KRATON

Balanced Mix Design & Pavement Design with VDOT PG76E-28

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VPRIS 2019

June 18, 2019

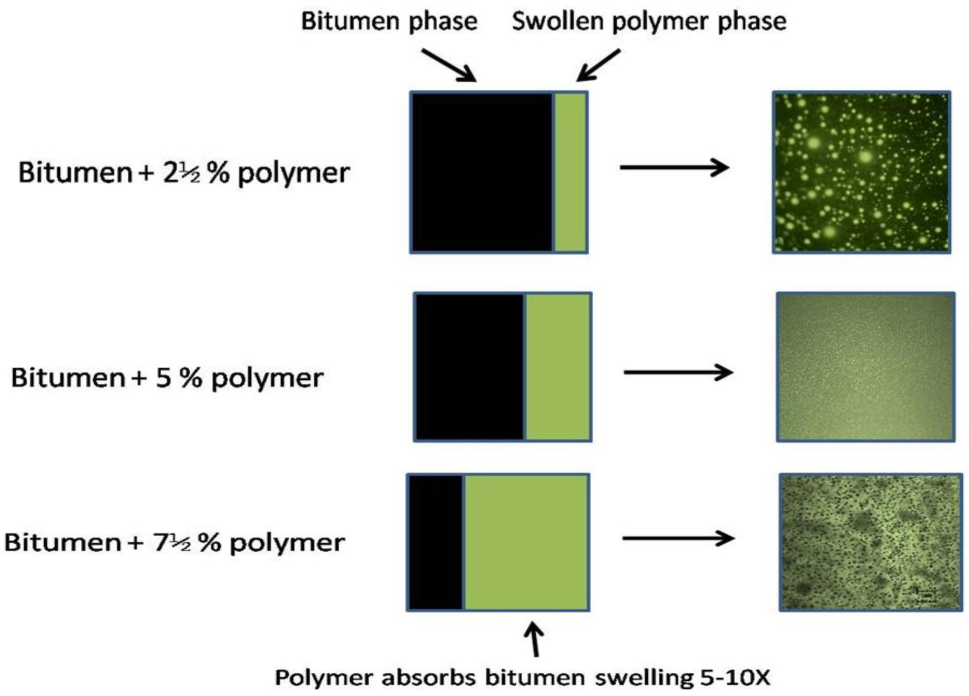
Outline

- What is highly modified asphalt?
  - In Virginia it's PG 76E-28
- NCAT test track section performance
- AASHTOWare^{TM} Pavement ME Design modeling
- FLEXPave^{TM} software modeling
- Mixture Design – Pavement Design
- Conclusions

Acknowledgements

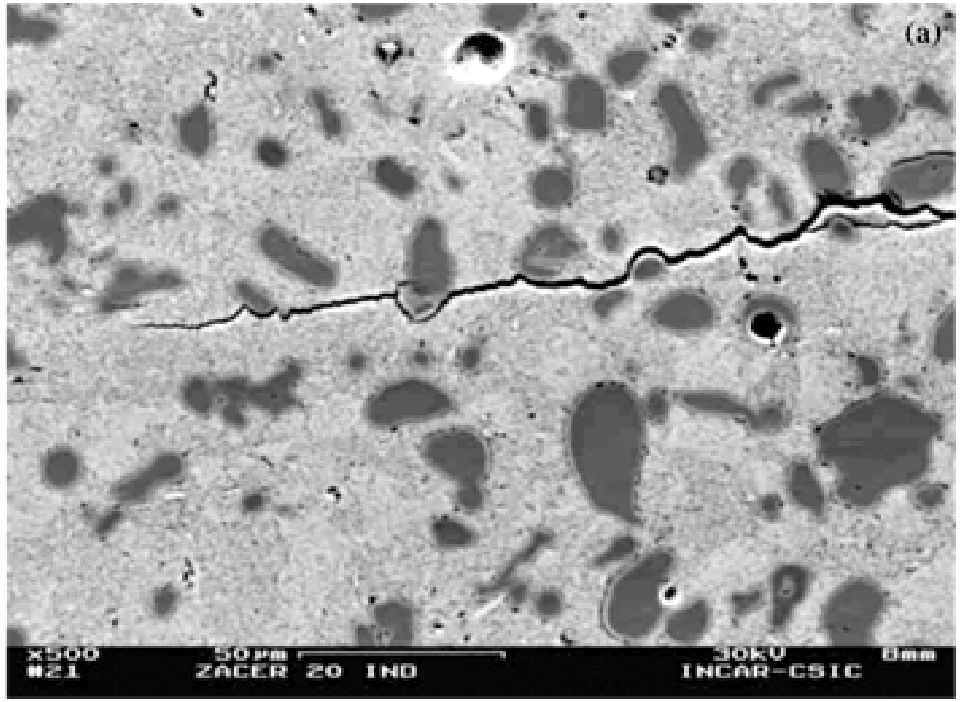
- Raj Dongre – DLSI
- Buzz Powell – NCAT
- David Timm – Auburn U
- Richard Willis – NAPA
- Richard Kim – NCSU
- Mary Robbins – NCAT
- Nam Tran – NCAT
- Adam Taylor - NCAT

What Is Highly Modified Asphalt?



Over 5,000,000 tons in over 70 projects around the world have demonstrated **superior performance** at **reduced thickness**.

- Highly Modified Asphalt is exactly what it says, asphalt with more than double the normal amount of SBS polymer.
- This gives a much denser polymer network with up to 10X rutting **and** fatigue cracking resistance.



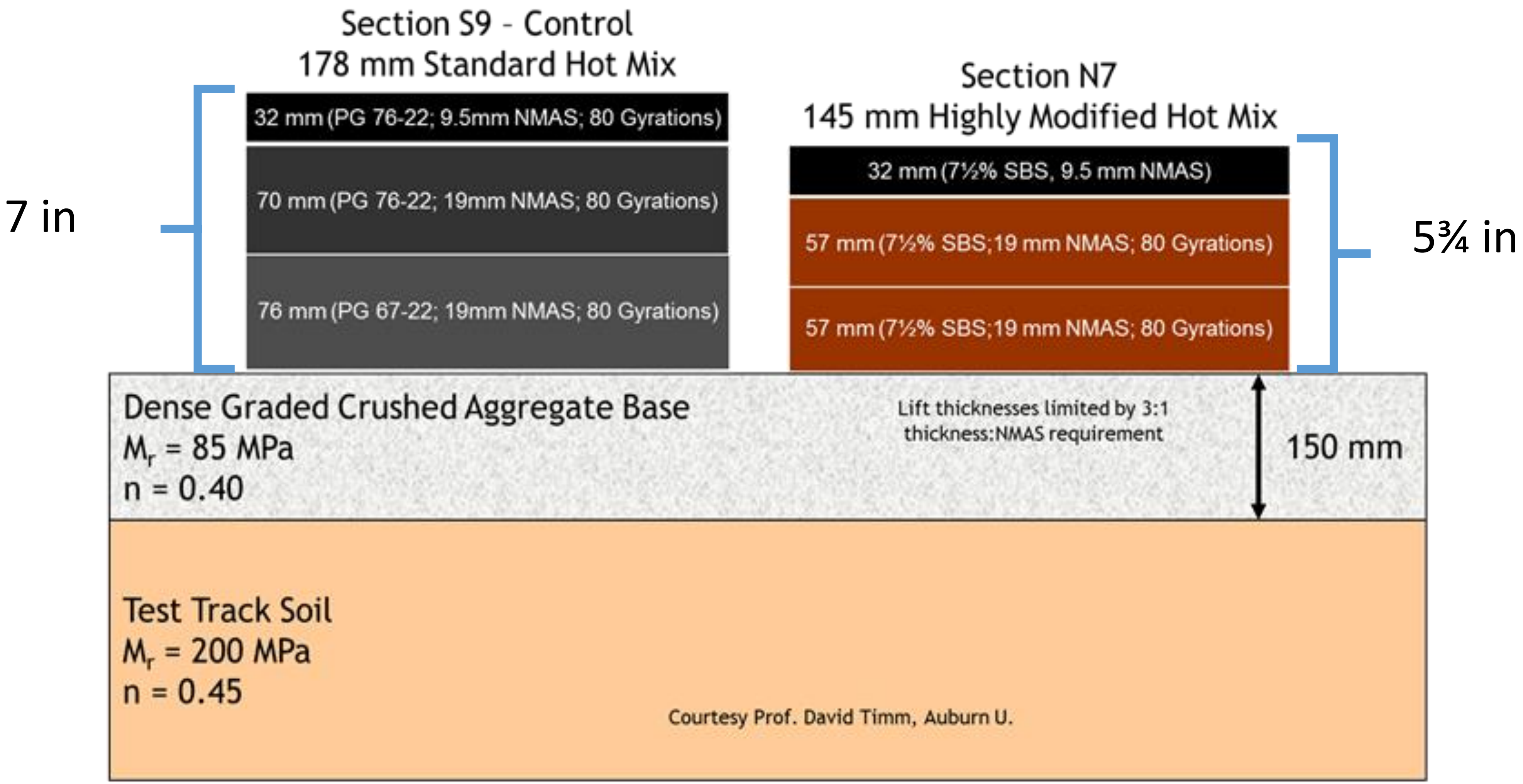
HiMA Specifications North America

Standard	AASHTO M 320	AASHTO T 301	AASHTO M 332	AASHTO T 350
	PG specification	Elastic Recovery	PG specification	MSCR Recovery
Alabama			PG 76E-22	90%
Alaska			PG 64E-40	90%
Florida			PG 76E-22	90%
Georgia			PG 76E-22	90%
Missouri			PG 76E-22	90%
Oklahoma			PG 76E-28	95%
Tennessee			PG 76E-28	90%
Utah			PG 70E-34	90%
Virginia			PG 76E-28	90%
Florida	~~PG 82-22~~	90%		
Iowa	PG 76-34	90%		
Minnesota	PG 76-34	90%		
New Hampshire	PG 76-34	90%		
Ohio	PG 88-22M	90%		
Oregon	PG 76-28	90%		
New York City	PG 76-34	90%		
Utah	PG 76-34	90%		
Vermont	PG 76-34	90%		
Washington	PG 76-34	90%		

National Center for Asphalt Technology Test Track

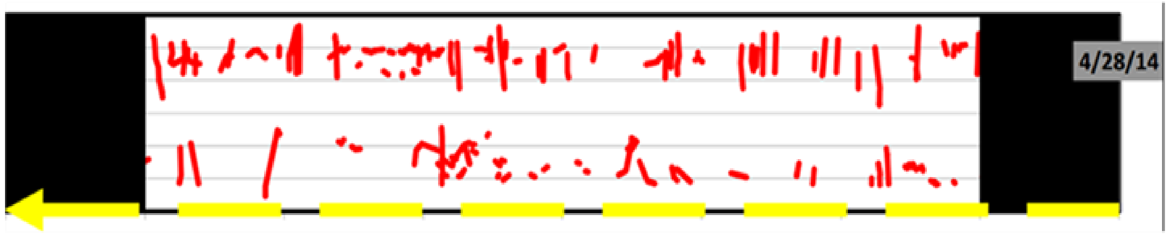
- 5 trucks, 16 h/day, 5 days/week
- Axle load: 18 kip
- Speed: 45 mph

Control (S9) and HiMA (N7) Section Designs



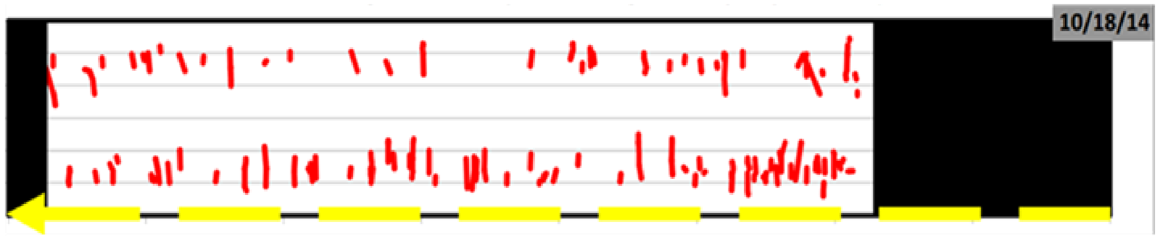
N7 Crack Map at 20 Million ESALs

S9



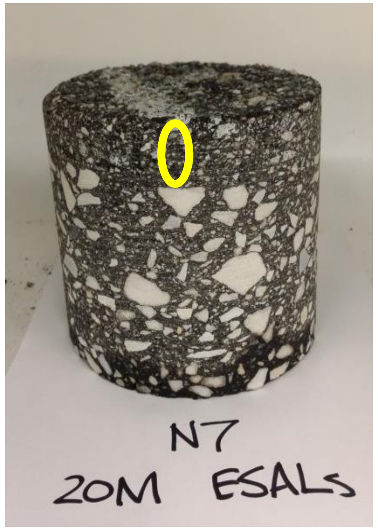
Lane - 10% Left wheel path - 13% Right wheel path - 21%

N7



Lane - 6% Left wheel path - 15% Right wheel path - 8%

S9 resurfaced at 17 million ESALs



N7 cracking is superficial top-down

AASHTOWare™ Pavement ME Design

- Traditional layered elastic model
- Comprehensive input data

- Fatigue cracking model
- $N_{f\text{-}HMA} = k_{f1}(C)(C_H)\beta_{f1}(\varepsilon_t)^{kf2\beta f2}(E_{HMA})^{kf3\beta f3}$ ← from AMPT tensile fatigue or flexural fatigue

- Permanent deformation model
- $D_{p(HMA)} = \varepsilon_{p(HMA)}h_{HMA} = \beta_{r1}k_z\varepsilon_{r(HMA)}10^{kr1}\eta^{kr2\beta r2}T^{kr3\beta r3}$ ← from AMPT Fn or other deformation test

Predicted damage summary

Pavement Distress	S9	N7
Total Permanent Deformation, mm	10.2	8.4
AC Permanent Deformation, mm	6.4	1.5
Bottom-Up Cracking, % Area	18	1.5

Measured damage summary

Pavement Distress	S9	N7
Total Permanent Deformation, mm	6.0	1.6
AC Permanent Deformation, mm	6.0	1.6
Bottom-Up Cracking, % Area	10	0

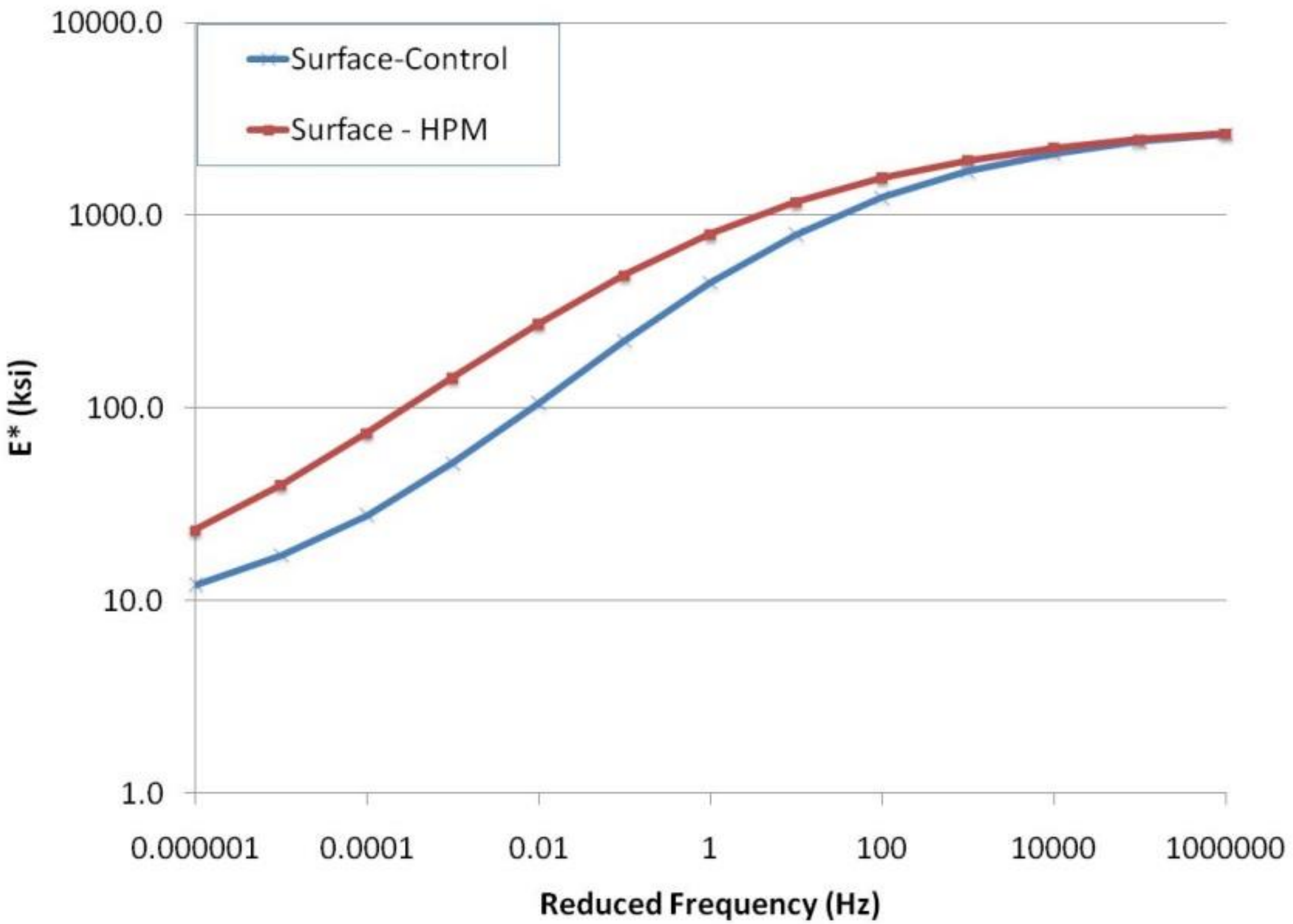
HiMA Market Applications – Where Does it Add Value?

- Structural Applications
  - With a sound base, thinner pavements with lower upfront cost
  - Demonstrated in many field applications & Ohio University APLF
  - With weak base, much longer lifetime can be achieved
- Thin Overlays
  - Superior resistance to reflective cracking BUT requires finer, richer mix.
- Preservation Surfacing such as micro surfacing
- Open Grade Mixes for Reduced Raveling
- SAMI Layers
- High Stress Applications – ramps, intersections
- AASHTOWare® Pavement ME Design works for HiMA designs

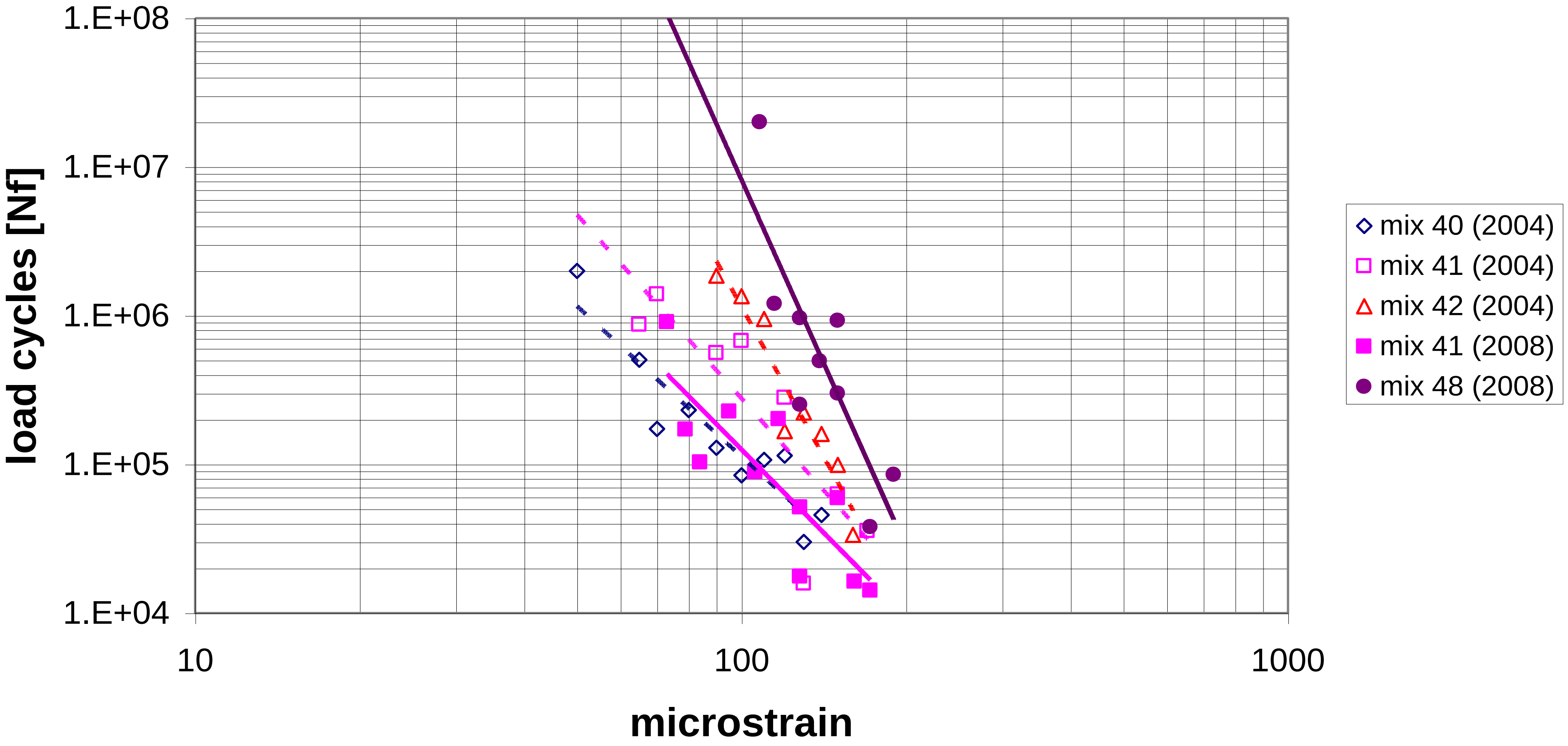
In General Terms, What Does HiMA Do to Mixture and Performance Characteristics?

- Modulus
- Cracking Resistance
- Rutting Resistance
- Cracking Versus Rutting
- Structural Integrity

Dynamic Modulus Testing Results – 9.5 mm NMAS Mixtures

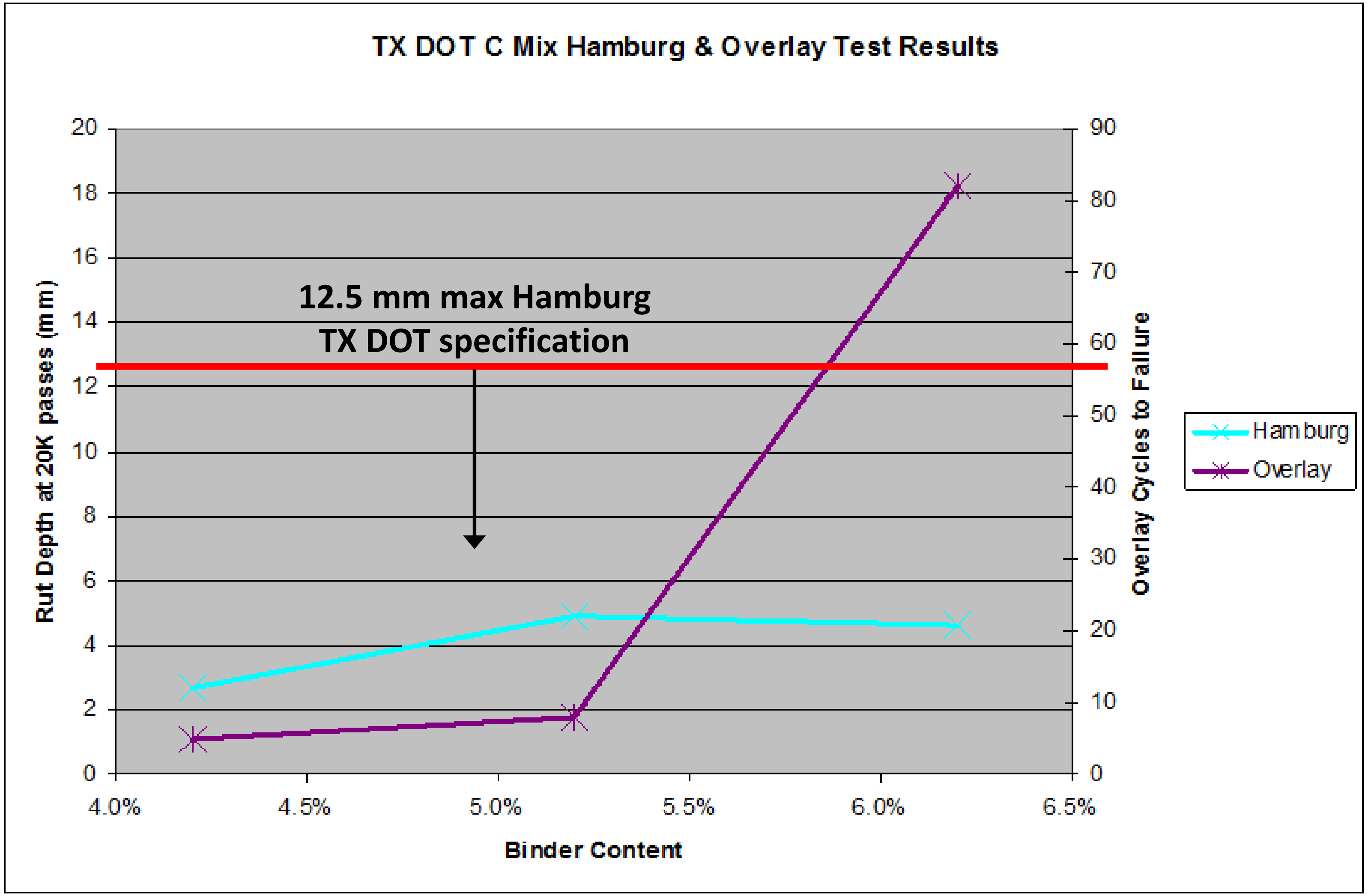


Four Point Bending Beam Fatigue Results

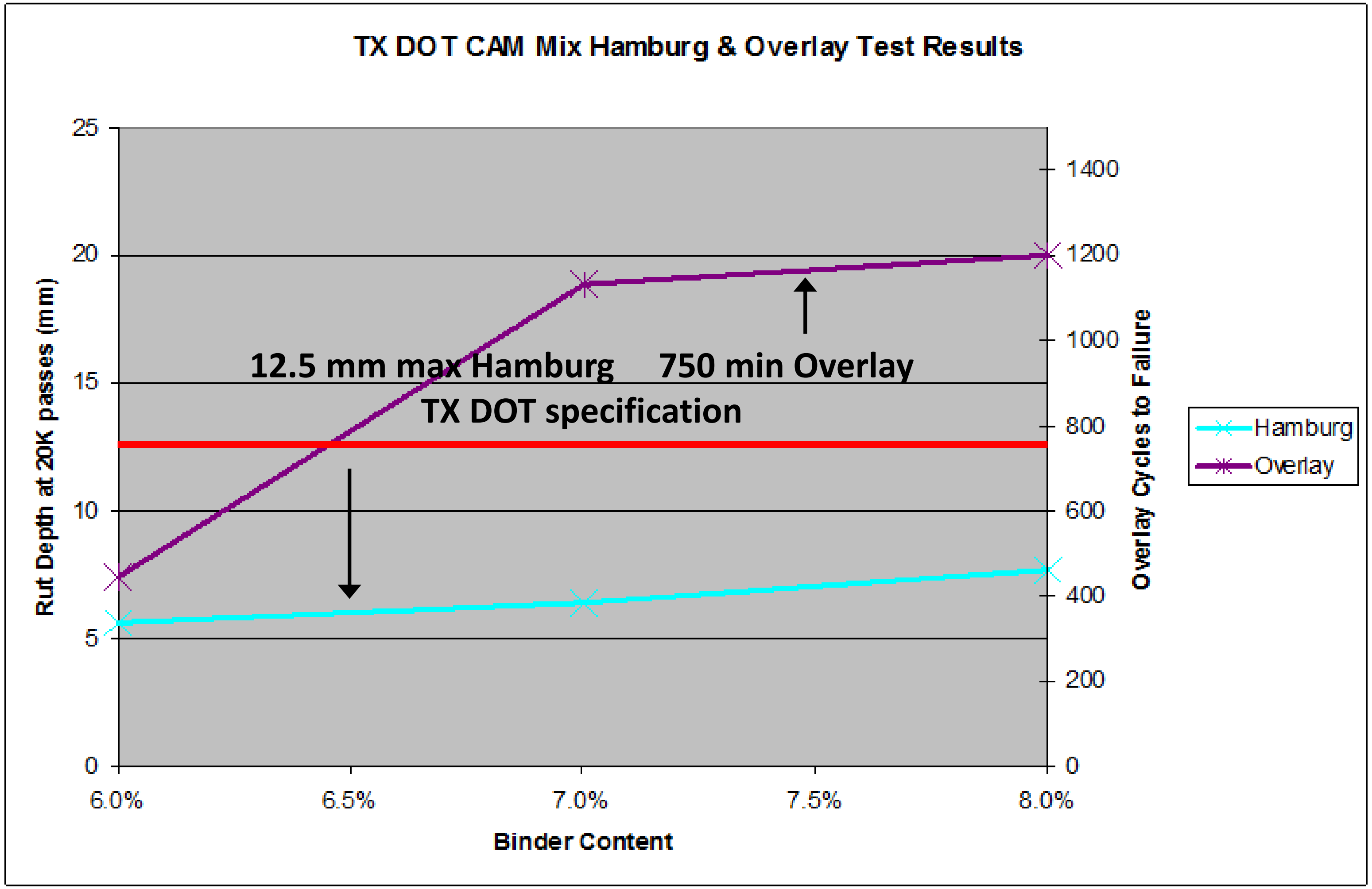


Full sinusoidal loading. Cited strains are ½ amplitude

TX DOT Overlay Specifications – Coarse Dense Mix



TX DOT Overlay Specifications – Fine Rich Mix



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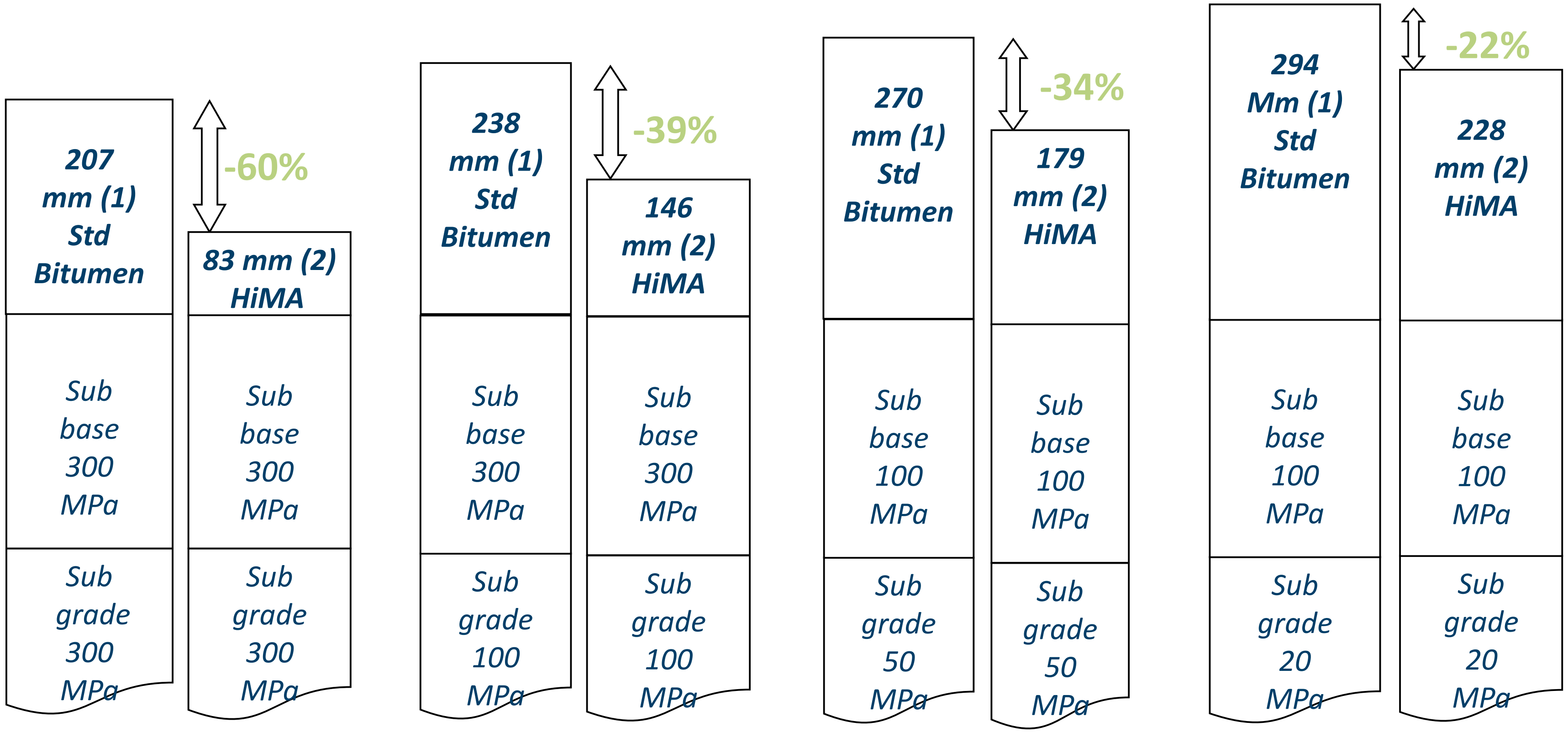
Thickness Reduction Capability



Good quality sub base → Poor quality sub base

(1) Thickness determined by asphalt strain criterion
(2) Thickness determined by sub grade strain criterion

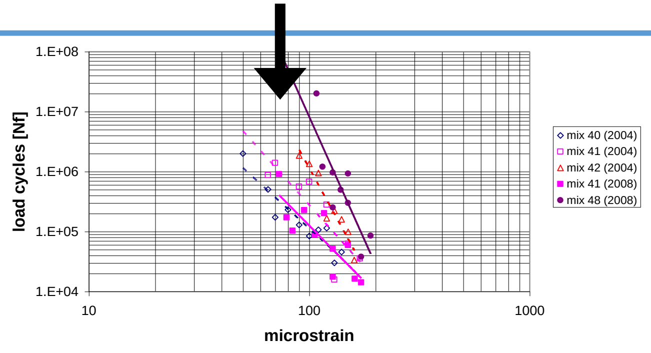
HiMA = Highly Modified Asphalt

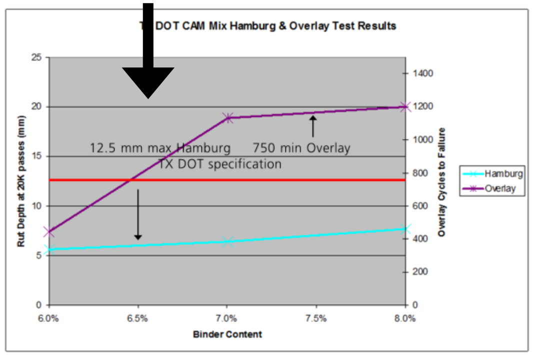
HiMA Mixture and Pavement Design Concepts

- So how should these observations apply to design principles?
- Structural Pavement – Strong Base
- Structural Pavement – Weak Base
- Overlay – Undamaged Pavement
- Overlay – Damaged Pavement
- Waterproof Bridge Deck
- SAMI

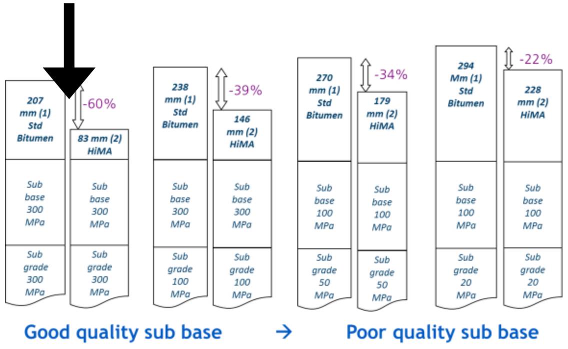
Structural Pavement – Strong Base

- Lowest strain. Best Case!
- Key distress—bottom up fatigue cracking
- Solution—standard mix design, perhaps slightly richer, 0.2-0.3%.
- Thinner pavement design for lower up front cost and life cycle cost for a perpetual pavement.



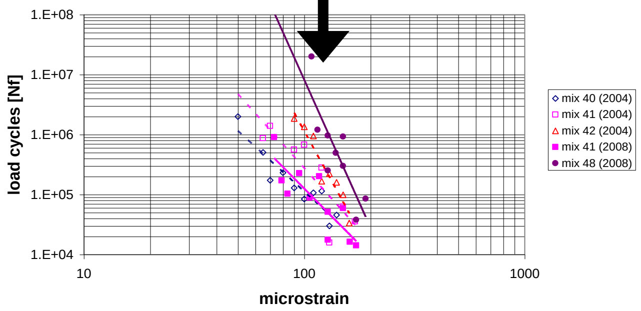


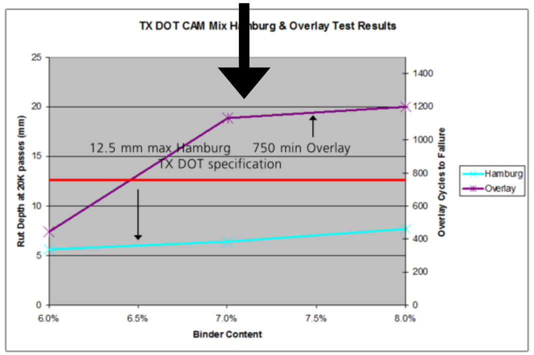
1 ¼" (PG 76-22 E, 9.5 mm NMAS, 80 gyrations)
2 ¼" (PG 76-22 E,19mm NMAS; 80 gyrations)
2 ¼" (PG 76-22 E;19mm NMAS; 80 gyrations)



Structural Pavement – Weak Base

- Moderate strain.
- Key distress—risk of subbase, subgrade damage, bottom up cracking.
- Solution—rich bottom layer, little or no thickness reduction.
- Likely more expensive up front cost, but perpetual pavement vs. rehab every few years.

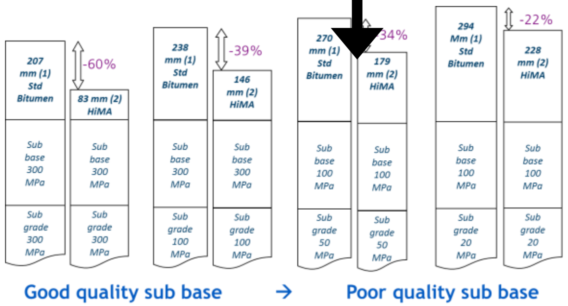




1¼” (7½% polymer; 9.5 mm NMAS)

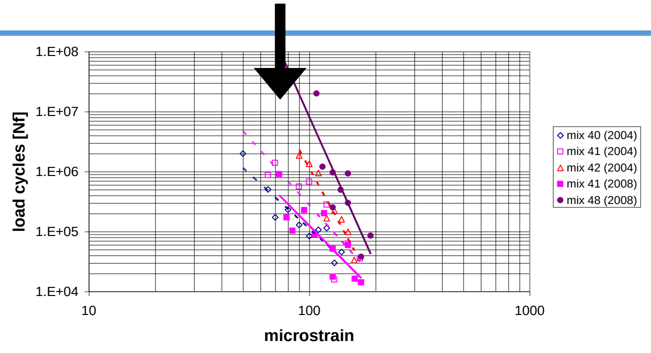
3¼” (7½% polymer;19mm NMAS; 80 Gyrations)

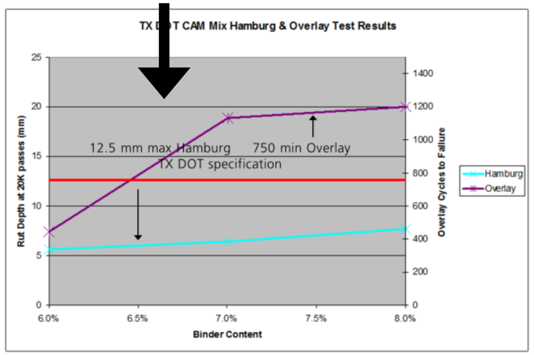
1¼” (7½% polymer; 9.5mm NMAS; 80 Gyrations)

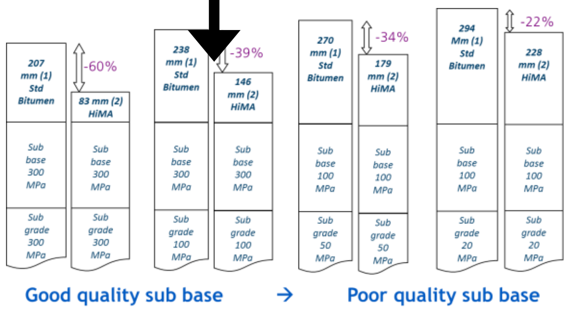


Overlay – Undamaged Pavement

- Low strain.
- Key distress—should be able to achieve substantial thickness reduction, but be aware of potential for rutting below surface.
- Solution—standard mix design, perhaps 0.2-0.3% richer to be on the safe side.
- Thinner pavement for lower up front cost and life cycle cost.







Overlay – Damaged Pavement

- Very high localized strain.
- Key distress—reflective cracking.
- Solution—take advantage of rutting resistance with a finer, richer mix than standard, e.g., New Jersey HPTO mix
- Mix expensive up front mix, but much better life cycle cost analysis.

SECTION 406 – HIGH PERFORMANCE THIN OVERLAY (HPTO)

406.01 DESCRIPTION

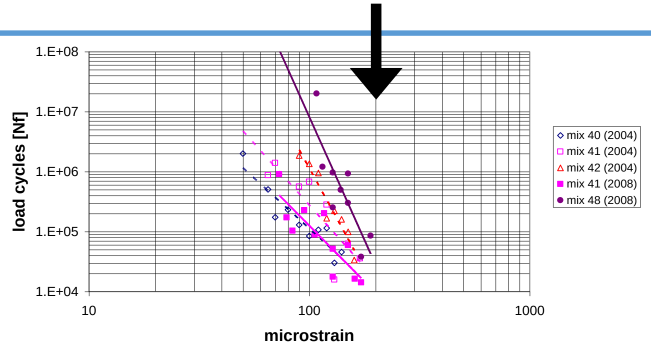
This Section describes the requirements for constructing high performance thin overlay (HPTO).

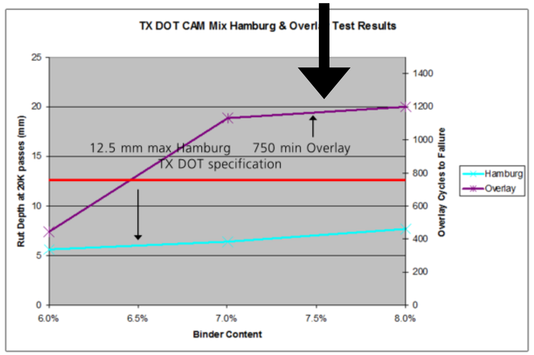
406.02 MATERIALS

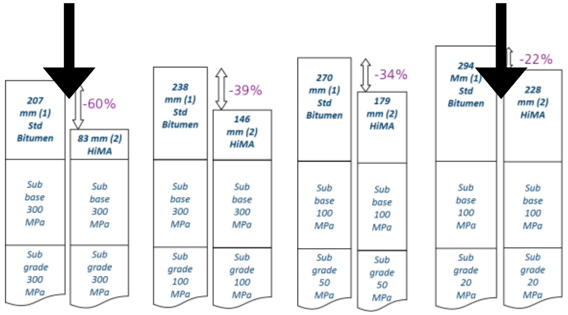
406.02.01 Materials

Provide materials as specified:

Tack Coat:
Emulsified Asphalt, Grade RS-1, SS-1, SS-1h, Grade CSS-1 or CSS-1h..902.01.03
HPTO...902.08



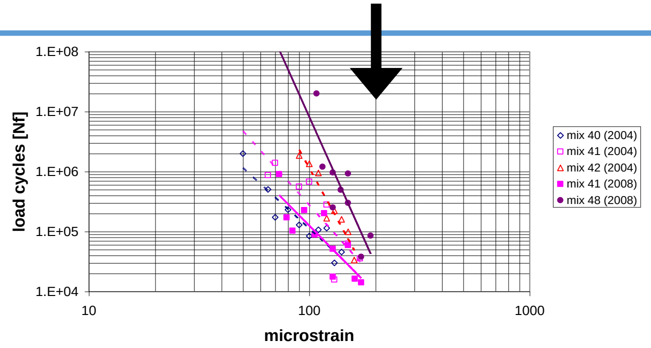


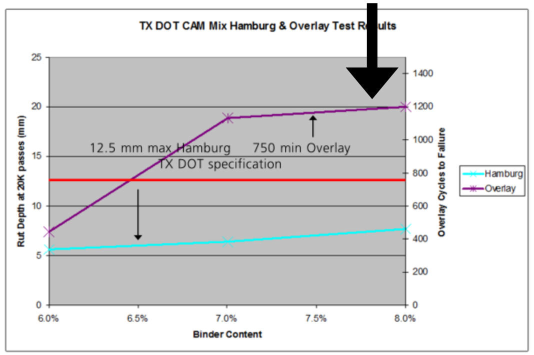


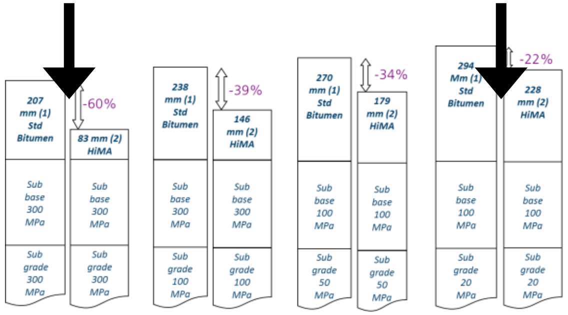
Good quality sub base → Poor quality sub base

Waterproof Bridge Deck Mix

- High strain. “Zero” voids.
- Key distress—fatigue cracking, water permeation
- Solution—very rich fine mix with <2% voids.
- Lower cost & far better workability than alternatives.







Good quality sub base → Poor quality sub base

SECTION 555 - BRIDGE DECK WATERPROOF SURFACE COURSE

555.01 DESCRIPTION

This Section describes the requirements for constructing bridge deck waterproof surface course (BDWSC).

555.02 MATERIALS

555.02.01 Materials

Provide materials as specified:

Tack Coat 64-22, PG 64-22 ....902.01.01
Tack Coat:
Cut-Back Asphalt, Grade RC-70....................902.01.02
Emulsified Asphalt, Grade RS-1, SS-1, SS-1h, Grade CSS-1 or CSS-1h....................902.01.03
Joint Sealer, Hot Poured....................914.02
Polymerized Joint Adhesive....................914.03

Stress Attenuating Mix Interlayer (SAMI)

- High strain. Low voids.
- Key distress—reflective cracking.
- Solution—very rich fine mix with low voids.
- Lower cost than thick structural layer.

ASPHALT MATERIALS & PAVEMENTS PROGRAM

November 2014

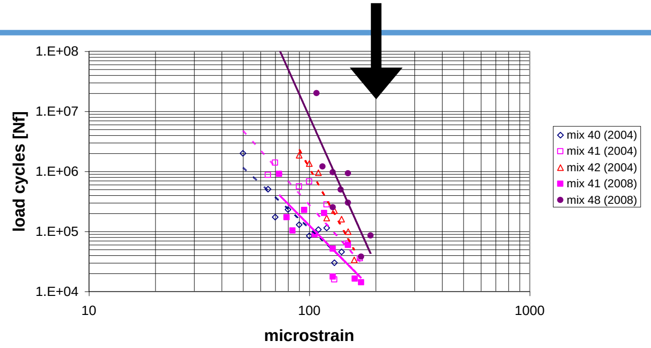
RESEARCH PROJECT TITLE
Assessment of Asphalt Interlayer Designed on Jointed Concrete

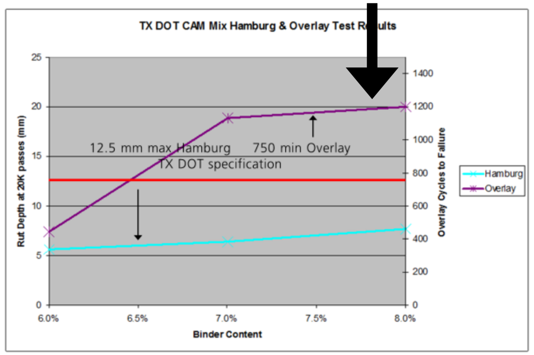
SPONSORS
Iowa Department of Transportation
(InTrans Project 13-475)
Federal Highway Administration

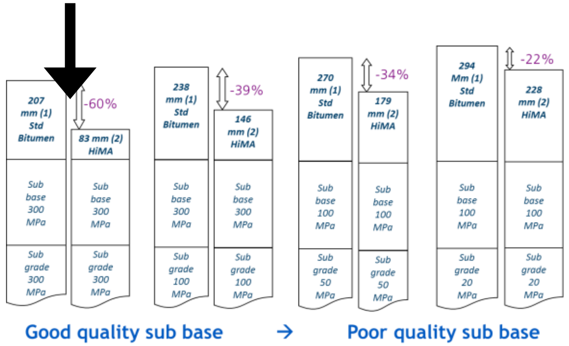
Assessment of Asphalt Interlayer Designed on Jointed Concrete

tech transfer summary

Based on the substantial reduction in reflective cracking and only marginal cost increases from using the interlayer on this research project, it is recommended that future hot mix asphalt (HMA) overlay projects in Iowa consider using the crack-relief interlayer to delay reflective cracking.



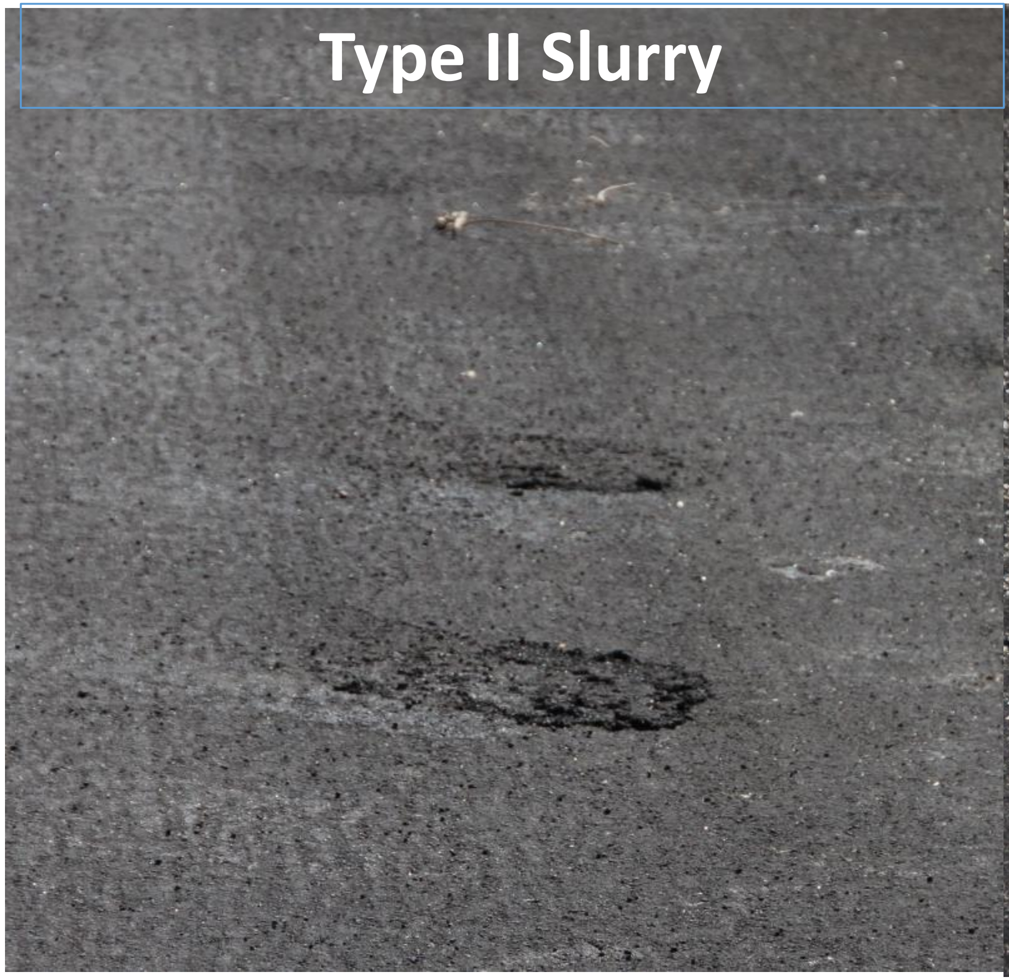


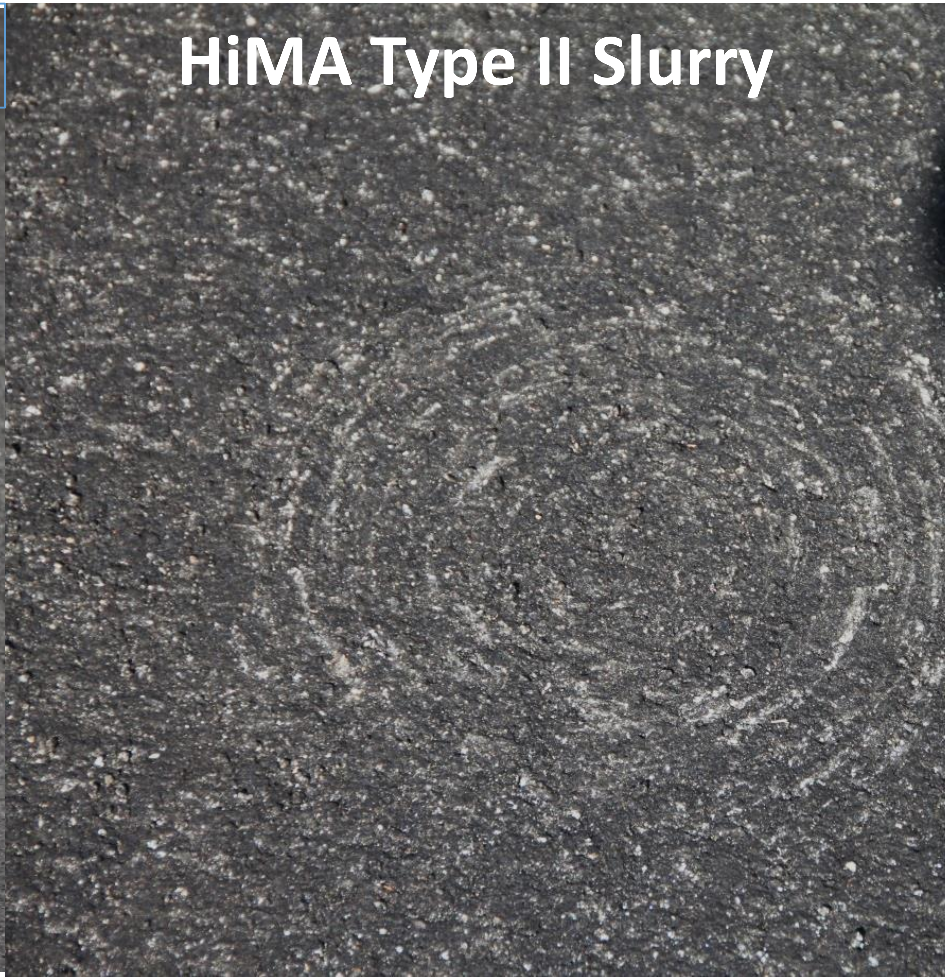


La Quinta, CA near Palm Springs Standard slurry on left shows tearing. HiMA slurry on right - only superficial scuffing. After one week of service

90% reduction in power steering burns in cul-de-sacs

1-31-2014





Ongoing Research

- Virginia
- Field Performance and Economic Analysis of Pavement Sections with Highly Polymer-Modified Asphalt Overlays – Habbouche, Boz, Diefenderfer, VTRC – started June 2019
- Florida
- Structural Coefficients of High Polymer Modified Asphalt Mixes Based on Mechanistic-Empirical Analyses and Full-Scale Pavement Testing – Habbouche, Hajj, UNR – in final review
- Evaluation of FC-5 with PG 76-22 HP to Reduce Raveling BE287: Final Report – Arámbula-Mercado, Karki, Park, TAMU, Caro, Torres, Sánchez-Silva, U de los Andes

Conclusions

- NCAT section N7 developed fine surface cracking late in its life, but forensic analysis showed that the cracking was minor top down cracking not impacting the structural integrity of the pavement.
- Highly modified asphalt may be useful in perpetual pavement design.
- Demonstrated performance up to 20 million ESALs shows that the thickness of pavement structures may be reduced while retaining or even improving long term performance.

Conclusions

- AASHTO M 332 specifications (plus R%) have been effective to specify HiMA binders for commercial applications.
- Standardized test methods in increasingly common use are adequate to characterize HiMA mixtures for the purpose of pavement design.
- The current Pavement ME Design protocol is suited to designing perpetual pavements with highly modified asphalts. Relative global calibration factor adjustment with Level 1 design gives performance predictions that agree well with actual field performance relative to known structures.

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