FHWA Pooled Fund Study

Development of Design Guide for Thin and Ultra-thin Concrete Overlays of Existing Asphalt Pavements

Presented by: Julie M. Vandenbossche, PhD, P.E.
-University of Pittsburgh-

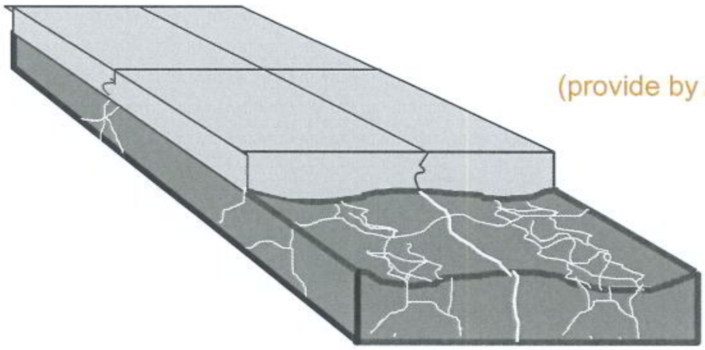
Pennsylvania Concrete Conference
Tuesday, January 27, 2009

Outline

- Definition
- Current procedures and their limitations
- Previous findings
- Project description

Definitions

Whitetopping… what is it???

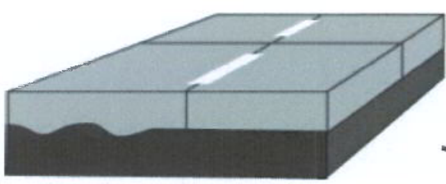


(provide by ACPA)

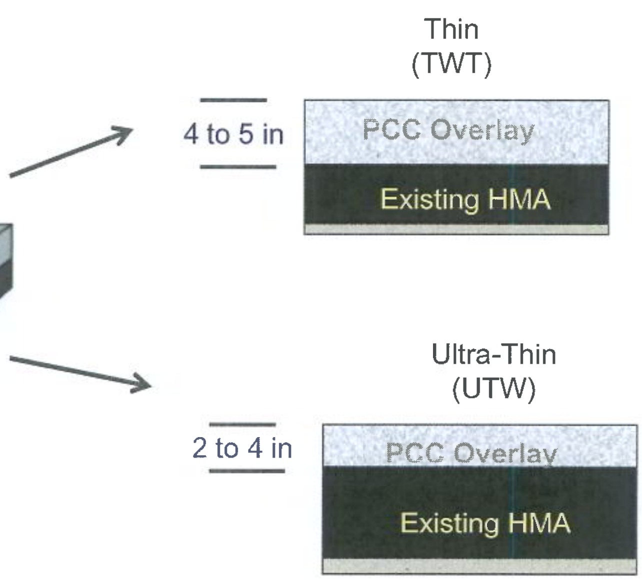
Concrete overlay of existing HMA pavement

Definitions

Whitetopping

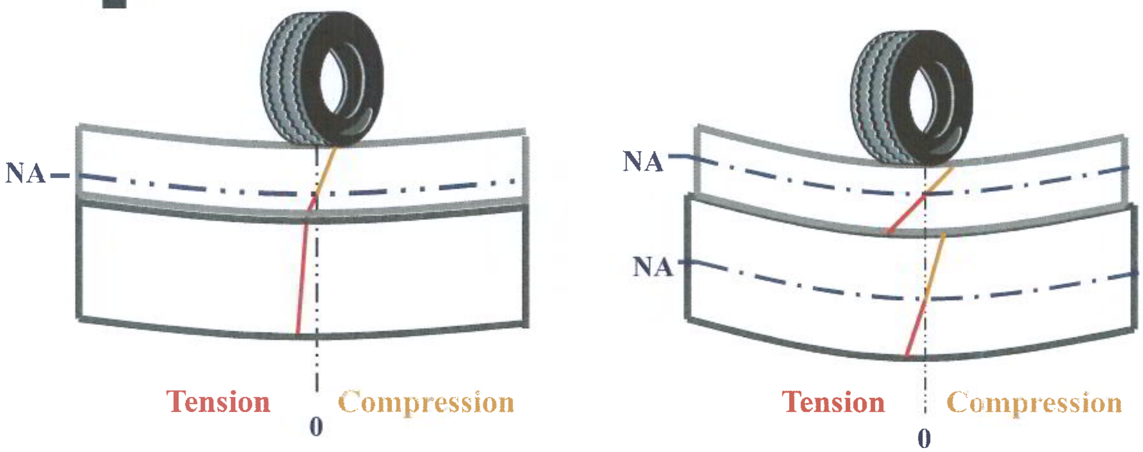


(provide by S. Tayabji)



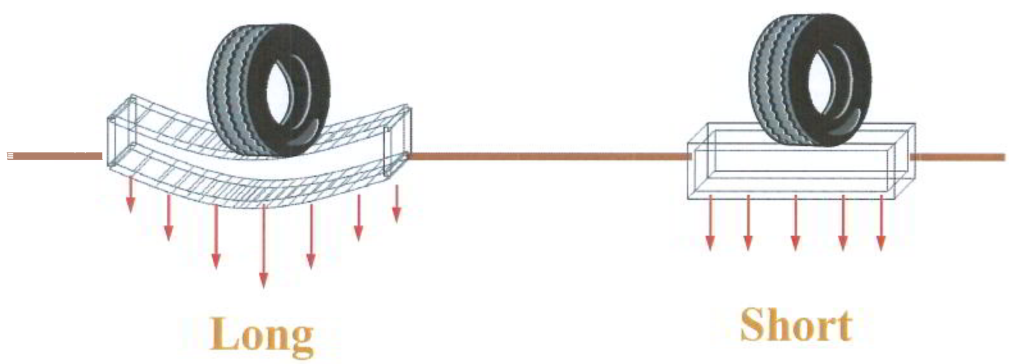
Bond *is* required

How does UTW work?



Bonded **Unbonded**

How does UTW work?

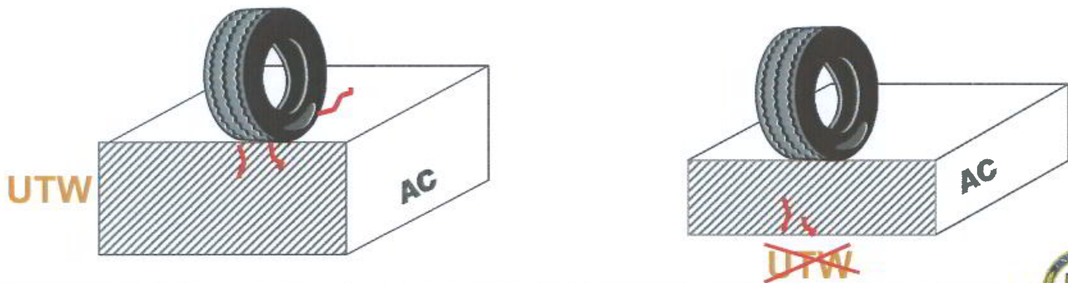


Joint Spacing

University of Pittsburgh Department of Civil & Environmental Engineering

When to consider UTW

- HMA thickness $\geq$ 4"
- No stripping/raveling
- No excessive bottom-up fatigue cracking



Debonding

Whitetopping

- TWT (4 to 5 in.) (*moderately loaded*)
  - State/county highways
  - Secondary routes
  - Collectors

- UTW (2 to 4 in.) (*lightly loaded*)
  - City streets
  - Urban intersections
  - Parking lots

(adapted from S. Tayabji)

Overlay design

Interim procedures available

- Thin overlays: Colorado DOT
- Thinner overlays: ACPA Interim Procedure
- ILDOT (University of Illinois)

- Slab thickness
- Joint spacing
  - 6 by 6 ft joint spacing widely used

What we know…

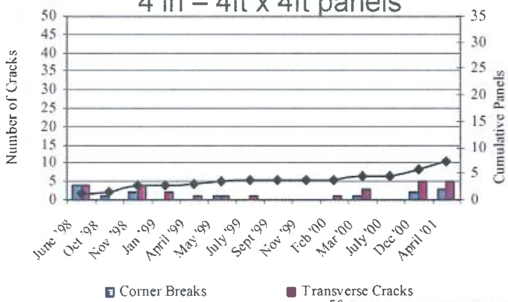
Mn/ROAD test sections

- 4 in – 4 x 4 ft Panels (polypropylene fibers)
- 3 in – 4 x 4 ft Panels (polypropylene fibers)
- 3 in – 5 x 6 ft Panels (polyolefin fibers)
- 6 in – 5 x 6 ft Panels (polypropylene fibers)
- 6 in – 10 x 12 ft Panels (polypropylene fibers)
- 6 in – 10 x 12 ft Panels (polypropylene fibers and dowels)

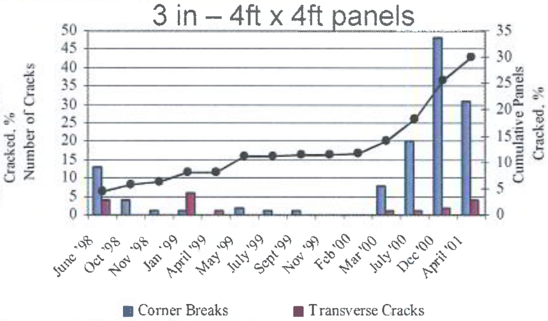
Interstate traffic: One-way ADT =24,000 with 12 % trucks

Optimizing panel size

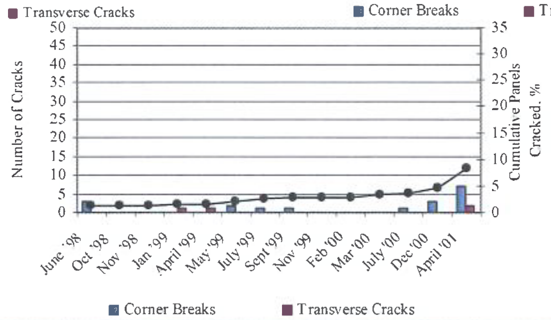
4 in – 4ft x 4ft panels



3 in – 4ft x 4ft panels



3in – 5ft x 6ft panels



Whitetopping Crack Summary

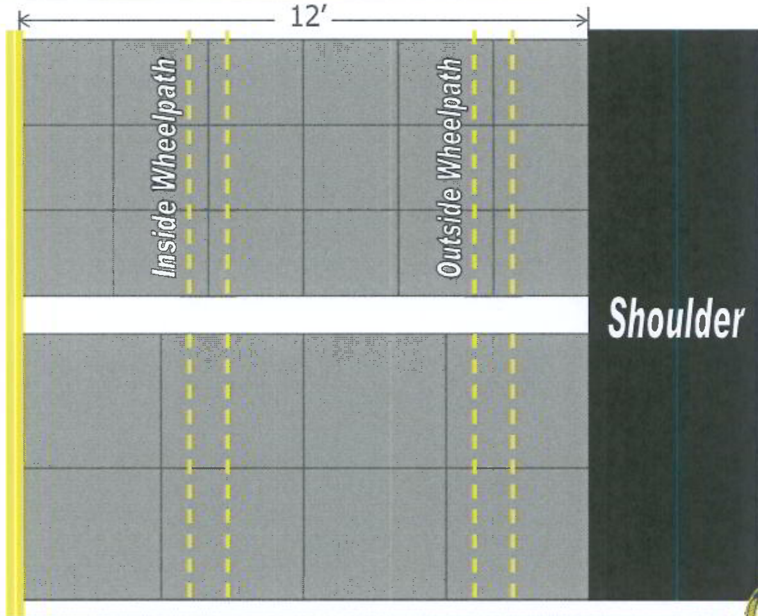
Cell	Panels Cracked (%)	Corner Cracks	Trans. Cracks	Long. Cracks
4”- 4’x 4’	7	14	27	0
3”- 4’x 4’	40	165	19	0
3”- 5’x 6’*	8	18	4	0
6”- 5’x 6’	0	0	0	0

***All transverse cracks in 3” – 5’x 6’ section are reflective cracks.**

Longitudinal joint layout

2' x 2' Panels

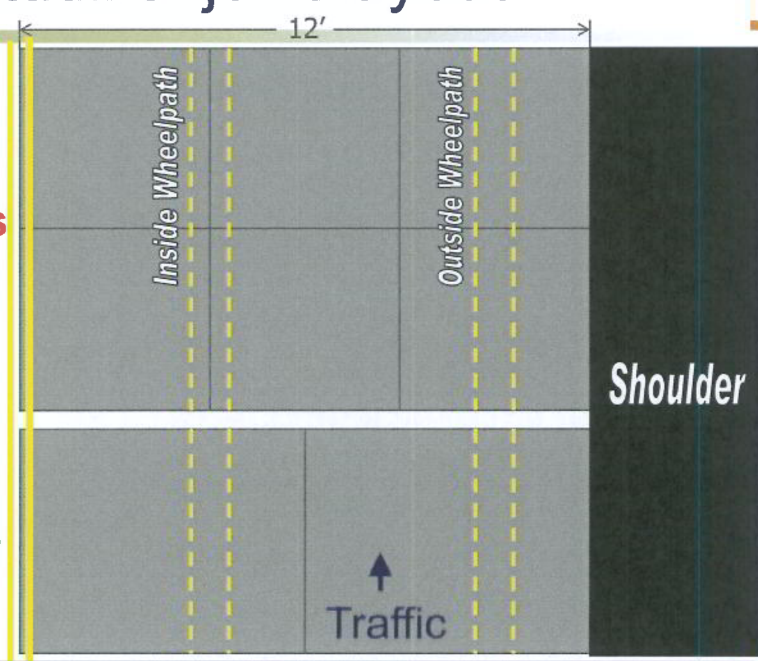
3' x 3' Panels



Longitudinal joint layout

4' x 4' Panels

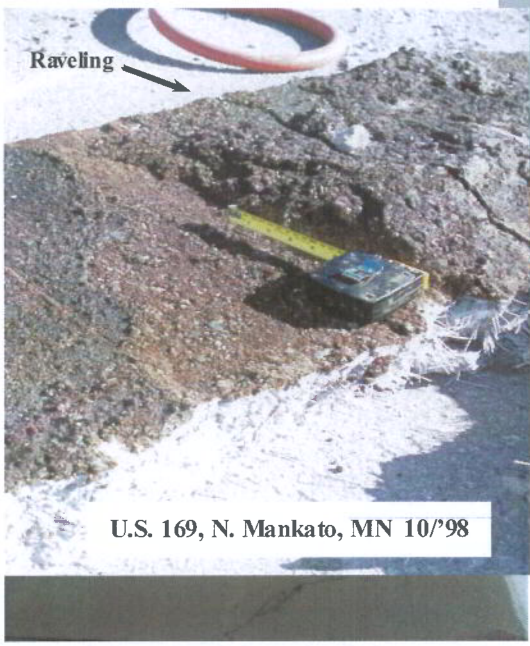
5' x 6' Panels



To seal or not to seal…

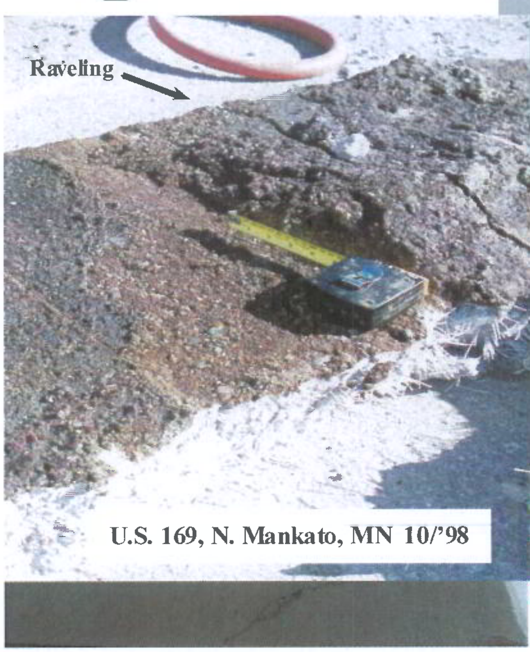
Findings in Minnesota

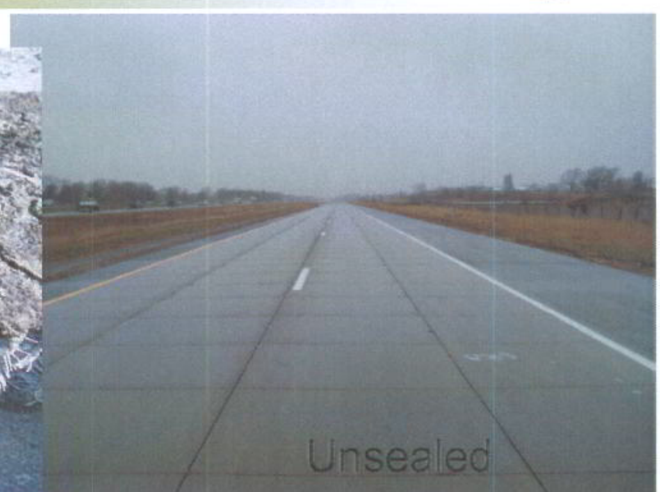
Findings in Minnesota



(Currently not considered)

Findings in Minnesota





Role of fibers in holding cracks/joints tighter??

Dowels???...

Findings in Minnesota

6 in -10 ft x 12 ft panels

0.75 in Dowels

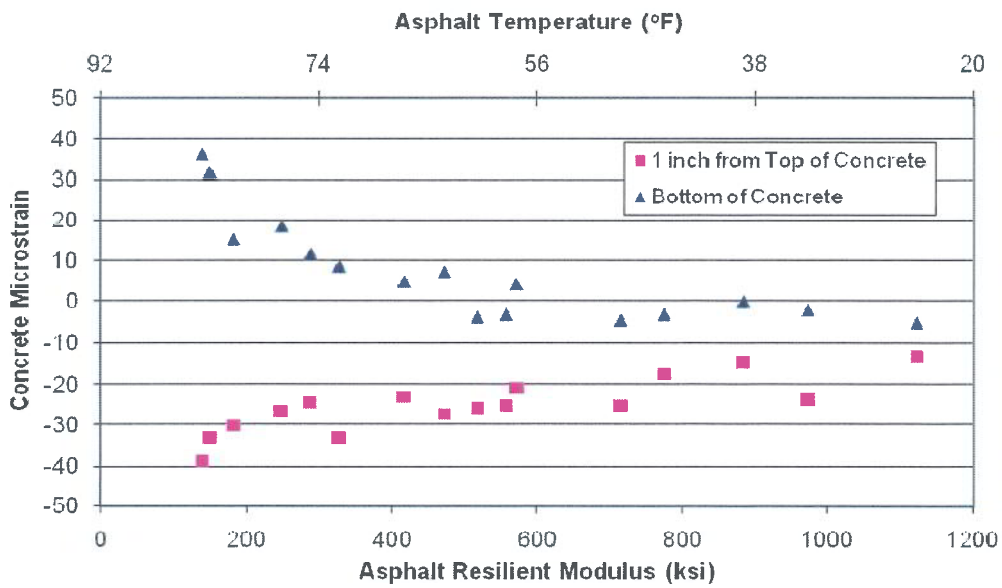
Undoweled

After 11 years of interstate traffic.

Climatic considerations…

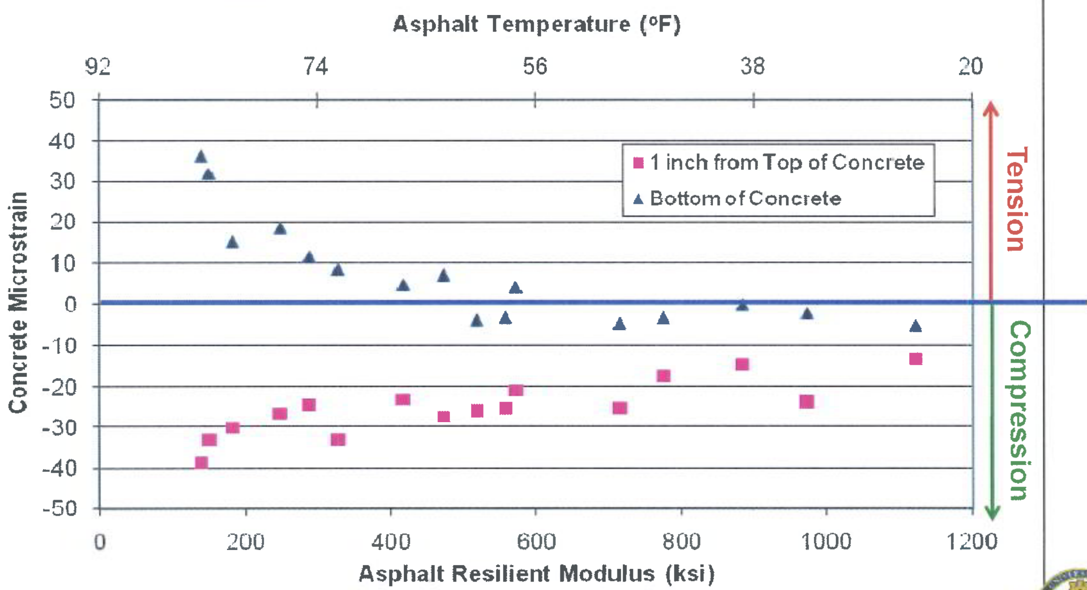
Seasonal effects

(Currently not considered)



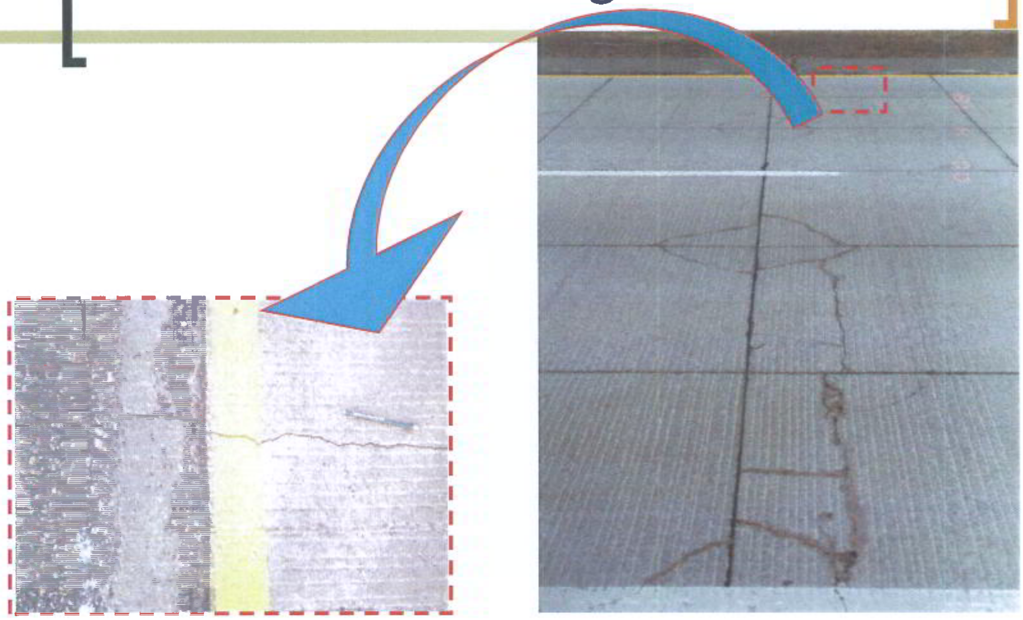
Seasonal effects

(Currently not considered)



Reflective transverse cracking…

Reflective cracking (Currently not considered)



Reflective cracking will most likely occur if….

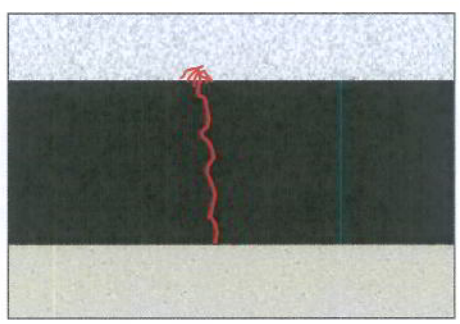
Located in cold climatic region

AND

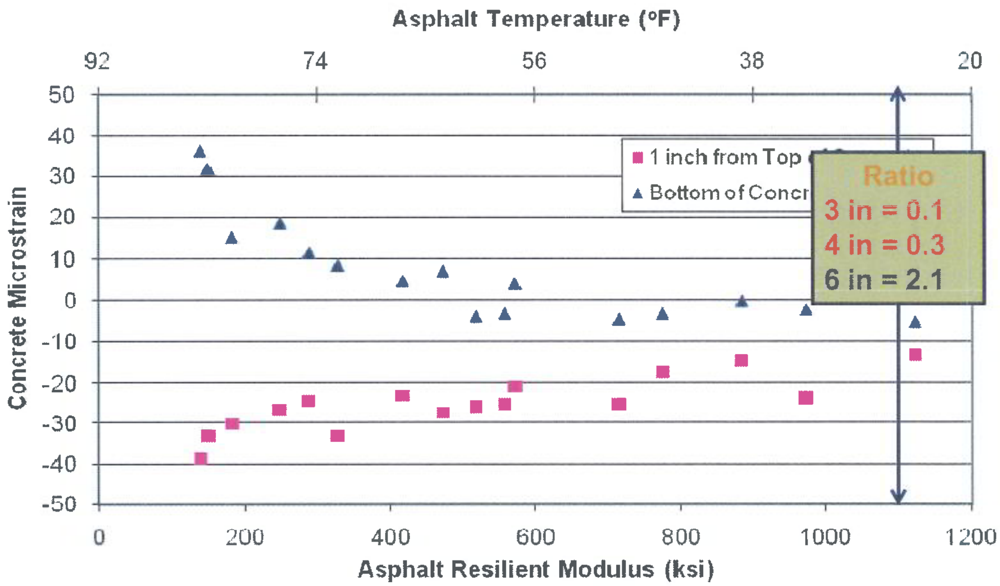
flexural stiffness of PCC < flexural stiffness of HMA

$$\text{Flexural Stiffness} = D = \frac{Eh^3}{12(1-\mu^2)}$$

$$\frac{D_{PCC}}{D_{HMA}} < 1 \Rightarrow \text{Reflective Cracking}$$



Reflective cracking will most likely occur if….



Reflective Cracking

Design	Flexural Stiffness Ratio	Reflective Cracking
3 in PCC / 3 in HMA	> 1	No
3 in PCC / 10.5 in HMA	< 1	Yes
4 in PCC / 9.5 in HMA	< 1	Yes
6 in PCC / 7.5 in HMA	> 1	No

Findings in Minnesota

A portion of panels along the 5ft x 6ft section have fibers:

Observations:
Fibers seem to reduce joint and crack width compared to section w/out fibers

Participating states

- Minnesota –**Lead**
- Missouri
- Mississippi
- New York
- Pennsylvania
- Texas

Some of the current limitations

- Modeling bond degradation
- Seasonal effects
- Reflective cracking
- Fatigue of HMA layer
- More accurate characterization of effect of fiber on performance

Project objectives

1. Study and understand the field performance history & limitations of current procedures
2. Develop a design guide based on mechanistic-empirical principles
3. Create a user-friendly spreadsheet based design guide and user's manual

Project tasks

Task 1: Identify, collect, compile & review performance data & info.

Duration: 6 mths
Est. completion date: Feb. 28, 2009

Points of Interest

- Typical distress observed as a function of climate, overlay structure, exiting condition of HMA, fiber inclusion, pcc mixture design, etc.

Task 2: Evaluate existing performance prediction/damage accumulation & structural response models

Duration: 8 mths
Est. completion date: Sept. 30, 2009

Points of Interest

- Models most suitable for predicting fatigue in overlay, exiting HMA (?) and bond at the HMA/PCC interface (?)
- Structural response models

Project tasks

Task 3: Develop implement laboratory/field study

Duration: 15 mths
Est. completion date: Aug. 31, 2010

Points of Interest

- Understanding the influence and modeling of HMA/PCC bond
- Scope can be revised based on needs identified in previous tasks, such as role of fibers in overlay performance

Task 4: Climatic considerations

Duration: 12 mths
Est. completion date: Oct. 28, 2009

Points of Interest

- Seasonal variation in HMA stiffness
- Development of temperature gradients in overlay

Project tasks

Task 5: Project suitability & characterization of in-place structure

Duration: 8 mths
Est. completion date: Dec. 31, 2010

Points of Interest
- Guidelines for suitability of a bonded overlay as rehab option
- Guidelines for developing inputs for design

Task 6: Development of design procedure

Duration: 13 mths
Est. completion date: May 31, 2011

Points of Interest
- Characterize structure & climate, structural analysis, performance criteria, materials, traffic (ESALs), geometry, reliability

Project tasks

Task 7: Future rehab guidelines for overlay

Duration: 3 mths
Est. completion date: June 30, 2011

Points of Interest
- Guidelines for suitability of a bonded overlay as rehab option
- Guidelines for developing inputs for design

Task 8: Final report

Duration: 7 mths
Est. completion date: Jan. 31, 2012

Project status

- Task 1: Identify, collect, compile and review performance data and information
  - Typical failures as a function of surface prep., HMA & PCC thickness, joint pattern, concrete mixture, existing HMA condition…
  - Role of fibers
  - Development of ACPA database in progress (limited data currently available)
  - Up to 4 state site visits
    - Minnesota (Nov. 2008)
    - Other states ???

Acknowledgments

- Federal Highway Administration –Jim Sherwood
- Minnesota –Tom Burnham Lead
- Missouri – John Donahue
- Mississippi - Bill Barstis
- New York – Mark Brinkman
- Pennsylvania – Mike Long
- Texas – Lisa Lukefa

THANK YOU

ANY QUESTIONS??