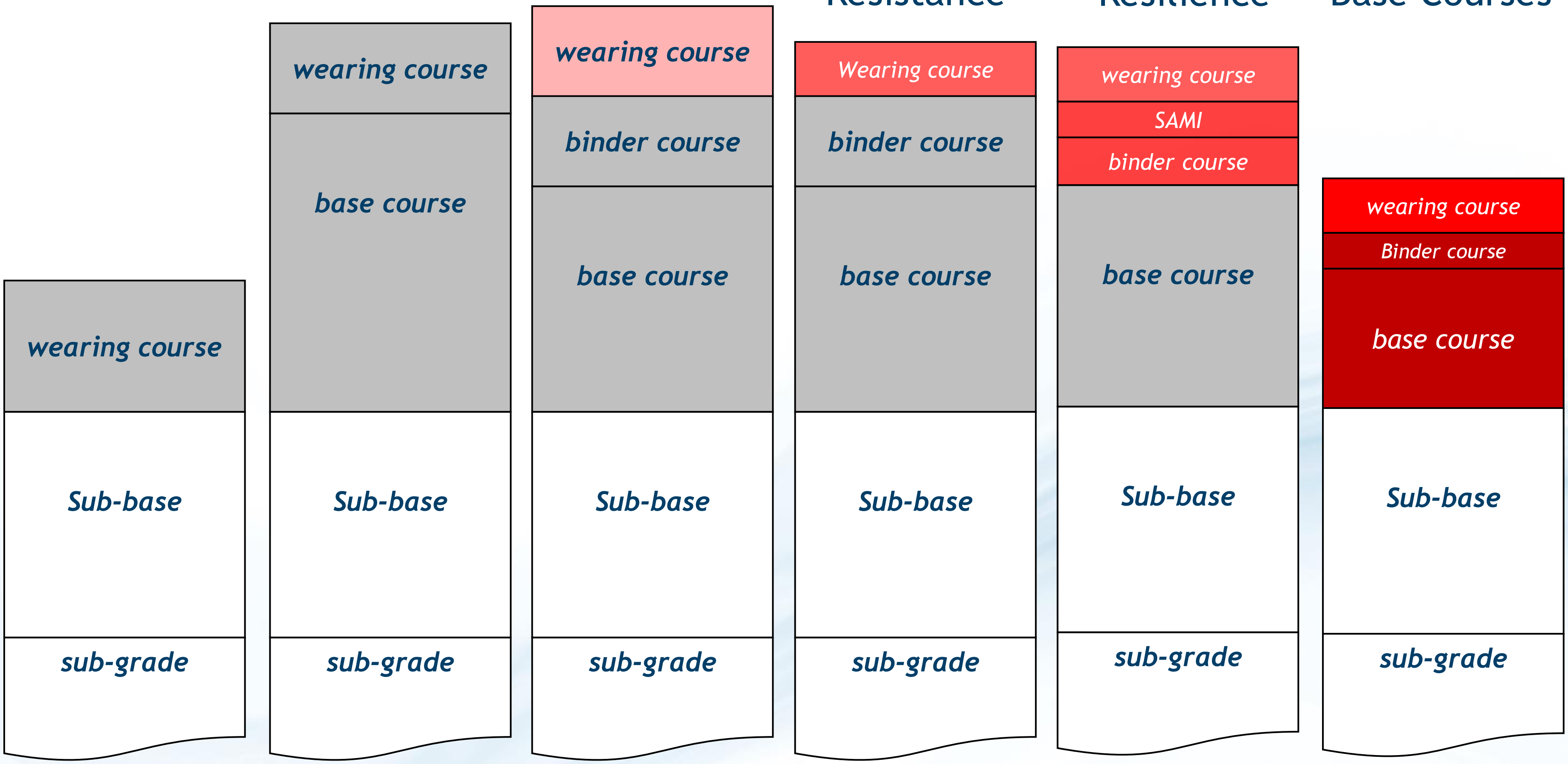


The importance of fatigue resistance



Thinner Base Layers

1900's	1950's	1970's	1980's	2000	2010
		3% SBS	5% SBS	6% SBS	7.5% SBS
				Soft Bitumen	Hard Bitumen
Original macadam	Increased Loading	Rut Resistance	Thin overlays Crack Resistance	Reflective Crack Resilience	Thinner Tougher Base Courses

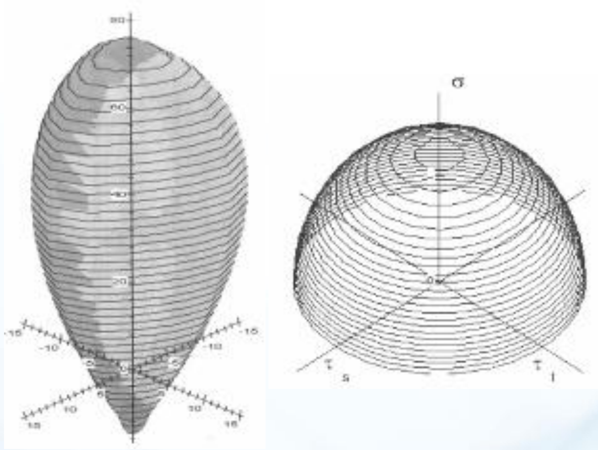


Testing & Modelling

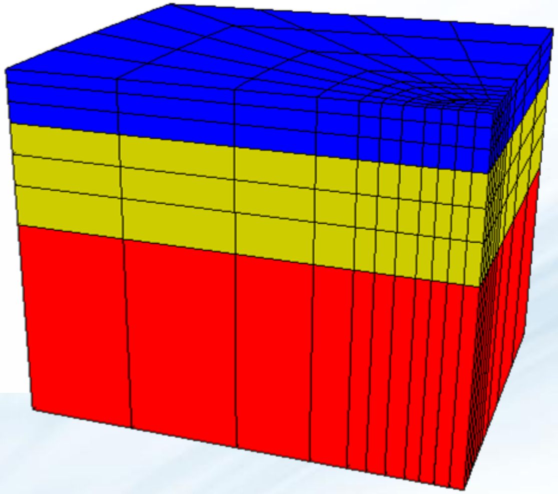
Polymer development needed

Asphalt fatigue tests

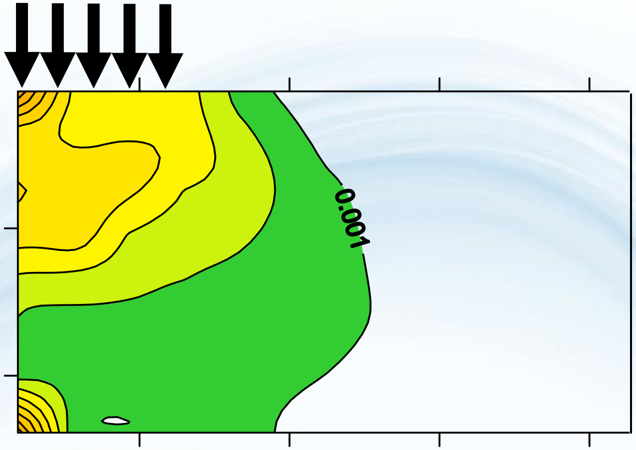
Fundamental asphalt tests



Modelling asphalt for 1 element



Modelling elements into a structure



Calculate ‘damage’ from repeated load

Making it possible with current equipment

Challenges:

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

⇒ Issues solved by adapting design of the polymer

Kraton™ D0243

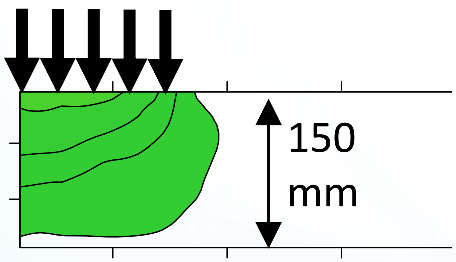
- Provides a low viscosity, even in hard bitumen at elevated SBS content
- Provides compatibility
- Provides storage stable PMBs with most base bitumen

Modelling: comparing options

1

7.5% D0243
150mm

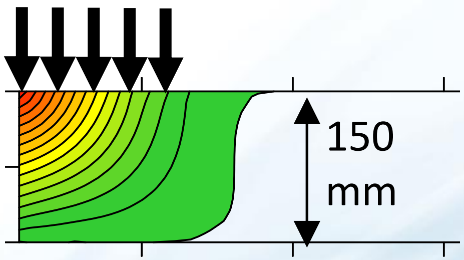
Limited damage



2

6% standard SBS
150mm

More damage
6% not enough
Better than 250mm unmodified

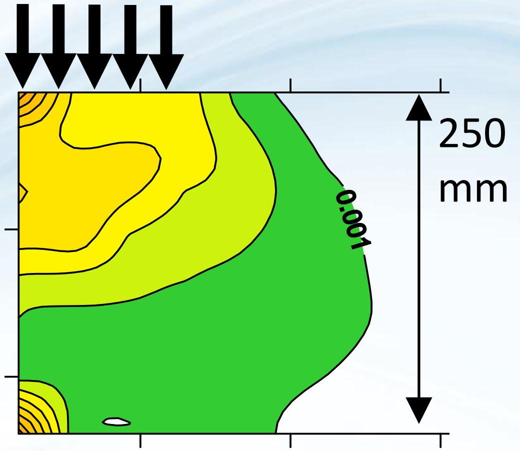


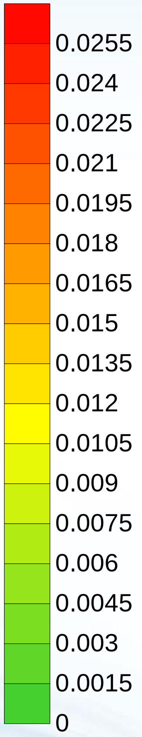
3

Unmodified
250mm

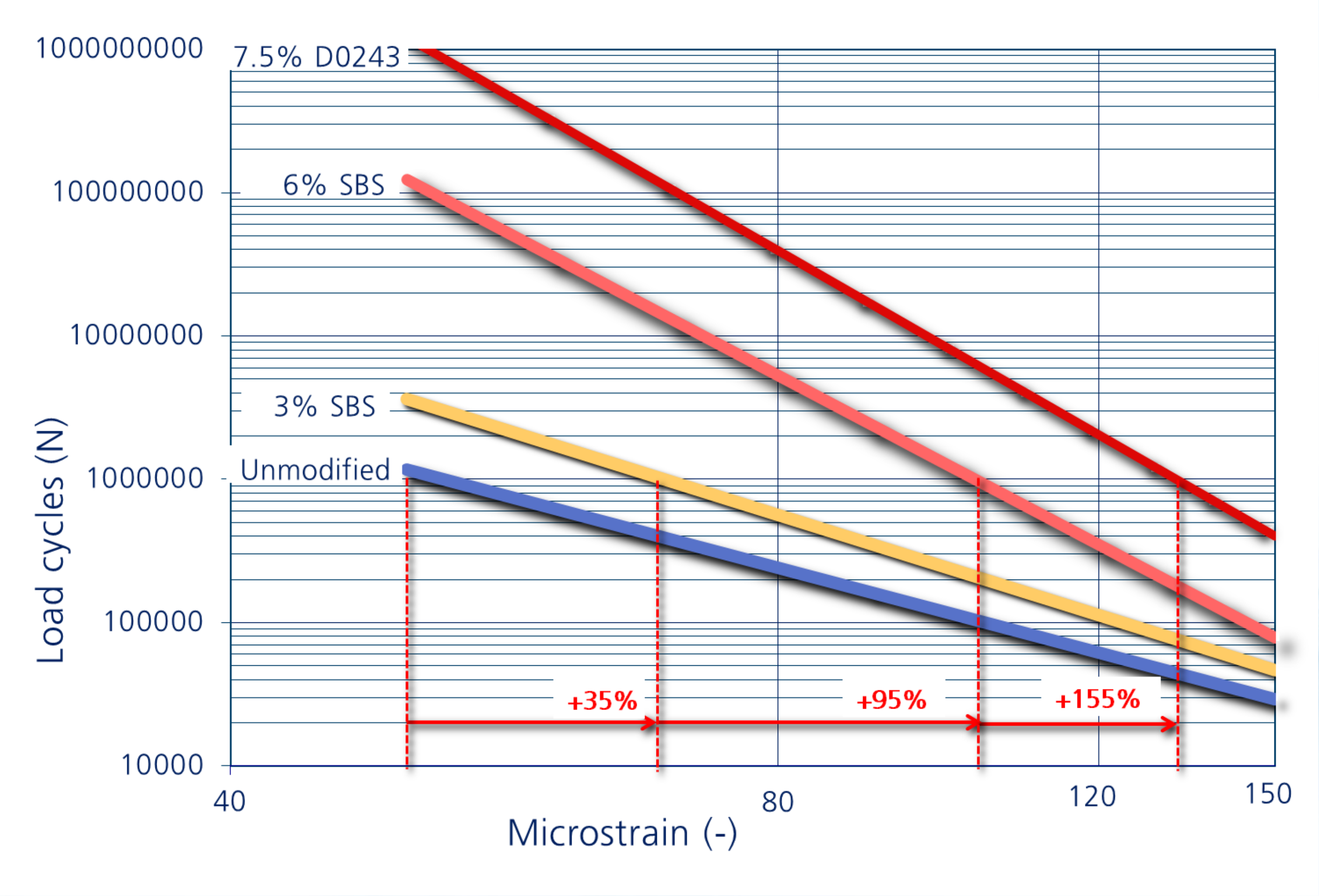
Lots more damage
Despite 66% thicker

Equivalent to 5x higher rutting depth than (1)





Fatigue lines

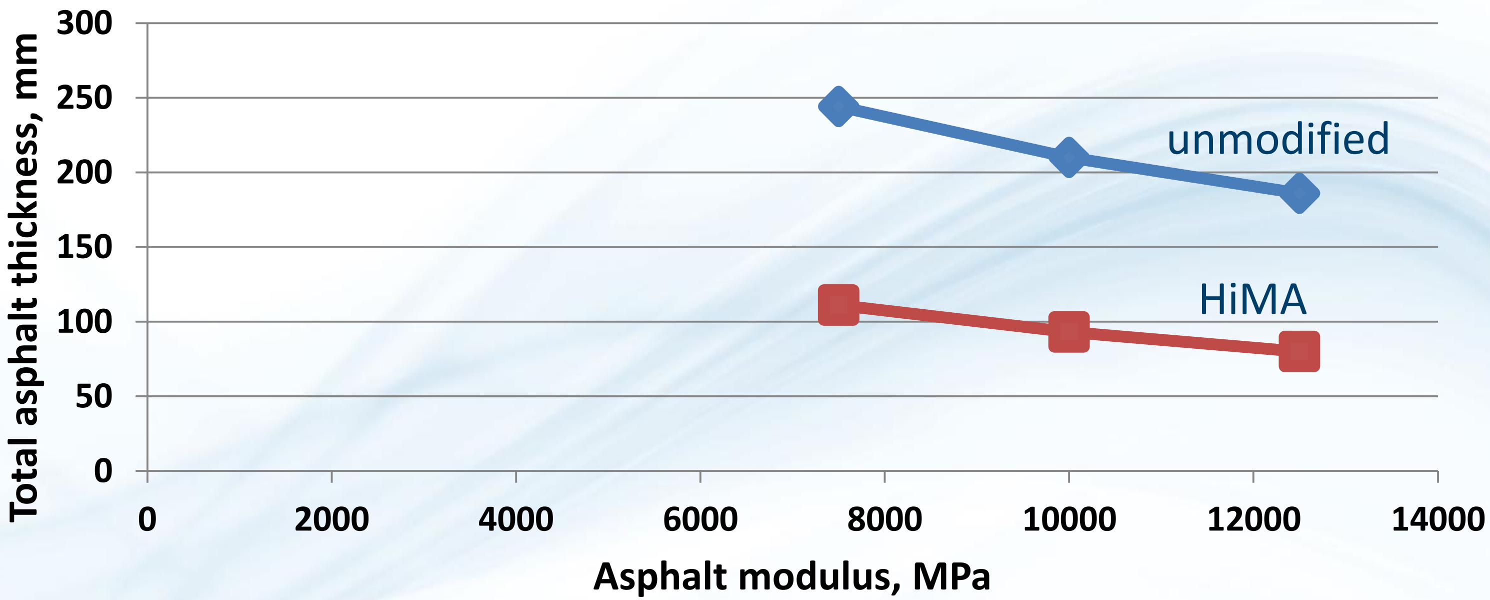


Measured with full sine loading in 4 point bending (20°C, 8 Hz)

Basis for model calculations

- Climate: Amsterdam
- Traffic: 10 million ESALs (1555 ESALs per lane per day, 15 year design period)
- Structure: Sub-base 400 mm; E = 300 MPa
- Subgrade infinite; E = 100 MPa

- Asphalt mix: continuous graded base course type mix (10.6% vol. bitumen; 5% voids)



NCAT Trial

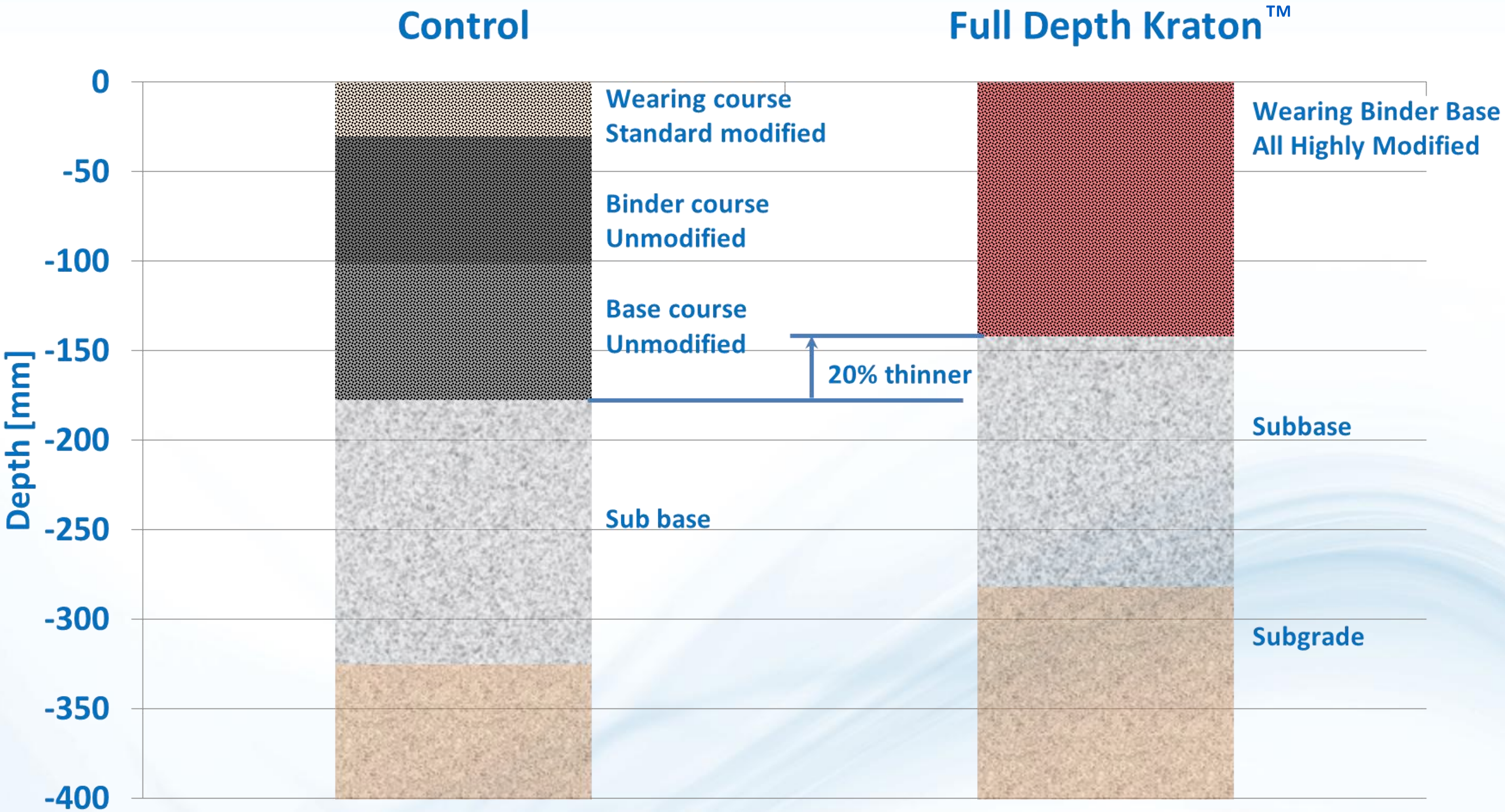
National Center for Asphalt Technology, Auburn, Alabama

- Test track with dedicated trucks
  10 year heavy traffic simulated in 2 years
- Began June 2009

Kraton™ Polymers sponsors:

- Reduced base course thickness test section
- Using Kraton HiMA base course binder
- Comparison to be made with standard thickness, unmodified base course section

NCAT pavement thickness reduction with Full Depth HiMA



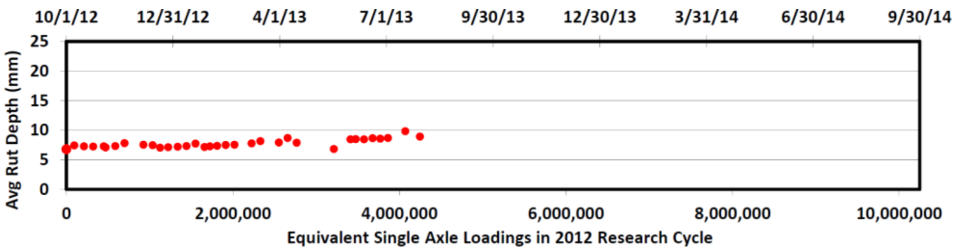
Please note that cost break-even is at approximately 25% reduction

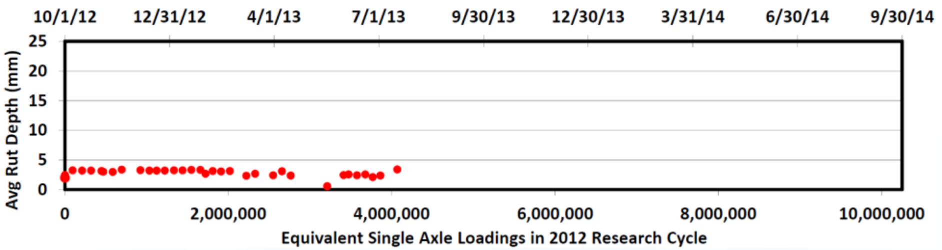
Results to date NCAT
Second cycle – add 10 million cycles to horizontal axis

Reference 7 inches asphalt

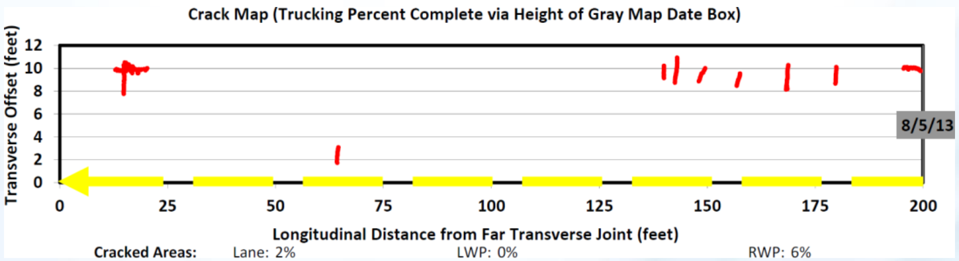
HiMA section 5.75 inches asphalt

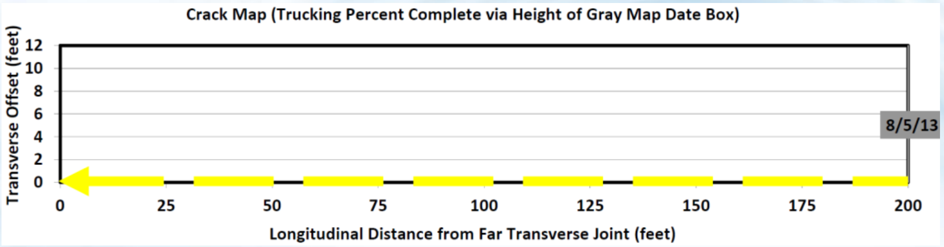
Rutting:





Cracking:





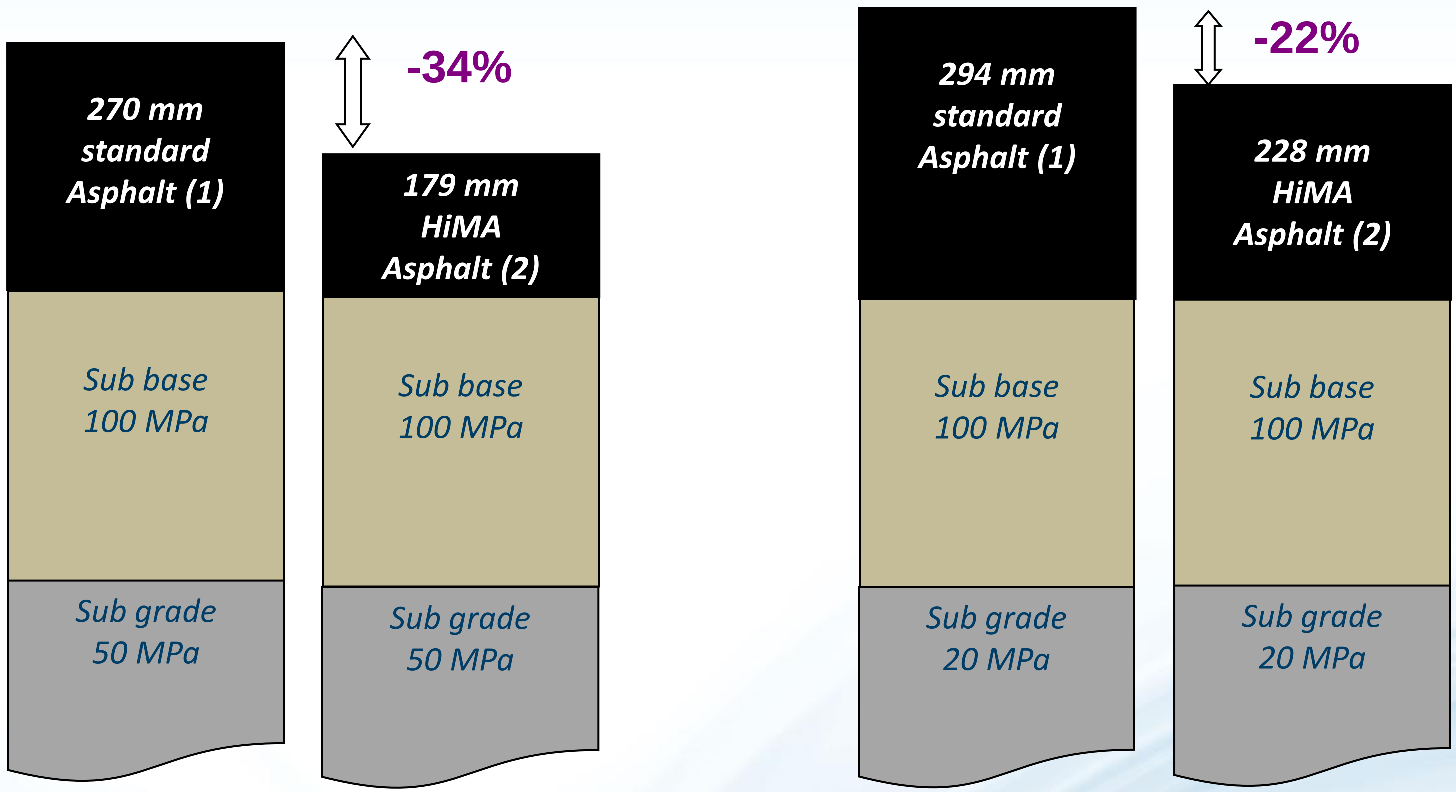
NCAT Section N8 : HiMA Rehabilitation

Standard rehab:
3.5MM ESALs

Failed

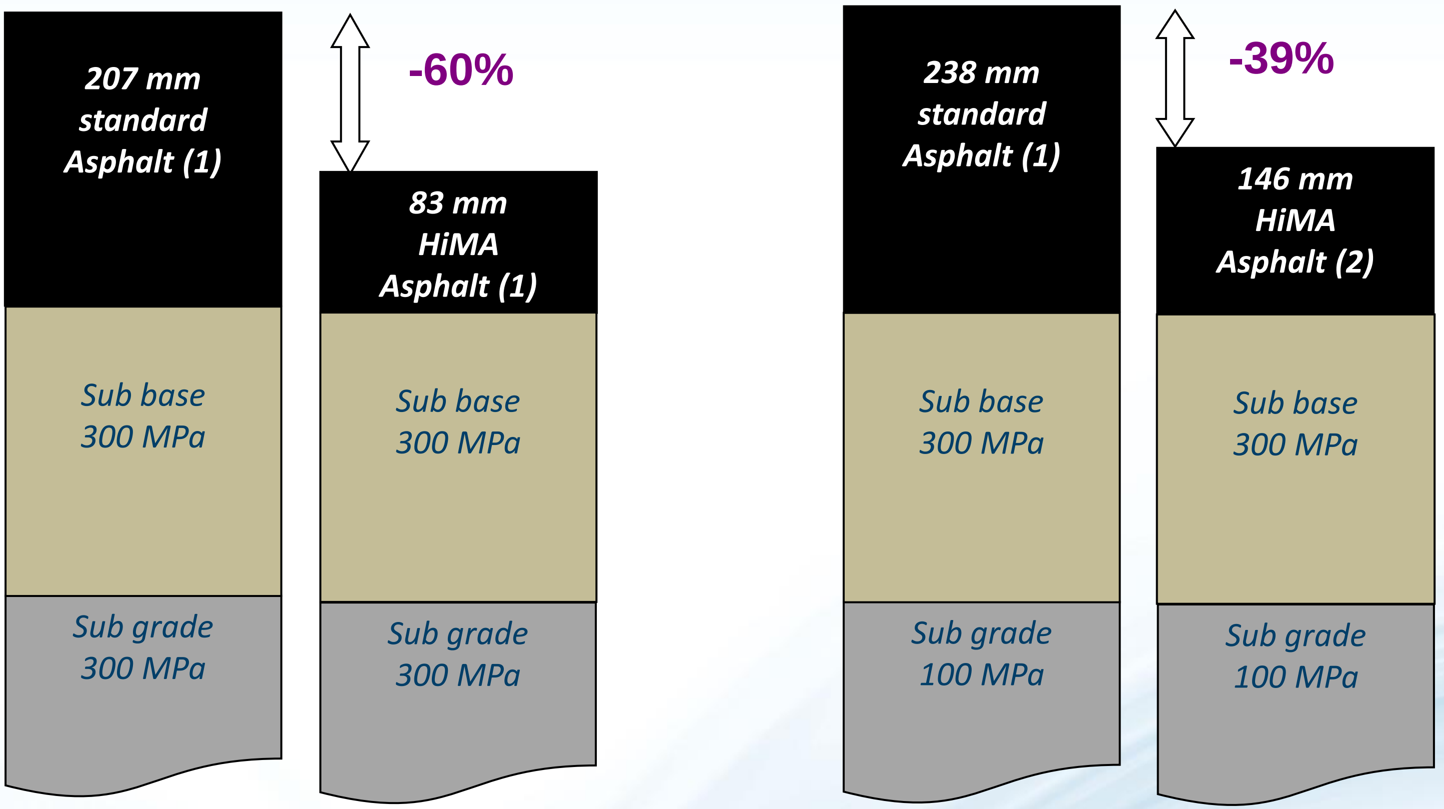
HiMA rehab
5.3MM ESALs

Thickness reduction capability with weak sub grades



(1) Thickness determined by asphalt strain criterion
(2) Thickness determined by sub grade strain criterion
HiMA = Highly Modified Asphalt

Thickness reduction capability with good quality sub base



(1) Thickness determined by asphalt strain criterion
(2) Thickness determined by sub grade strain criterion
HiMA = Highly Modified Asphalt

Applications

Enabling…

Longer pavement life for heavily trafficked roads (cities, road trains)

20-35% reduced asphalt thickness on poor sub grades

Up to 60% reduced asphalt thickness on stabilized base layers

Eco-friendly paving by less material use

Stronger pavements where height/depth constraints apply

Trials and commercial applications (not by number, but type of application)

- Container port pavement (New Zealand)
- Overlay on cement stabilized base (Brazil)
- Overlays on old cracked pavement (Brazil and US)
- Overlay over SAMI and cracked surface (Brazil)
- Full depth constructions (US, Australia, Turkey)
- Bridge decks (US)
- Hot sprayed chip seals (Brazil)
- Micro-surfacing (US)

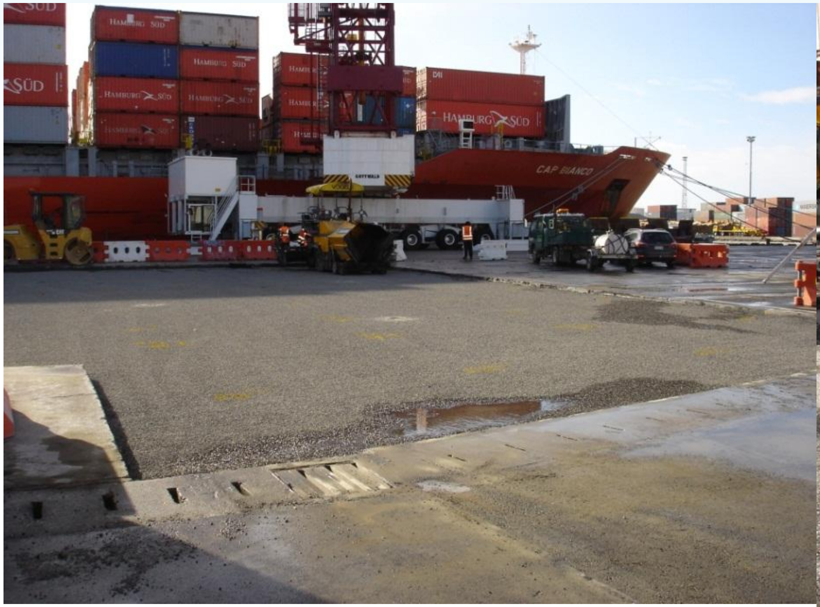
- None of these shows any sign of failure and all live up to the expectations. In most cases significant cost savings achieved, in some aiming for performance improvement

New Zealand: Port of Napier 150mm rehab - Sept 2010

Higgins:

- >100 tonne axle loads
- 100mm base course using 28 mm mix with 4.6% binder, 5% voids binder using 40/50 bitumen modified with 7.5% D0243 and no oil
- 50mm wearing course of 14mm mix in 5% SBS modified 80/100 bitumen

100mm one pass - paving at 8˚C, great workability



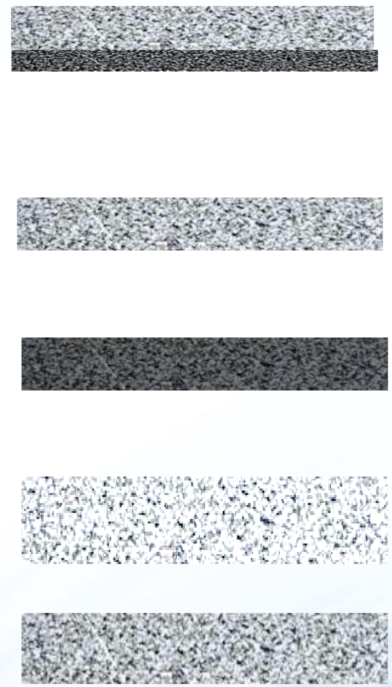
Still going strong after 2 years

Distressed pavement repair options using Kraton™ D0243

Brazil – OHL trial March 2012 – BR116 south of Sao Paulo

32% thickness reduction

Four designs using SBS



1. 3% SBS in pen 65/80
   Wearing 50mm
   7% D0243 in pen 50/70
   SAMI 25mm
2. 3% SBS in pen 65/80
   Wearing 75mm
3. 7% D0243 in pen 50/70
   Wearing 75mm
4. 3% SBS in pen 65/80
   Wearing 110mm
5. Unmodified control
   110mm pen 30/50

All asphalt 19mm Superpave mix
SAMI Sieve 200 fines

Brazil - OHL December 2012 - BR116 Régis Bittencourt
Results - 9 months old

LANE 2 – TRUCK LANE: EXTREMELY HEAVY

3% SBS AM 65/80
Wearing course 50mm
+ 7,5% D0243 pen 50/70
SAMI 25mm

0,33% of the area
Is cracked

Control Section
75mm 3-4% SBS
AM 65/80

6,0% of area is
cracked

Control Section
110mm 3-4% SBS
AM 65/80

3,0 % of area is
cracked

LANE 1 – VERY HEAVY TRAFFIC

3% SBS AM 65/80
Wearing course 50mm
+ 7,5% D0243 pen 50/70
SAMI 25mm

No cracks

7,5% D0243 pen 50/70
Wearing Course 75mm

No cracks

Control Section
75mm 3-4% SBS
AM 65/80

No cracks

Control Section
110mm 3-4% SBS
AM 65/80

No cracks

Concluding remarks

Modified asphalt base courses

- Thickness reduction of 20-60% in pavements
  - Reduce eco impact by reduced resource use
  - Up front cost reduction

- Enhance performance for sustainability
  - Perpetual pavements without excessive base courses

- Enabled by Kraton™ polymer innovations
  - Efficient grafting of polymer and bitumen
  - Compatibility and workability

- Next steps
  - Testing of highly modified overlays in many trial sites
  - Applying the concept on the road globally

Kraton, the Kraton logo and design, the Cariflex logo, Cariflex, Nexar and the Giving Innovators Their Edge tagline and in some cases, their expression in other languages are trademarks of Kraton Performance Polymers, Inc. and are registered in many countries throughout the world

Publication Disclaimer

We believe the information set forth above to be true and accurate, but any findings, recommendations or suggestions that may be made in the foregoing text are without any warranty or guarantee whatsoever, and shall establish no legal duty or responsibility on the part of the authors or any Kraton Polymers entity. Furthermore, nothing set forth above shall be construed as a recommendation to use any product in conflict with any existing patent rights. All Kraton Polymers entities expressly disclaim any and all liability for any damages or injuries arising out of any activities relating in any way to this publication or the information set forth herein.