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TRANSPORTATION RESEARCH BOARD

Concrete Overlays of Asphalt

March 11, 2021

@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

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RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

#TRBwebinar

Learning Objectives

1. Identify factors important to the selection, design, and construction of COAs
2. Discuss recent advancements in COAs
3. Discuss state experiences with COAs

#TRBwebinar

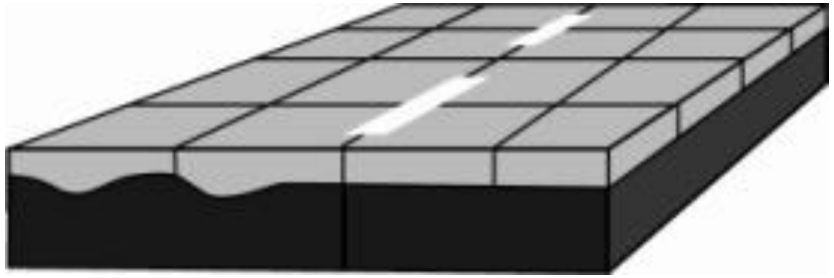
TRB Webinar: Concrete Overlays of Asphalt

Julie M. Vandenbossche, P.E., Ph.D.

University of Pittsburgh

March 11, 2021

Concrete overlays:



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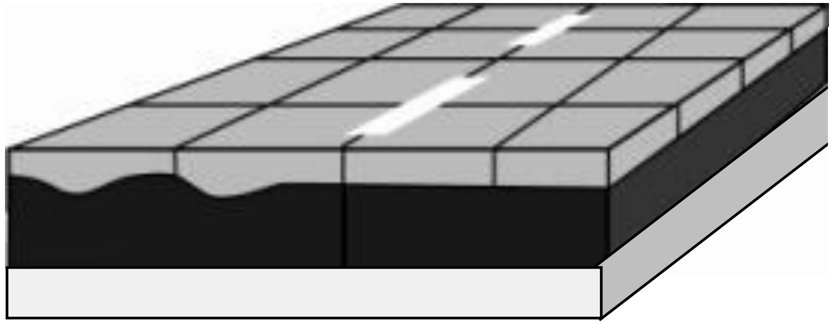


HMA pavement

Composite pavement

<u>Design and construction considerations:</u>

What should be used to determine the overlay thickness?

Is the quality of the remaining asphalt important?

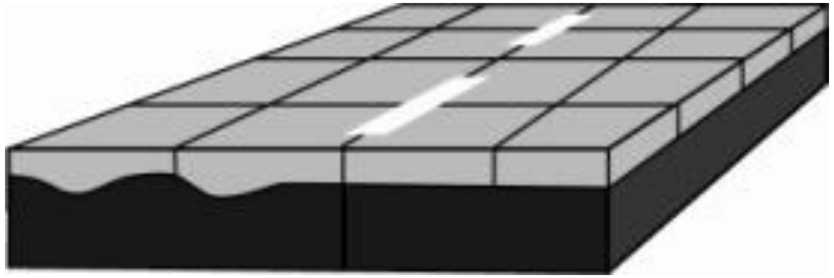
Is the thickness of remaining asphalt important?

Is surface prep/cleanliness important?

Concrete overlays: Bonded

$D_{HMA} \geq 4$ in → bonded

$D_{HMA} < 3$ in → Unbonded



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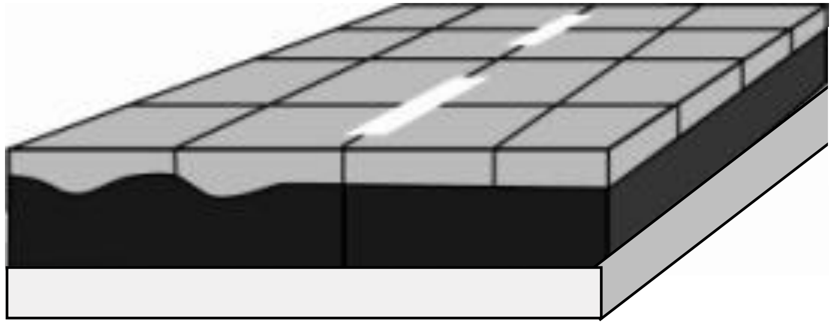


HMA pavement

Composite pavement

Design and construction considerations:

BCOA ME
University of Pittsburgh

PvD AASHTOWare Pavement ME Design

CoDOT Design Procedure

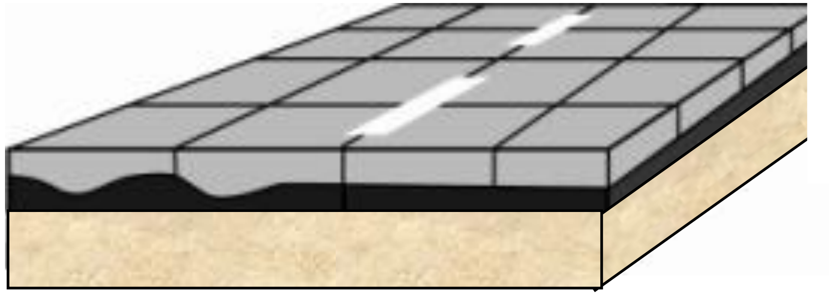
ACPA

/// BCOA THICKNESS DESIGNER ///

Concrete overlays:

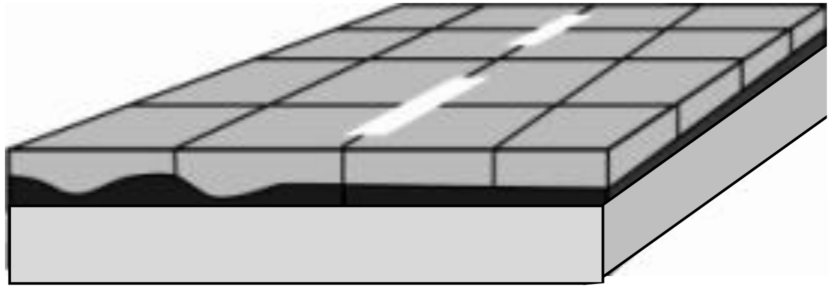
$D_{HMA} \geq 4$ in → bonded

$D_{HMA} < 3$ in → Unbonded



HMA pavement

or

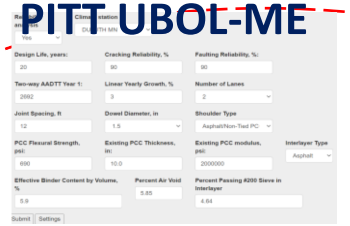


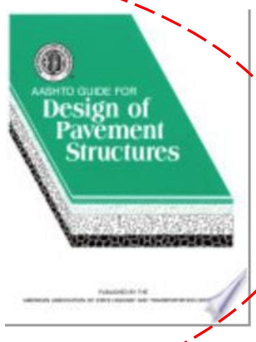
Composite pavement

Design and construction considerations:

Design as a JPCP on HMA base.

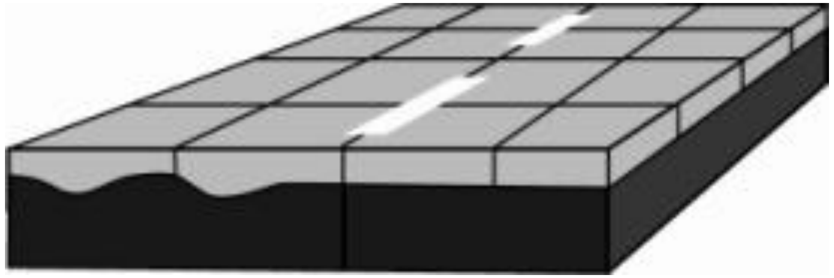
PITT UBOL-ME





Design as a unbonded concrete overlay of concrete.

Concrete overlays: Bonded



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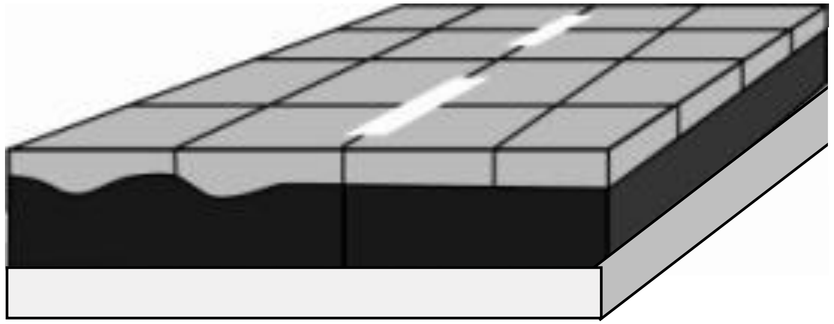


HMA pavement

Composite pavement

Research & implementation experience:

- Minnesota
- California
- Louisiana

Research and Implementation of Concrete Overlay on Asphalt in California

Angel Mateos, John Harvey, Miguel Millan,
Rongzong Wu, Fabian Paniagua, Shuo Yang
University of California Pavement Research Center

Dulce Rufino Feldman, Deepak Maskey, Biplab Bhattacharya
California Department of Transportation

Charles Stuart
Southwest Concrete Pavement Association

TRB Webinar
Concrete Overlays on Asphalt (COA) – Research and Implementation
March 11, 2022

Presentation Outline

1. Initial research based on accelerated pavement testing with the Heavy Vehicle Simulator (HVS), 2015-2017
   - What are the three main takeaways?
2. Pilot implementation phase, starting in 2018
   - What are the three main takeaways?
3. What are the topics that require further research and solution?

Main takeaways from the HVS testing

What did we test?

11 COA sections

- 4 concrete mixtures
- Slab size: 6×6, 8×8, and 12×12 ft.
- Slab thickness: 4.5 and 6 in.
- Asphalt base thickness: 2 and 4 in.
- Asphalt base type: old asphalt and new asphalt

Main takeaways from the HVS testing

What is the HVS?

The Heavy Vehicle Simulator (HVS) is an accelerated pavement testing machine capable of applying...

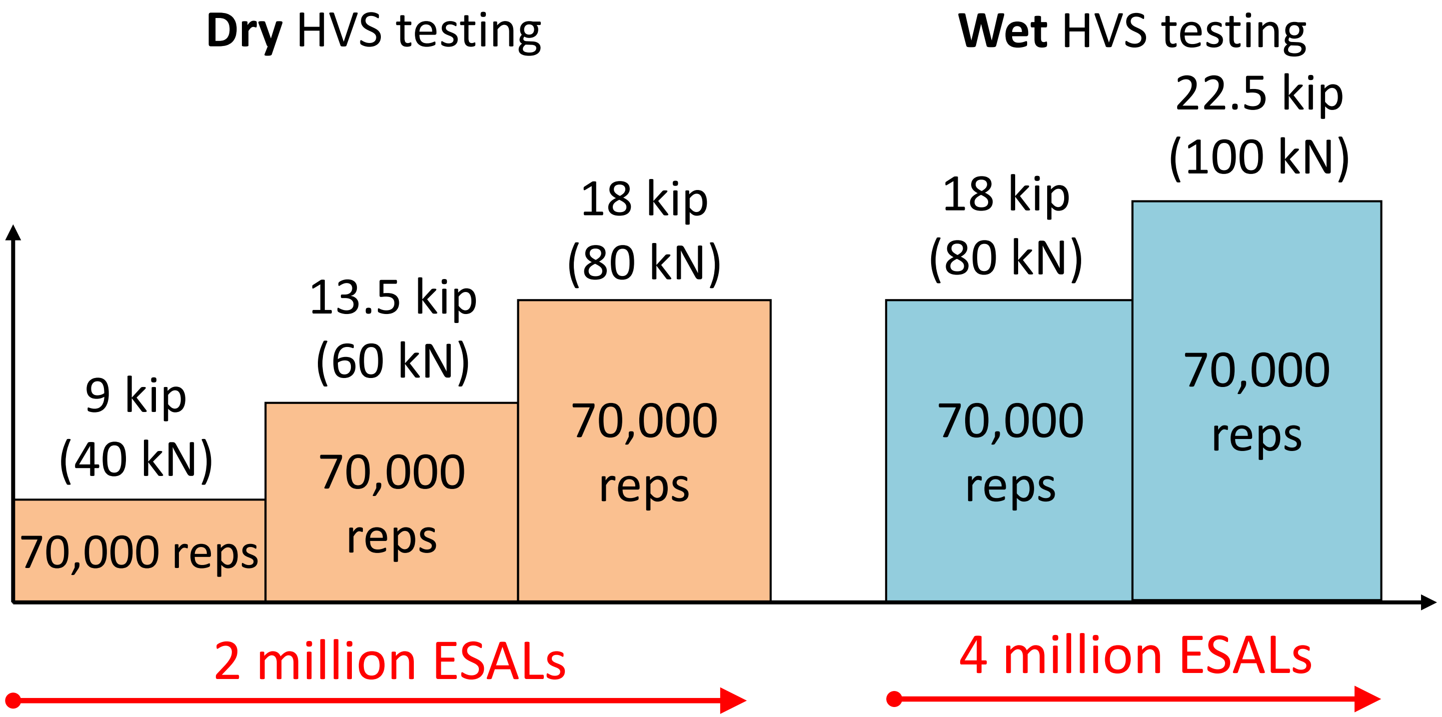
- 800 load repetitions per hour
- Up to 25 kip (110 kN) wheel load

...the HVS intends to reproduce long-term in-service traffic damage in a compressed time period.

Main takeaways from the HVS testing

How did we test the COA sections?

- "Dry" testing: 210,000 repetitions up to 18 kip wheel load (36 kip single axle)
- "Wet" testing: 140,000 repetitions up to 22.5 kip wheel load (45 kip single axle)... plus flooded conditions and channelized traffic



Wet HVS test: 10 days flooding + water supply during HVS testing

Main takeaways from the HVS testing

What are the three main takeaways?

1. Do not underestimate the structural capacity of a “relatively thin” (4.5 in.) concrete overlay
    - Despite the high load level (over twice the legal limit in California),
    - ...despite the flooding conditions...
    - ...despite the channelized traffic at slab shoulder edge...
    - ...the HVS loading (over 6 mill. ESALs) did not produce any cracking in any section.

A third phase of the HVS testing focused on the weakest section of the test track (with 12×12 ft. slabs). The test continued at 22.5 kip wheel load, flooded conditions, and channelized traffic at slab shoulder edge... Corner cracking occurred after 13.3 million ESALs.

Main takeaways from the HVS testing

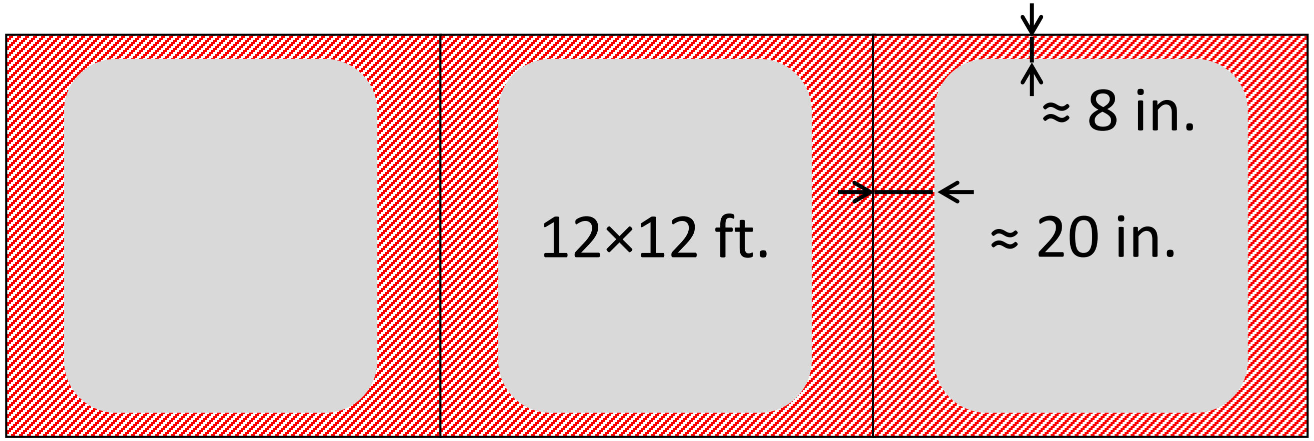
What are the three main takeaways?

1. Do not underestimate the structural capacity of a "relatively thin" (4.5 in.) concrete overlay

What are the three main takeaways?

2. In dry climates like Californian, COA performs better with half-lane width slabs than with full-lane width slabs: 6×6 ft. better than 12×12 ft.

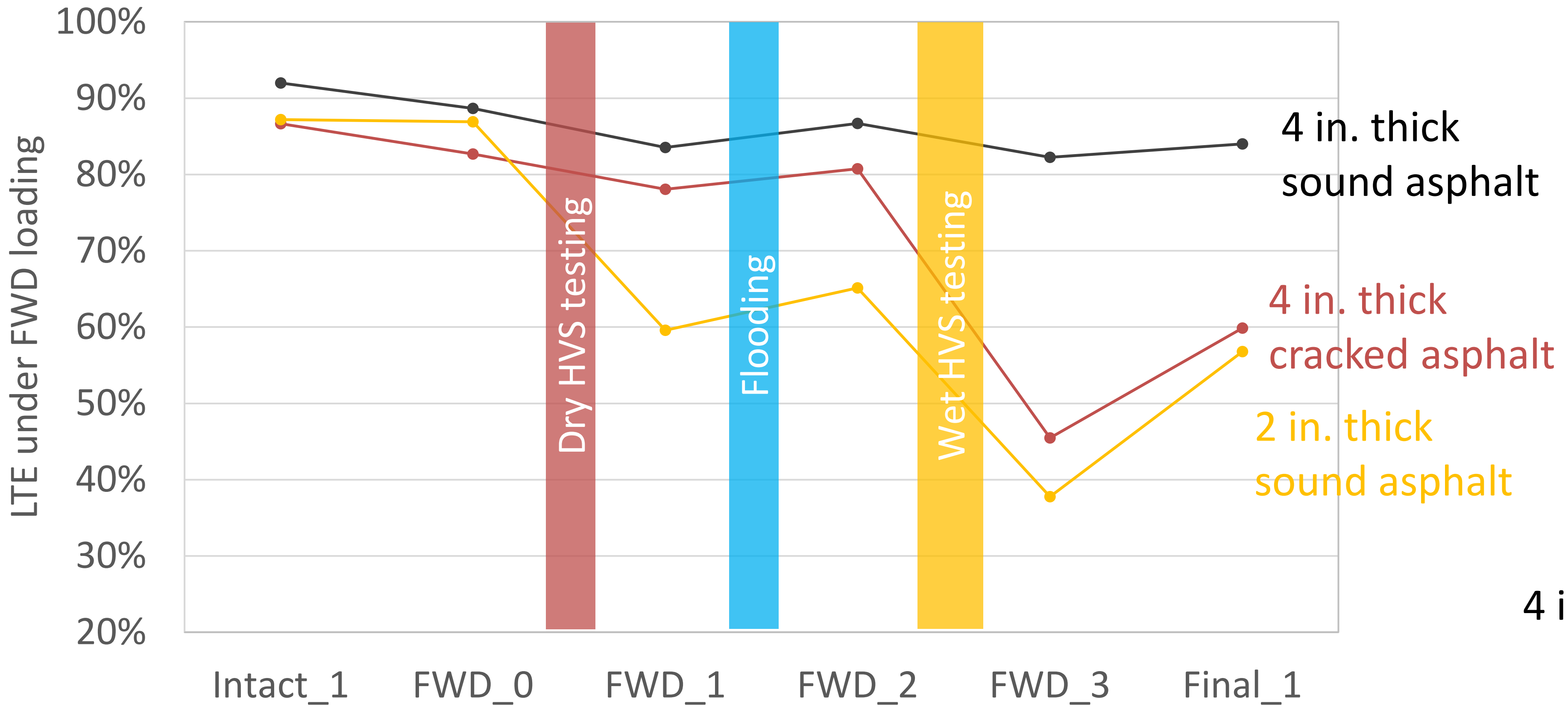
- The 12×12 ft. slabs presented delamination around the perimeter (no delamination observed in 6×6 ft. slabs)
- For the 12×12 ft. slabs, the LTE was relatively poor before the HVS testing (for 6×6 ft. slabs, the LTE was stable over 80%, unaffected by HVS testing in most sections)
- Delamination and poor LTE (12×12 ft. slabs) were NOT related to traffic but to environment

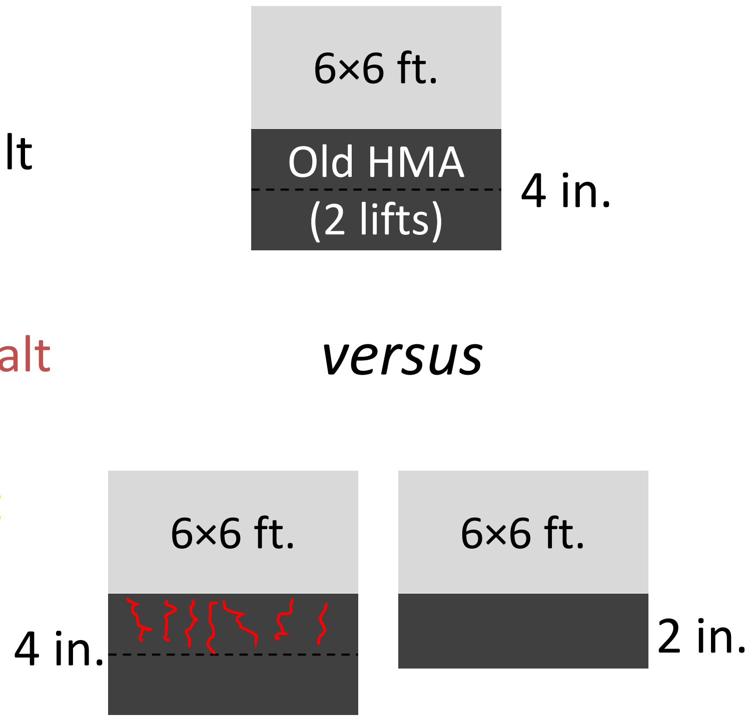


Main takeaways from the HVS testing

What are the three main takeaways?

3. Thickness and condition of the asphalt base are important.
   - Compared to the COA sections with 2 in. asphalt base or asphalt in poor condition, the sections with 4 in. of sound asphalt base presented better LTE performance.





Main takeaways from the HVS testing

Summary, Conclusions, and Recommendations available at 40-page report...

https://escholarship.org/uc/item/5g04q2mb

A well-designed, well-built 6×6 COA placed on top of an asphalt base that is in fair to good condition can provide 20 years of good serviceability on most of California's non-interstate roadways.

August 2019
Summary Report: UCPRC-SR-2018-01

Development of Improved Guidelines and Designs for Thin BCOA: Summary, Conclusions, and Recommendations

Authors:
A. Mateos, J. Harvey, F. Paniagua, J. Paniagua, and R. Wu

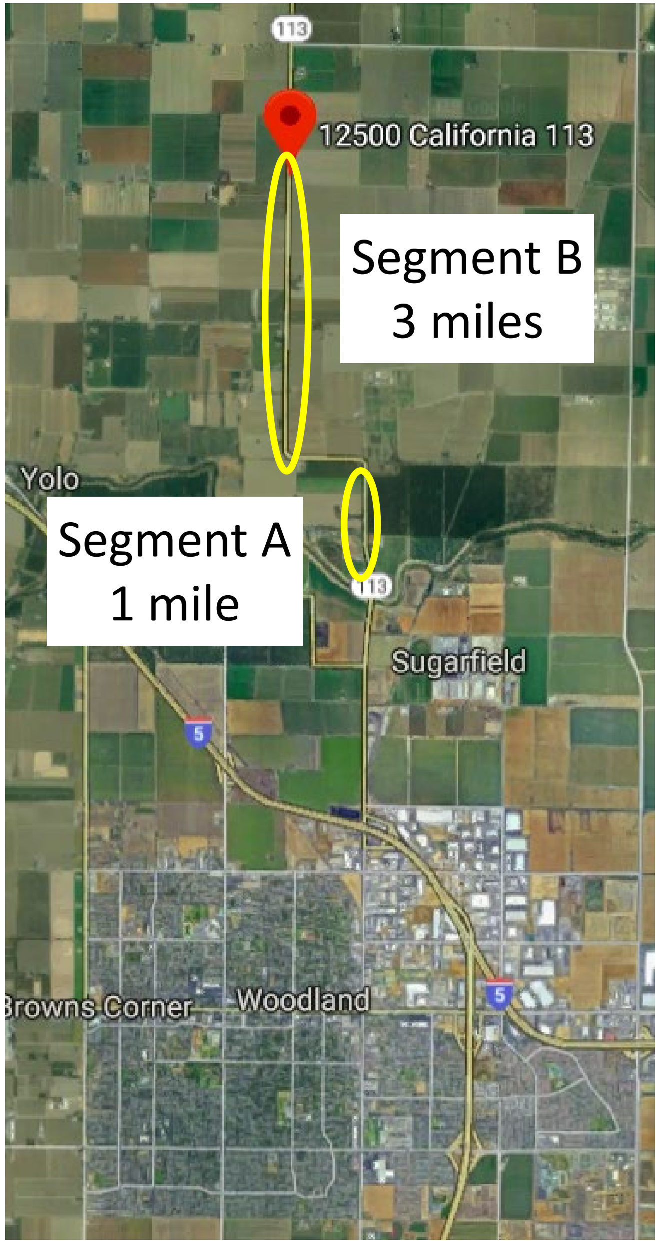
Partnered Pavement Research Center (PPRC) Strategic Plan Element (SPE) 4.58B:
Evaluate Early-Age and Premature Cracking for PaveM and LCCA (whitetopping);
Project Task 2878: Thin Whitetopping

PREPARED FOR:
California Department of Transportation
Division of Research, Innovation, and System Information
Office of Materials and Infrastructure Roadway Research

PREPARED BY:
University of California
Pavement Research Center
UC Davis, UC Berkeley

Main takeaways from the pilot implementation

Pilot implementation of COA in State Route 113



- Two-lane road, AADTT 570 (two-way)
- Pre-milling asphalt surface condition: fair (moderate cracking)
- Pre-milling asphalt thickness: 8-10 in.
- 6 in. thick slabs
- Required milling 6 in. to maintain road surface elevation (related to flooding risk)
- Design included 6×6 interior slabs and 8×6 exterior slabs (widened lane), tiebars, unsealed joints
- Rapid Strength Concrete with 450 psi flex. strength @ 24 hours
- Overlay was built between 2018 and 2019

Main takeaways from the pilot implementation

What are the three main takeaways?

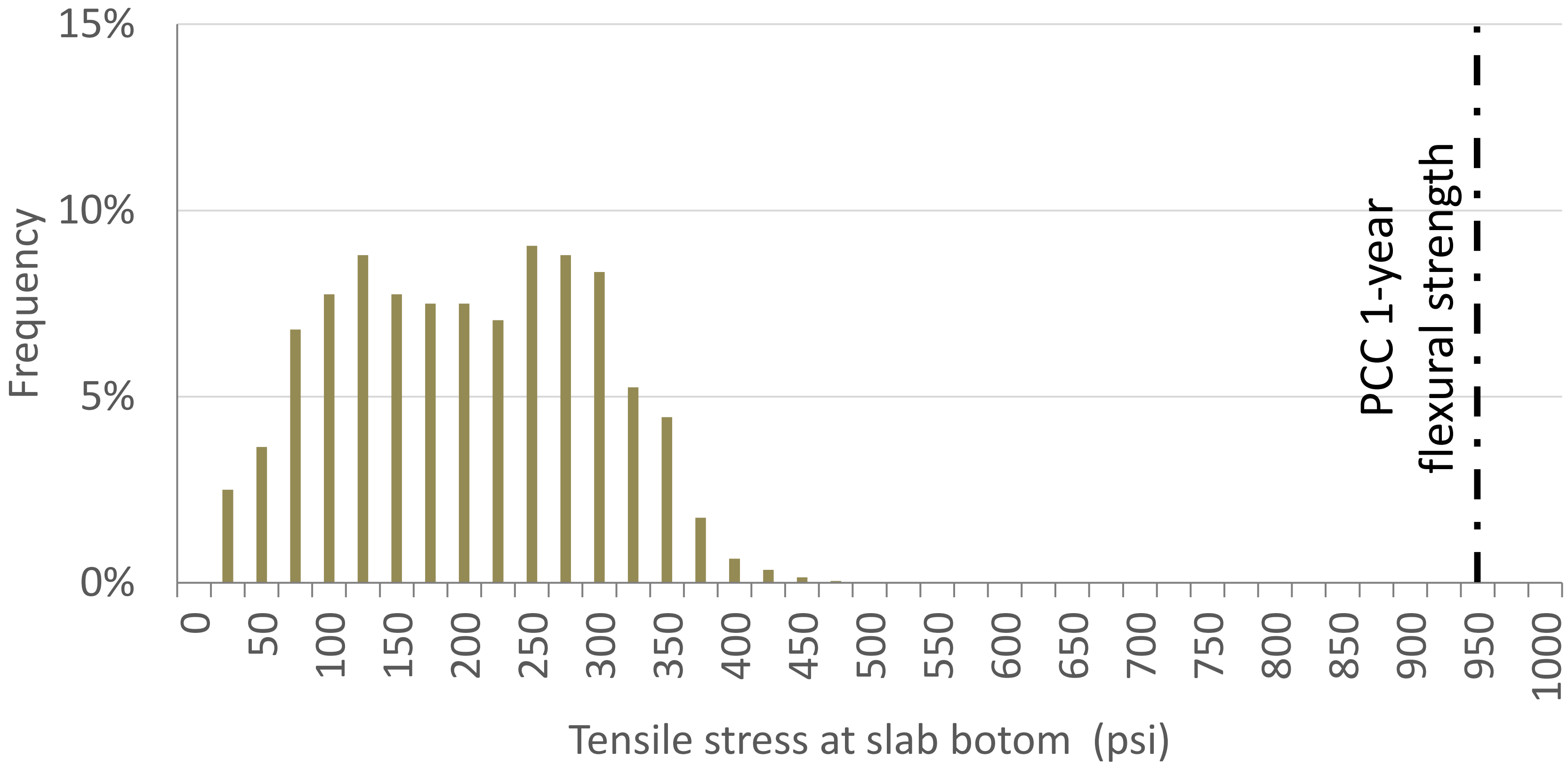
1. COA structure can be strong despite having barely any contribution from the asphalt base.

- After the milling operation, cracking and areas of delamination were present all over the project.
- Post-milling asphalt thickness between wheelpaths was 1-4 inches; most remaining asphalt was in poor condition.
- Initial concern since this project would not perform as a standard “thin BCOA”.

Main takeaways from the pilot implementation

What are the three main takeaways?

1. COA structure can be strong despite having barely any contribution from the asphalt base.
   - Mechanistic-empirical analysis, based on strain measured with resistive gages, combined with Monte Carlo simulation (variability of strain and strength), indicated that the tensile stresses created by heavy trucks are much lower than concrete strength.

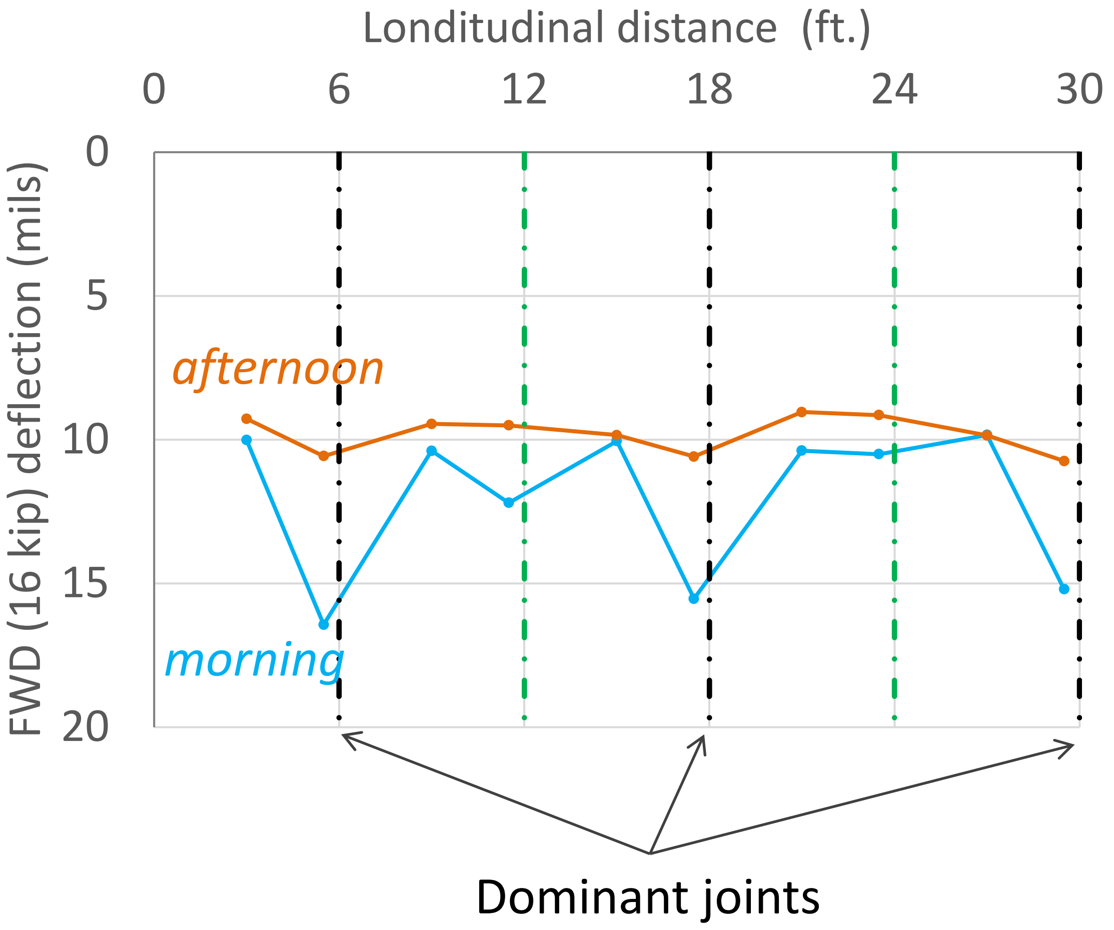


Monte Carlo simulation of the pass of a single axle overloaded 10% during winter time (lowest LTE)

Main takeaways from the pilot implementation

What are the three main takeaways?

2. Alternation of “dominant” and “passive” transverse joints. California is not immune to this issue of COA with short slabs (e.g. 6×6).



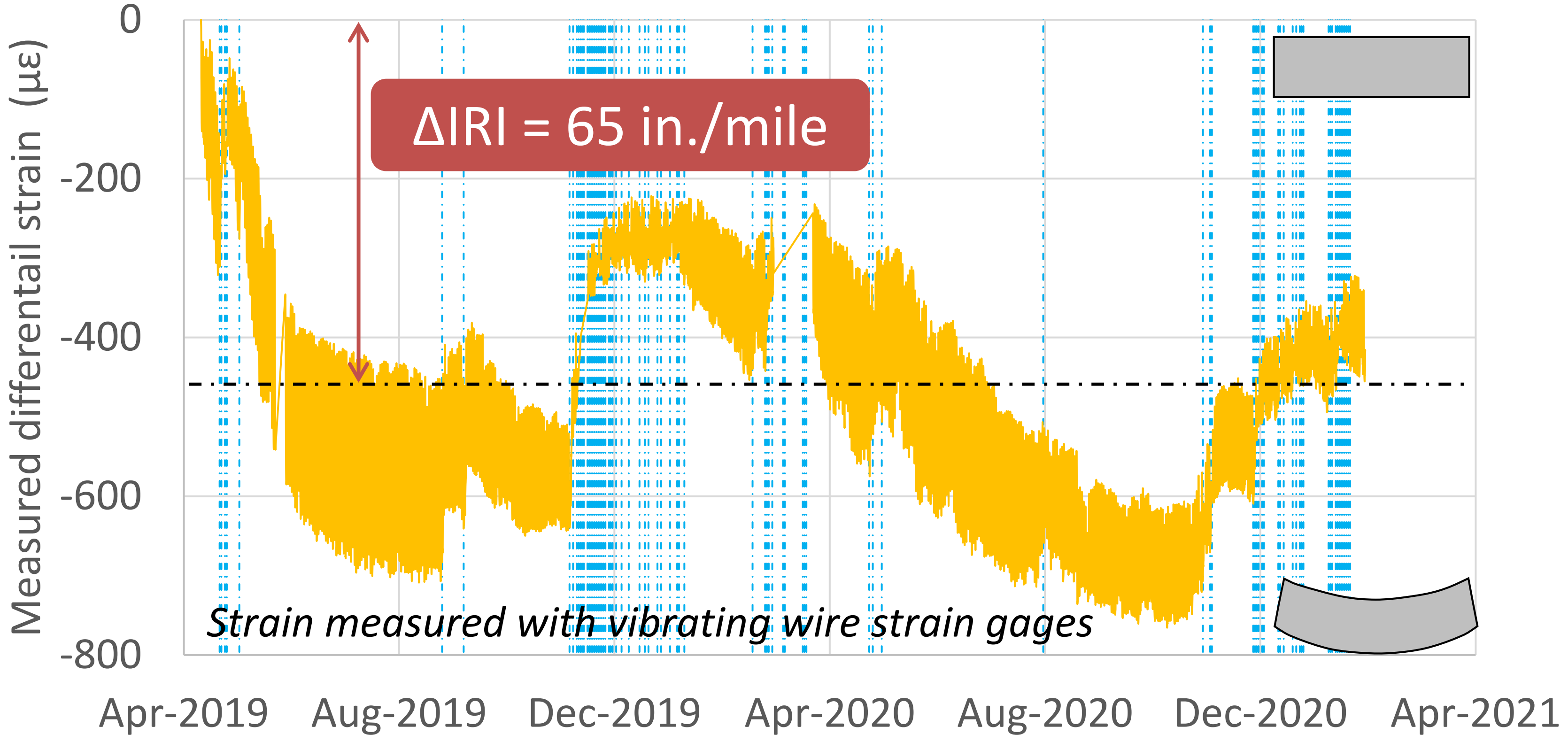
What do we know so far?

- The outcome is not necessarily due to lack of transverse joint deployment
- The dominant joints are the joints that deploy first
- The dominant joints match in the two lanes paved in different days (sympathy transverse joint deployment)
- Slab thickness may be an important factor
- The impact on structural capacity is not minor: PCC tensile stress doubles in *dominant* compared to *passive* transverse joints

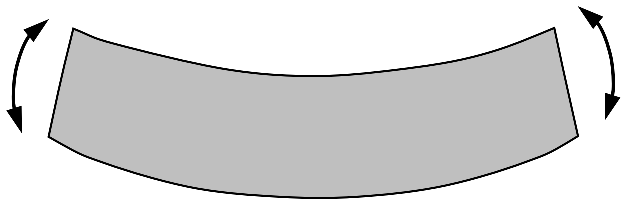
Main takeaways from the pilot implementation

What are the three main takeaways?

3. Conducting blanket grinding right after construction is not the optimum, especially in dry climates with thin slabs.
    - Blanket grinding is not uncommon in California due to strict post-construction IRI requirements (60 to 75 in./mile target)
    - Ideally, we want to wait one summer before conducting the grinding operation



Drying shrinkage trend: top shrinks versus bottom.



Main takeaways from the pilot implementation

Summary of initial performance report...

Publication in *eschlarship* coming soon

https://escholarship.org

XXX 2021

Technical Memorandum: UCPRC-RR-2021-XX

Concrete Overlay on Asphalt Pilot Project at Woodland SR113: Initial Performance

Authors:
Angel Mateos, John Harvey, Miguel Angel Millan, Fabian Paniagua, and Shuo Yang

Partnered Pavement Research Center (PPRC) Strategic Plan Element Number 3.39: Implementation and Field Performance Evaluation of Concrete Overlay on Asphalt (DRISI Task 3201)

PREPARED FOR:
California Department of Transportation
Division of Research, Innovation, and System Information
Office of Materials and Infrastructure

PREPARED BY:
University of California
Pavement Research Center
UC Davis, UC Berkeley

What are the topics that require further research and solution?

1. Dominant transverse joints
    - Better having two “B” transverse joints instead of one “A” and one “C”
    - Can we solve this issue?
2. Transverse joint load transfer efficiency (LTE)
    - How to predict LTE, including loss of LTE under traffic?
    - LTE needed for faulting and IRI
3. Long-term concrete-asphalt bonding
    - Can we predict/improve long-term concrete-asphalt bonding?
    - Reconsider full PCC-asphalt bonding hypothesis of current ME design procedures
4. COA performance in warm-dry climates like most California
    - Most experience come from wet climates (Minnesota, Illinois, Iowa, part of Colorado)
5. Extrapolation of ME design methods to scenarios where the asphalt base is not ideal (very thin and/or highly damaged asphalt base)
    - Some extrapolation may be straight forward

Conclusions

- The COA rehabilitation is already an alternative in Caltrans road network
- Some steps still required to full implementation
- Overall, the outcome of research and pilot implementation phases is highly positive
- While COA is a mature technology, some topics still require further research

Evaluation of Concrete Overlays over Asphalt (COA) under Accelerated Loading in Louisiana

Moinul Mahdi, PhD.
Zhong Wu, PhD., P.E.
Tyson Rupnow, PhD., P.E.

Outline

- Objectives
- Experimental Design
- Accelerated Pavement Testing
- Discussion of Results
- Summary

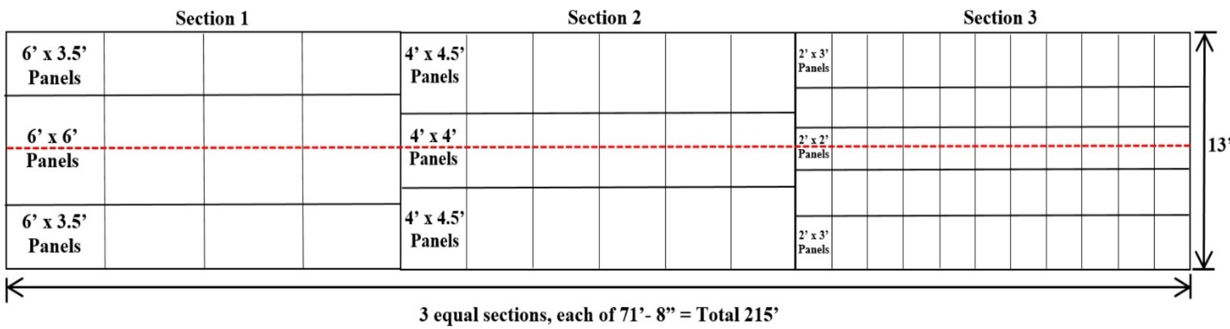
Objectives

- The overall objective of this research was
  - to evaluate the structural performance and load carrying capacity of COA pavement structures through accelerated pavement testing
  - to characterize the influence of in-situ bond strength on the performance of COA pavements.
  - to evaluate the potential benefits of using COA pavements and to develop a guidelines for COA pavements in Louisiana.

COA Experimental Design

COA Pavement Test Section

- **Three full scale** COA pavement section with **6-in., 4-in., and 2-in.** overlay thicknesses
- Saw-cut joints were prepared at a **2 × 2 ft., 4 × 4 ft. and 6 × 6 ft.** panel spacing on the loading areas of the 2-in., 4-in. and 6-in. overlays, respectively.
- Each pavement section is **13-ft. wide and 72-ft. long**.
- The existing pavement consists of a 3-in. existing AC layer, an 8.5-in crushed stone layer over a 10-in. cement stabilized subgrade,



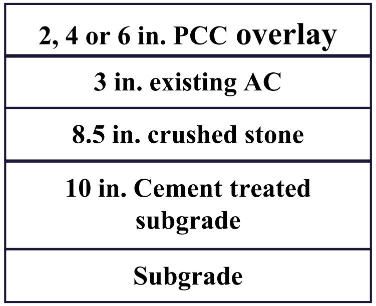


Figure: Pavement Cross Section

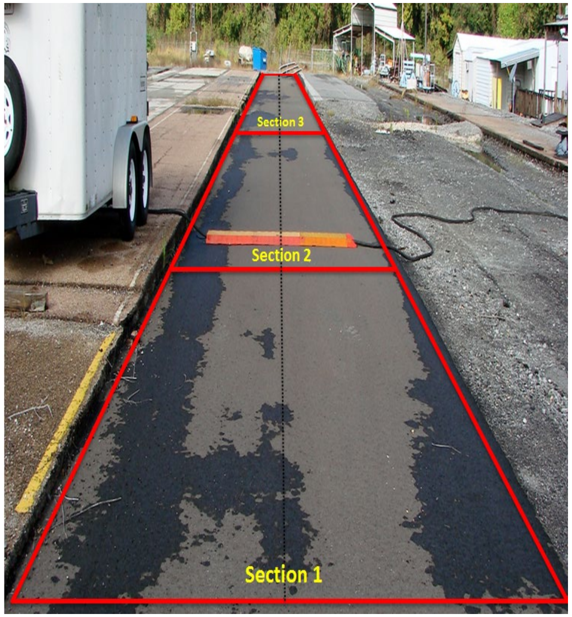


Figure: Old HMA Sections

Construction of COA Pavement Section

Milling and Surface preparation

Placement of concrete overlay

Levelling and Troweling of concrete

Broom Finish of COA sections

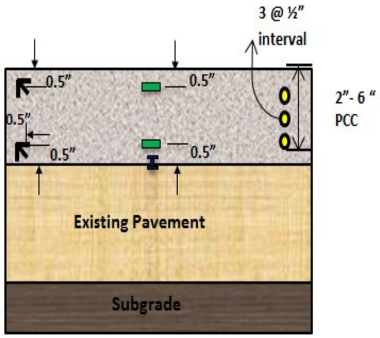
Curing of COA sections

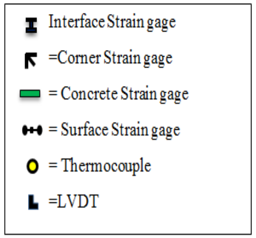
Saw Cut Joints

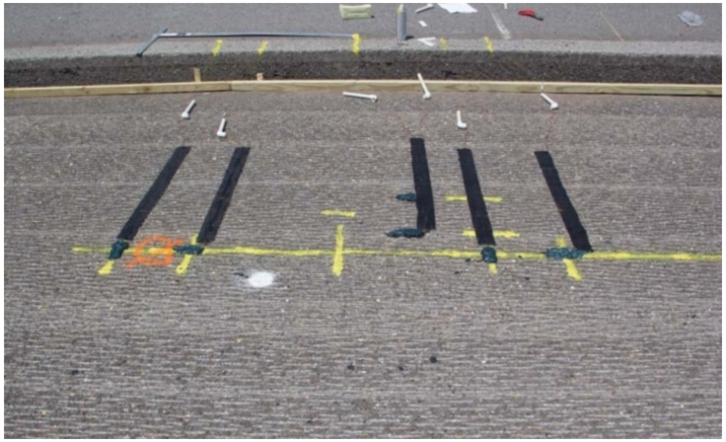
Instrumentation of COA Sections

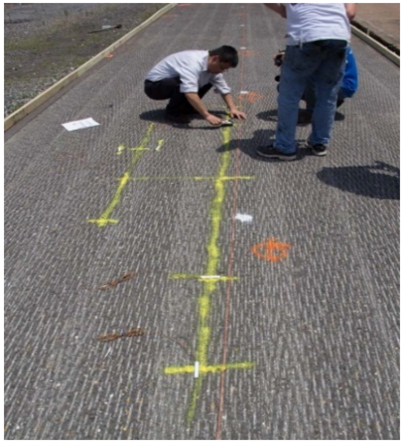
Strain gages used:

- Concrete strain gage (Tokyo Sokki PML-60-2L)
- Interface strain gage (WFLM-60-11-2LT)
- Surface strain gage (Tokyo Sokki PL-120-11)
- Corner strain gage (PLR-60-11)









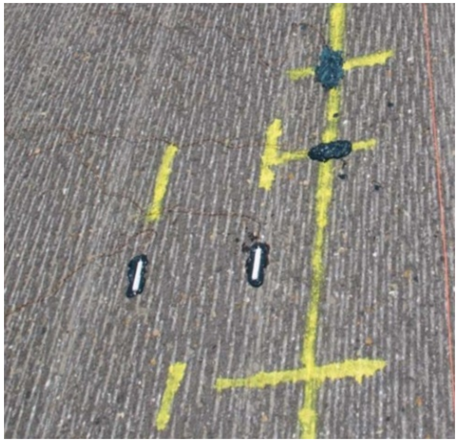
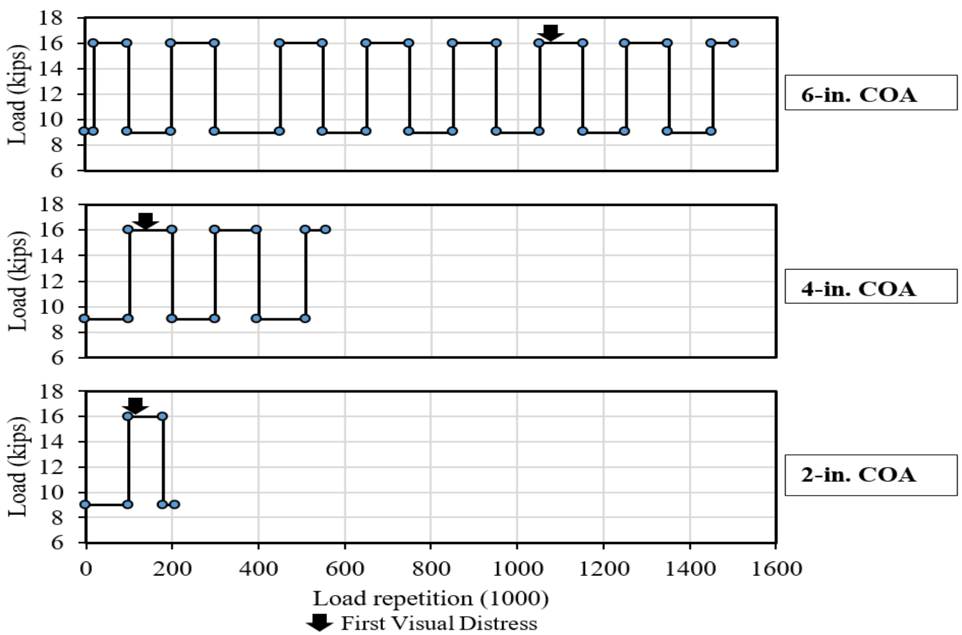


Figure: Instrumentation of COA Sections

Accelerated Pavement Testing

Accelerated Pavement Testing

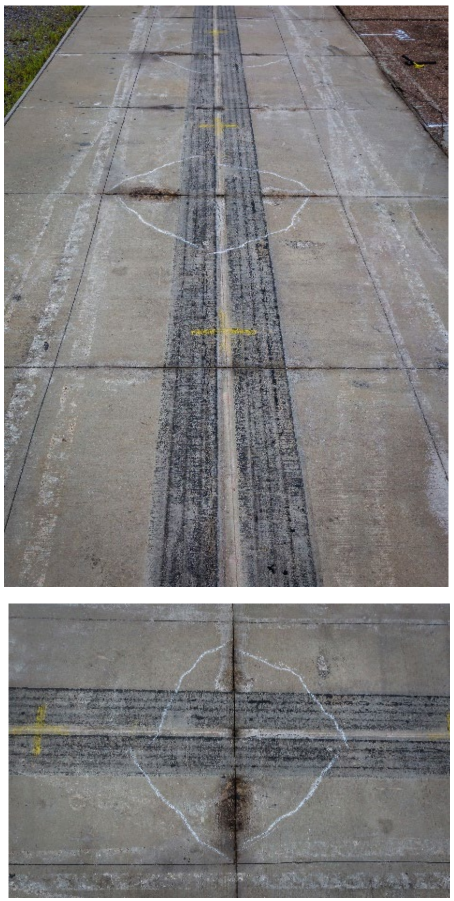
- **ATLaS 30**
- Dual-tire load
- Load: up to 30 kips
- Speed: 3~6 mph
- Bi-directional loading
- Effective loading length: 42 ft.
- About 10,000 passes/day



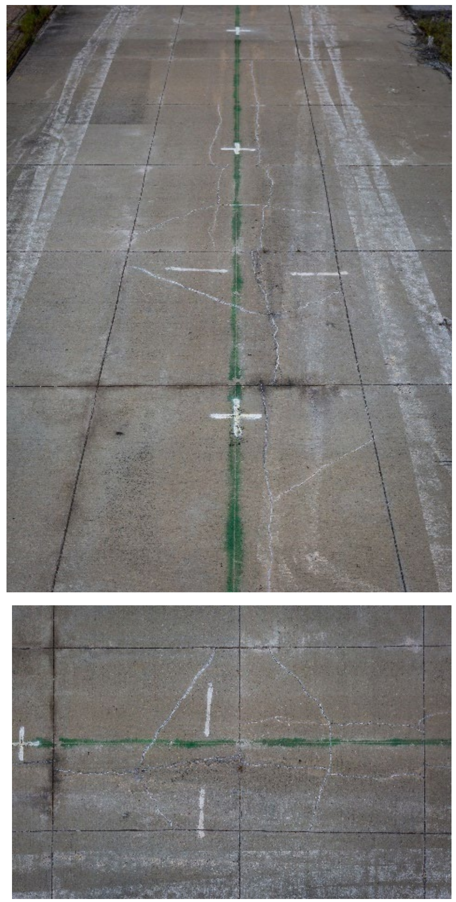
- Overall, one and half million-load repetitions (9 kip & 16 kip) were applied on the 6-in. COA section; 560,000 repetitions were loaded on the 4-in. sections; and 210,000 repetitions were added on the 2-in. section

COA Pavement Performance

- In situ failure conditions of each COA test section tested in this study



6-in. Section

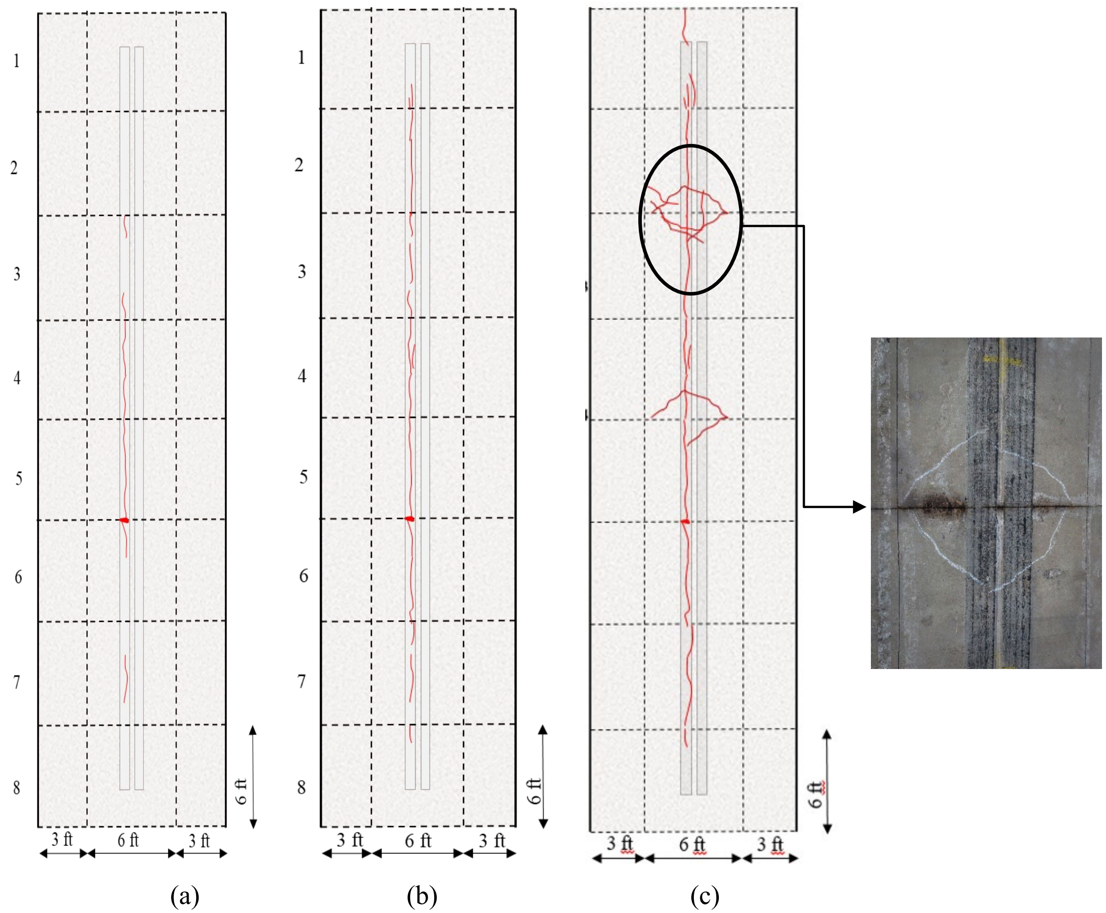


4-in. Section

2-in. Section

Crack Propagation of 6in. COA Sections

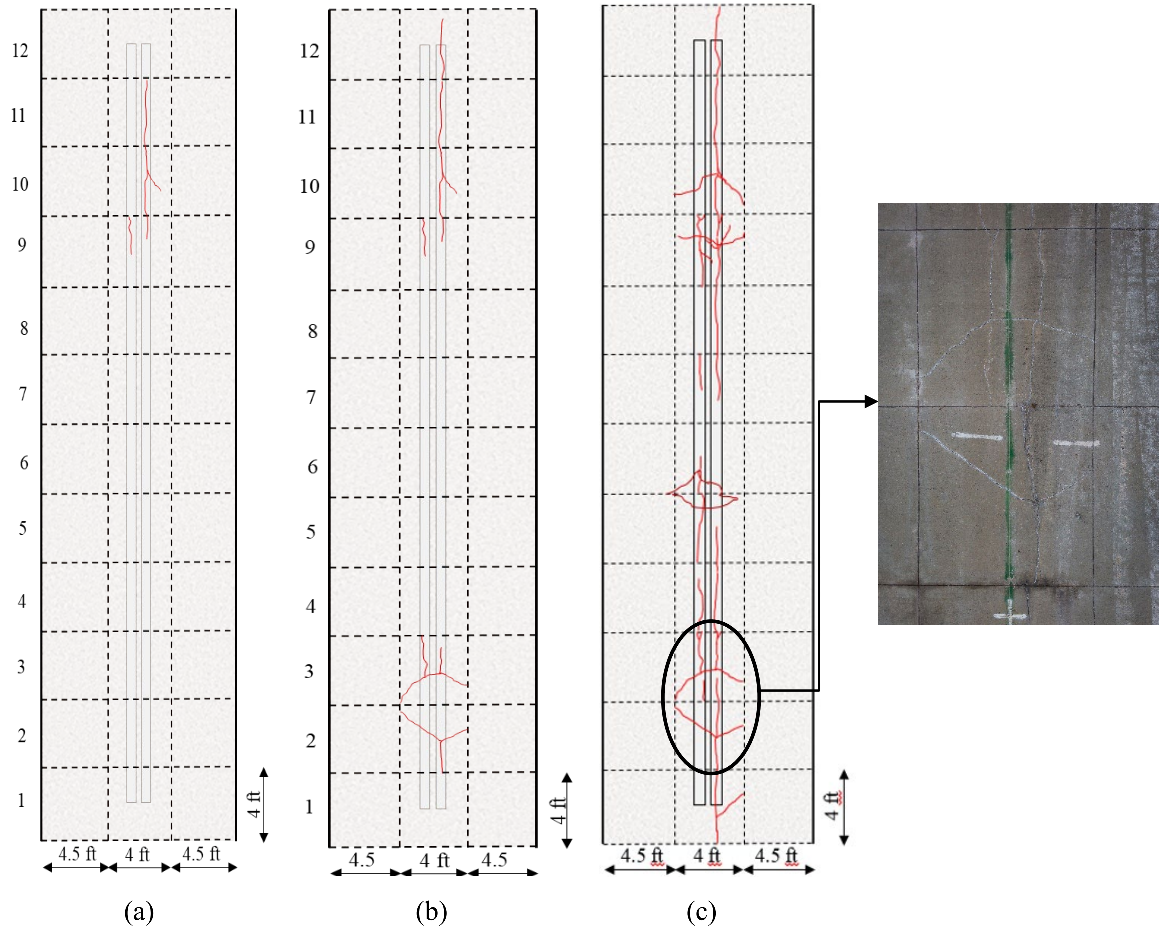
- A total of one and half million-load repetitions (i.e., 750,000 of 9-kip and 750,000 of 16-kip) were applied on the 6-in. BOCA section
- The crack was initiated in longitudinal direction initially followed by random fatigue cracking.
- Cracks initiated near the joint location and at the weakest subgrade location.
- Load repetitions are equivalent to **8.9 million ESALs** for the 6-in COA sections and approximately 51% of the loaded area was cracked.



Crack mapping of the 6-in. COA section at load repetition of (a) 1,100,000; (b) 1,500,000; and (c) 1,700,000

Crack Propagation of 4in. COA Sections

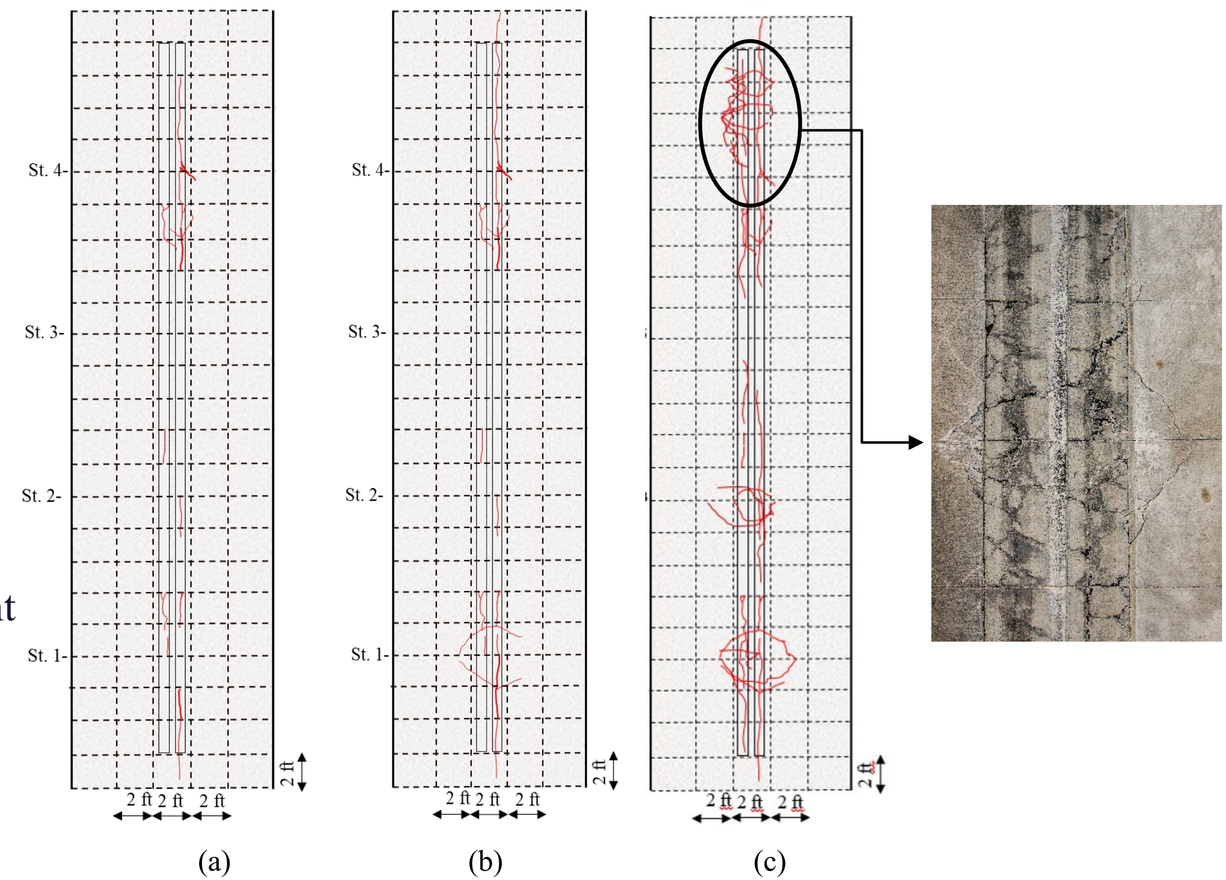
- A total of 560,000 repetitions (i.e., 310,000 of 9-kip and 250,000 of 16-kip) were loaded on the 4-in. sections.
- The crack was initiated in longitudinal direction initially followed by corner cracks.
- Cracks initiated near the joint location and at the weakest subgrade location
- Load repetitions are equivalent to **3.5 million ESALs** for the 4-in COA sections and approximately 54% of the loaded area was cracked.



Crack mapping of the 4-in. COA section at load repetition of (a) 200,000; (b) 350,000; and (c) 550,000

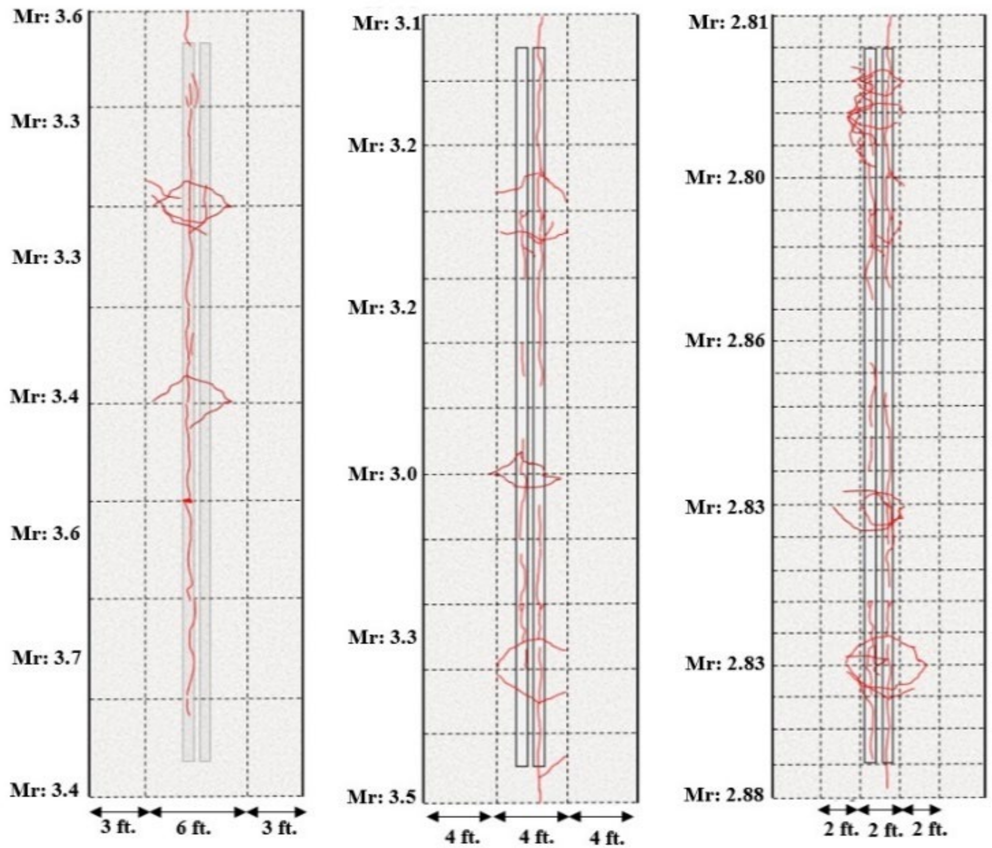
Crack Propagation of 2in. COA Sections

- A total of 210,000 repetitions (i.e., 130,000 of 9-kip and 80,000 of 16-kip) were added on the 2-in. section
- Corner cracks developed first and severe localized failure observed.
- Severe cracking observed at the weakest subgrade location
- Load repetitions are equivalent to **1.2 million ESALs** for the 2-in COA sections and approximately 59% of the loaded area was cracked.



Crack mapping of the 2-in. COA section at load repetition of (a) 150,000; (b) 180,000; and (c) 200,000

Crack Mapping of Failed COA Sections



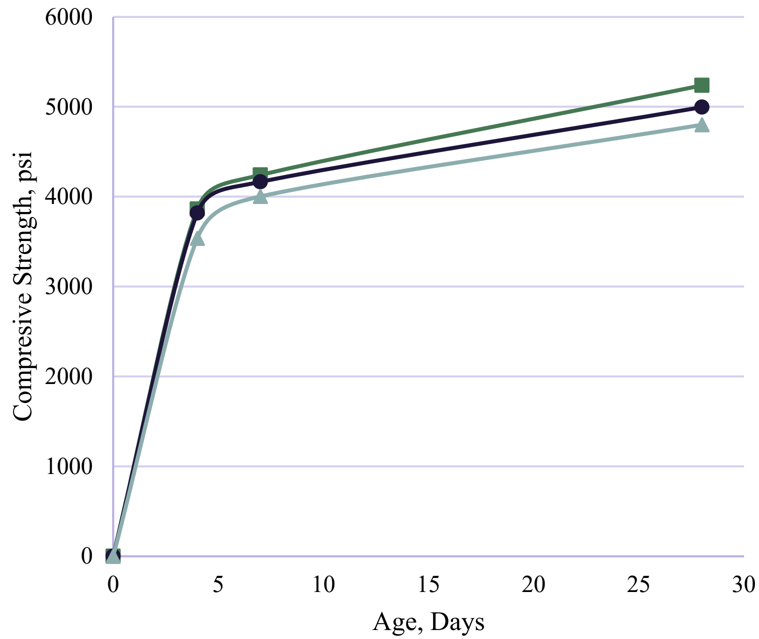
6-in. Section **4-in. Section** **2-in. Section**

- The majority of the cracks found in the 6-in. section were longitudinal cracks, followed by random cracks.
- On the other hand, more corner cracks were found on the 2-in. and 4-in. sections.
- This supports the current mechanical-empirical COA design guideline

Discussion of Test Results

Laboratory Test Results

- Cylindrical samples were prepared during construction for compressive strength test
- Flexural strength tests was conducted on field prepared beam samples



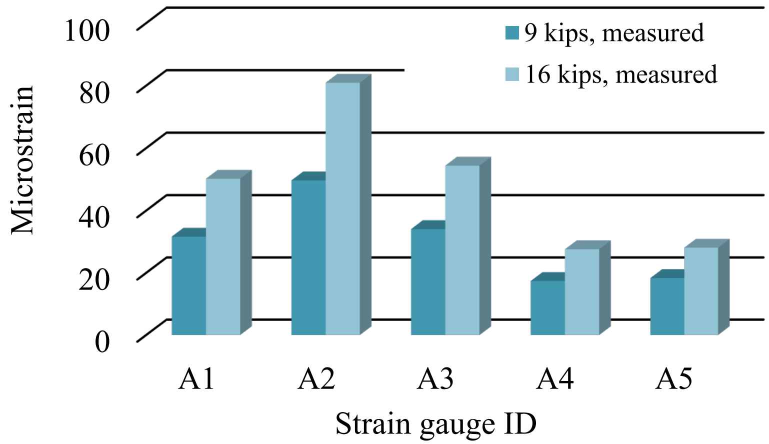
Compressive strength Test Results

Age: 28day	6in	4in	2in
Sample1	685	707	651
Sample2	715	774	658
Sample3	669	725	609
Avg.	**690**	**735**	**639**

Flexural strength Test Results

Instrumentation Results

- Strain gauge **A2** measured the most **critical transverse strain** underneath a saw-cut joint
- A **higher transverse strain** indicates a **longitudinal cracking potential**, which resulted in the cracking pattern
- The strain Gauges A4 and A5, which were installed adjacent to each other, showed much **lower longitudinal strain** readings as compared with others at the bottom of saw-cut joints



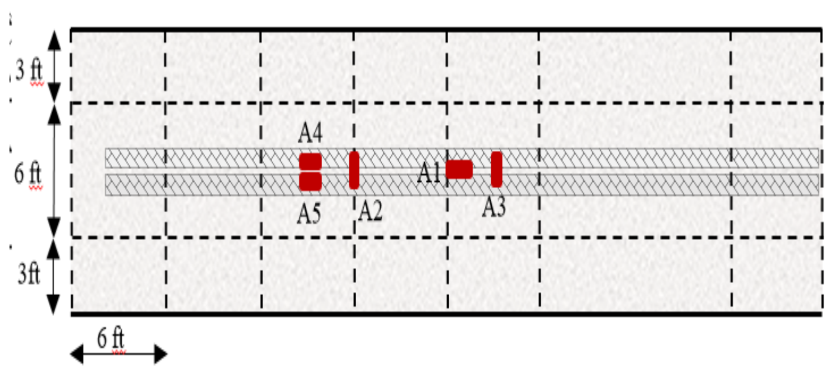


Figure: Instrumentation responses under accelerated loading

NDT Test Results

- **Summary of Backcalculated PCC Moduli and Average IRI**

	PCC Modulus, E (ksi)			IRI (in/mile)		
Section	**Before loading**	**After Loading**	**Reduction (%)**	**Before loading**	**After Loading**	**ΔIRI**
6-in. COA	4030	1788	**60**	150	216	**97**
4-in. COA	4612	1626	**61**	155	255	**100**
2-in. COA	3081	484	**85**	235	444	**193**

- FWD deflections under four load levels (i.e., 9,000-, 12,000-, 15,000- and 25,000-lb) were used to evaluate possible voids formed underneath the COA slabs
- All three test sections had no indications of voids (i.e., the relative size of voids are less than 2.0 mils) before the APT loading
- At the end of this experiment all three sections were found to have at least one location with the relative size of voids greater than 2.0 mils.

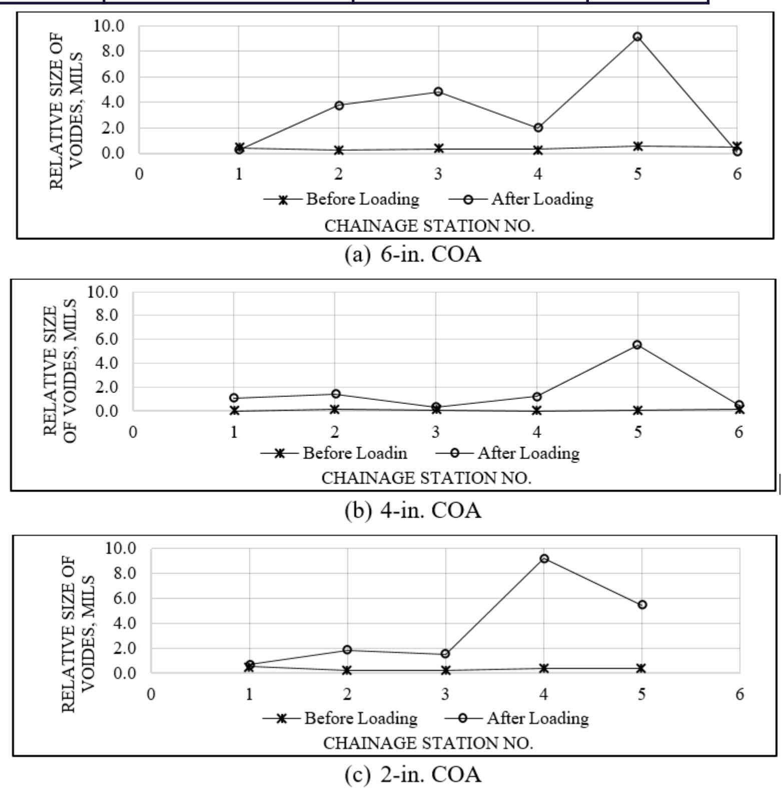
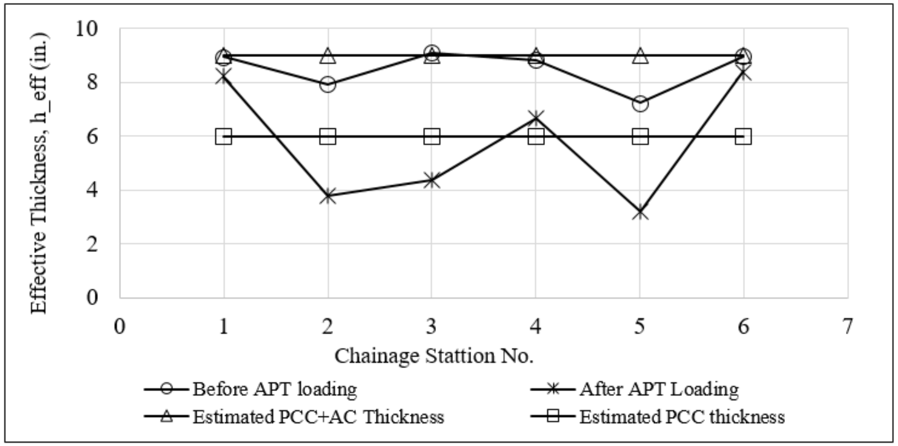


Figure: Loss of support on COA test sections

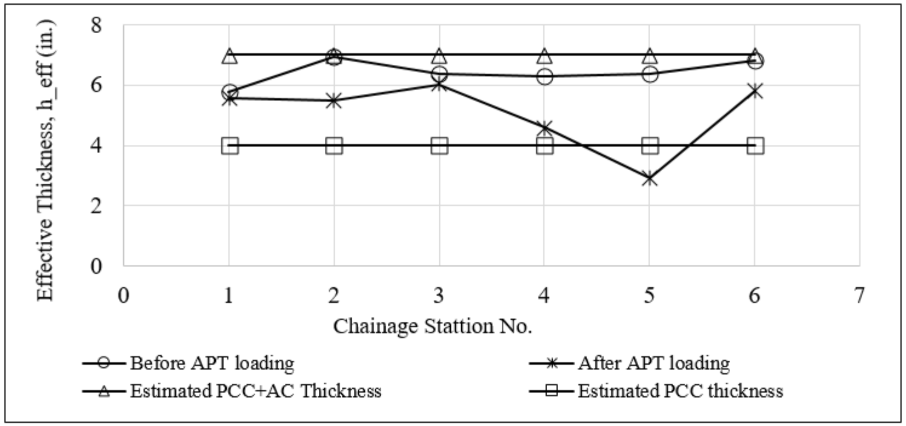
NDT Test Results

- **Backcalculated effective slab thickness before and after APT testing**

- At the beginning of the APT testing, the calculated effective thickness for both pavement test section indicates sufficient support stiffness
- At the end of the APT testing, a decrease in effective thickness was observed at multiple location on both COA pavement section.
- This decrease may be due to the deterioration in the asphalt and PCC layer or could be due to the debonding at the PCC asphalt interface.



(a) 6-in. COA with 6 by 6 slabs



(b) 4-in. COA with 4 by 4 slabs

Figure: Effective slab thickness before and after APT testing

Bond Strength Characteristics

- In-situ tensile pull of test results

	6-in. COA Bond Strength (psi)		4-in. COA Bond Strength (psi)		2-in. COA Bond Strength (psi)	
Core Location	**Loaded**	**Unloaded**	**Loaded**	**Unloaded**	**Loaded**	**Unloaded**
1	97.2	104.4	95.7	116.1	124.7	197.3
2	62.4	101.5	0*	66.72	88.5	95.7
3	98.6	132.0	92.8	166.8	0.00	117.5
4	42.1	113.1	42.1	102.9	0.00	131.9
Average	75.1	112.8	57.7	113.13	53.3	135.6
% Reduction	**33.4**		**49.1**		**60.7**	

* a complete core could not be drilled due to debonding

- The pull-off test was conducted after 2 years of overlay placement and the bond strength could be affected by the differential movements between substrate and overlay due to temperature and shrinkage

Figure: Pull-off Test of COA Sections

Forensic Investigation

- A post mortem transverse trench slab was cut on a failure area of each test section after the APT testing
  - The majority of longitudinal cracks under the wheel path are bottom-up cracking.
  - It also revealed that the saw cutting joints were cracked through along the PCC slab thickness at the end of APT loading.

2in. COA **4in. COA** **6in. COA**

(a) Crack initiating debonding

(b) Crack propagating to AC

(c) Saw cut joint cracked through

(d) Debonding at interface

Forensic Trenches of COA pavement sections

Summary and Conclusion

- The 6-in. COA had a **superior load carrying capacity** compared to the 4-in. and 2-in. concrete overlays tested in this study.
- Fair to good bond strengths were found on all COA sections. A bond strength criterion can be specified to determine the bonding failure for COA pavements. Based on this experiment, it is recommended that the bond strength should be considered to predict the interface bonding failure and in the fatigue analysis for BCOA pavement design.
- A slab panel size should not be more than **half the lane width**, which would result in a greatly reduced number of wheel loads on the slab corners as well as reduced joint forming and sealing costs.
- A well designed thin (4 to 6 in.) COA pavement with half-lane width slabs placed on top of a good to fair milled asphalt base can be a good alternative to the current practice of asphalt concrete surfacing for those roadways with heavy truck trafficking in Louisiana.

Acknowledgements

This project was supported by the Louisiana Department of Transportation and Development (LADOTD) and the Federal Highway Administration (FHWA) under LTRC Project 14-4C.

Thank you!

Research and Implementation of COA in Minnesota

Tom Burnham, P.E. | Senior Road Research Engineer, Minnesota Department of Transportation

TRB Webinar: Concrete Overlays of Asphalt

3/11/2021

Topics

- **History of COA research in Minnesota**
- **Implementation and field performance**
- **Lessons Learned**
- **What's next?**

COA Research in Minnesota

- **TH30 Amboy, MN - 1993**
  - **MnDOT's first modern whitetopping**
  - **8.5 mile project: 4 COA test sections (2.5 miles total length)**
  - **Very low volume rural road**
  - **6" JPCP, 12'x12' panels, on 4.25" HMA over cement treated soil base**
  - **Variables: doweled joints, milled vs unmilled HMA, bond breaker**

Lessons learned:

- **Perfect application, still in service – very low volume road**
- **Easily rehabbed (@age 18 yrs)**
- **Section with bond breaker = worst performance**

COA Research in Minnesota

- **US 169 North Mankato, MN – 1995**
  - **Medium volume intersection (102 ft long)**
  - **Milled down to 9” of HMA**
  - **3” JPCP and FRC (structural fibers and non-structural fibers)**
  - **Variables: panel size (6’x10’, 6’x12’), fiber type (3 lbs/yd^3 polypropylene, 25 lbs/yd^3 polyolefin)**

Lessons learned:

- **Performance history difficult to find**
- **Short lived – frequent stopping of heavy trucks = cracking!**
- **“Shrinkage” fibers provide no performance enhancement**
- **“Structural” fibers did not significantly slow crack growth**

COA Research in Minnesota

- **TH14 North Mankato, MN – 1996**
  - **Lower volume, heavy truck traffic route**
  - **6”, 4.5” & 3” FRC (structural fibers), on 5.5” to 8.5” of milled HMA**
  - **Variables: panel size (5’Lx6’W,4.5’Lx6’W, 10’Lx12’W), fiber type (25 lbs/yd^3 polyolefin)**

Lessons learned:

- **Short lived - significant faulting**
- **Structural fibers did not prevent joint faulting**
- **Some panel buckling**

COA Research in Minnesota

- **Elk River, MN - 1997**
  - **3 Medium volume intersections**
  - **Heavy truck loadings (frequent stopping)**
  - **3” JPCP/FRC, 3” remaining HMA (marginal condition)**
  - **Variables: panel size (4’x4’, 6’x6’), fiber type and dosage (3 lbs/yd^3 polypropylene, 25 lbs/yd^3 polyolefin)**

Lessons learned:

- **Short lived – significant cracking**
- **Need minimum 3” of good HMA**

Photo from https://pubsearch.dot.state.mn.us/research/pdf/2002MRRDOC001.pdf

COA Research in Minnesota

- **MnROAD – 1997**
  - **Test Cells 92-97**
  - **Medium volume interstate traffic**
  - **Inlays into full depth 13” HMA (4 years old at time)**
  - **Variables**
    - **Thicknesses: 3”, 4”, 6”**
    - **Panel sizes: 4’x4’, 5’Lx6’W, 10’Lx12’W**
    - **Doweled, undoweled (larger panel thicker cells)**
    - **Fiber: 3 lbs/yd^3 polypropylene, 25 lbs/yd^3 polyolefin**

COA Research in Minnesota

- **MnROAD – 1997**

Lessons learned:

- **Keep longitudinal joints away from wheel paths**
- **Shrinkage fibers do not contribute to load capacity**
- **Ultra-thin sections failed in cracking before faulting**
- **10'Lx12'W undoweled joints faulted significantly**
- **10'Lx12'W panels cracked in half longitudinally (seeking 6'width)**

❖Cell 96", 6" FRC, 5'Lx6'W panels with heavy fiber dosage still in service (24 yrs); Multiple HMA surface treatments due to ongoing severe joint deterioration

COA Research in Minnesota

- **MnROAD – 2004**
  - Test Cells 60-63
  - Medium volume interstate traffic
  - 7” and 8” remaining HMA
  - Panel size: 5’Lx6’W
  - Variables
    - Thicknesses: 4”, 5”
    - Joints sealed, unsealed

Lessons learned:

- 4” unsealed section failed first (loss of bond)
- Joint faulting began after 5 years
- Some breached joint seals performed worse than unsealed joints

COA Research in Minnesota

- **MnROAD, MN – 2008**
  - **Test Cells 114-914**
  - **Medium volume interstate traffic**
  - **Thickness: 6”**
  - **Unsealed joints**
  - **Variables**
    - **5” to 8” remaining HMA (15 yrs. old)**
    - **Panel size: 6’Lx6’W, 12’Lx6’W**
    - **Dowels: None, 1” dia. 2 ft o.c., thin plates (in 12’L panels)**

Lessons learned:

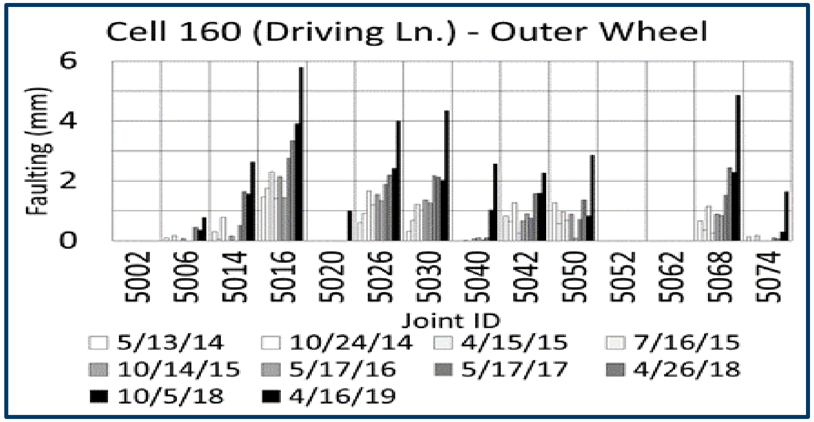
- **Minimal panel cracks (including no reflective cracks)**
- **Significant faulting in undoweled cells**
- **Some distress over widely spaced dowels**
- **Panel migration (loss of bond)**

COA Research in Minnesota

- **MnROAD, MN – 2013**
  - ➢ Test Cells 160 and 162
  - ➢ Medium volume interstate traffic
  - ➢ Synthetic structural fibers (20% RSR)
  - ➢ 6'x6' panels, ***sealed*** joints
  - ➢ Variables
    - 4" and 5" (6.5 lbs/yd^3 structural fibers)
    - Remaining HMA 6"- 7"

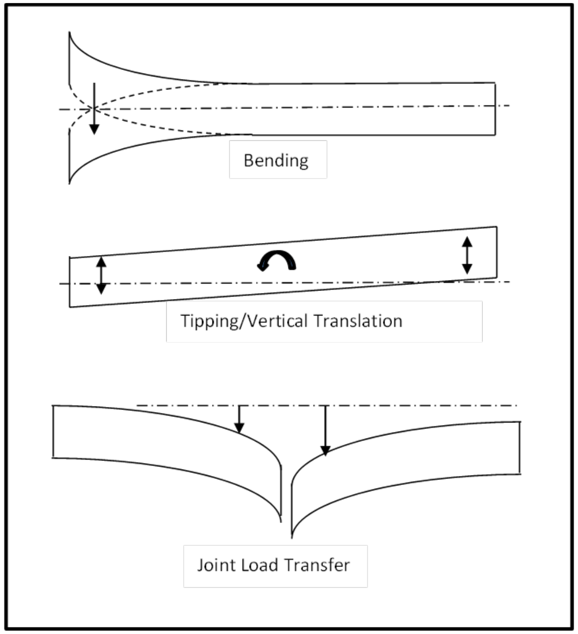
Lessons learned:

- Less cracking than non-fiber Cells 60-63
- Noticeable faulting after 5 years
  - ➢ 4+ million ESALs
  - ➢ Fibers struggle to slow faulting



COA Research in Minnesota

- **Characterization of COA panel movement**



Findings: COA panels *bend*, not rock

Burnham, Thomas R., Huerta, Santiago B., and Manik Barman. *"Characterizing the Movement of Thin Concrete Overlay Panels Subject to Truck Loads."* Proceedings of International Conference on Concrete Pavements. San Antonio, Texas. August 28- September 1, 2016. pp. 150-166.

Statewide Performance Study

- 26 Large scale projects in Minnesota (pre - 2015)
  - MnDOT
    - TH30 (1993)
    - TH212 (2009)
    - I-35 (2009)
    - TH56 (2010)
    - TH24 (2014)
  - County
    - 21 projects (2009-2014)
- 21 MnROAD test sections
  - Test cells (1993-2013)


Development of Performance Curves for Whitetopping in Minnesota

PHASE 1 - FINAL REPORT

Prepared by:

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Field Condition Surveys

- GPR for thickness variation
- 3 core samples
  - Assess bond quality
  - GPR thickness calibration
  - HMA assessment (associated project selection study)
- Profiled for IRI (multiple times)
- Visual distress surveys (multiple times)
- Fault measurements (limited # joints)

Field Observations

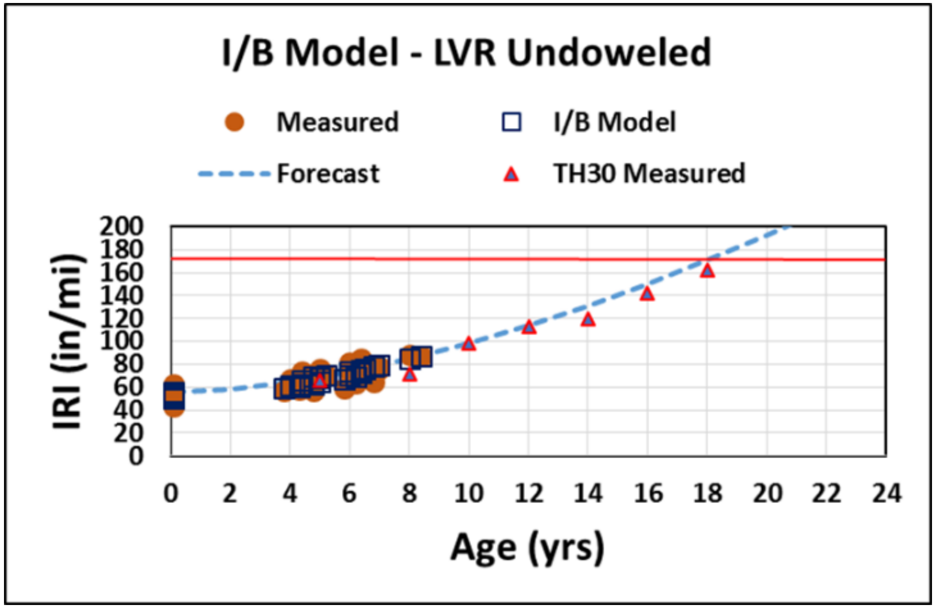
- **Most projects are good to very good condition**
  - **Most are still "young" (8 or less yrs. old)**
  - **Some longitudinal cracking**
  - **Surprising lack of transverse reflective cracks**
    - **I-35 cracked early, but has stabilized (no repairs)**
  - **Little to no maintenance on most projects**

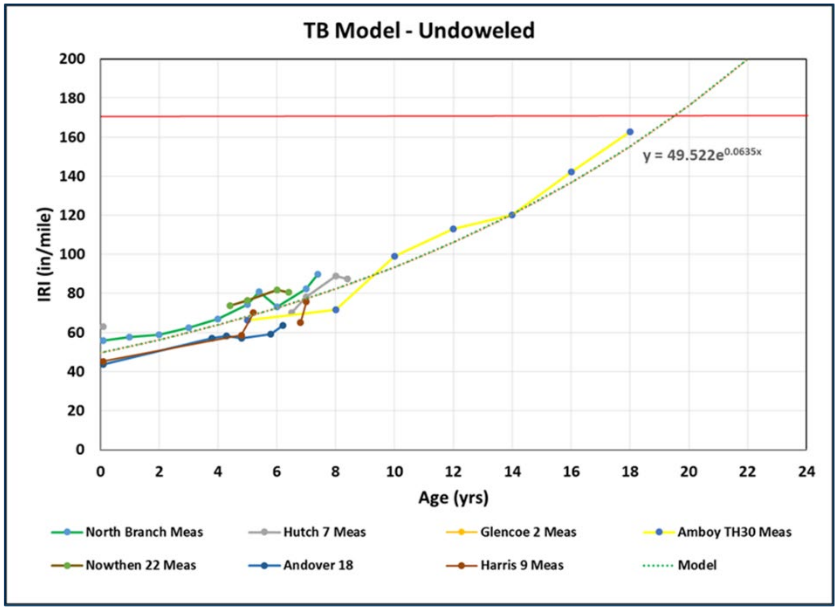
- **Cause of distresses**
  - **Construction practices (thickness variation due to milling)**
  - **Design (matching joints to HMA cracks)**
  - **Buckled panels ("light" panels, incompressibles)**

Field Observations

- **Faulted transverse joints in projects with heavy truck volumes/loads**
  - **Attempts to match overlay joints to underlying HMA cracks seems to lead to early faulting (full-depth vertical movement)**
  - **TH22 Olmsted County project had to be diamond ground after 5 years of service**
- **With shorter joint spacing, not all joints deploy**

Overall Performance Models





For Minnesota conditions: ~ 18 to 20 years to IRI =170 in/mi (assuming no maintenance or rehab)

NCHRP 01-61 Study

- **Evaluation of Bonded Concrete Overlays on Asphalt Pavements**
  - **National study of COA performance**
  - **Under final review**
  - **Final Report to be published in 2021**

Lessons Learned

- **If designed and constructed properly:**
  - Very low maintenance
  - 20+ years life under lighter traffic
  - Easy to repair
    - Full panel repairs
    - Diamond grinding

TH 30 Amboy: 27 years old

- **Keep longitudinal joints away from wheel path**
  - Corners breaks on 4’x4’ panels
  - Small, square-like, panels work best (6’x6’)

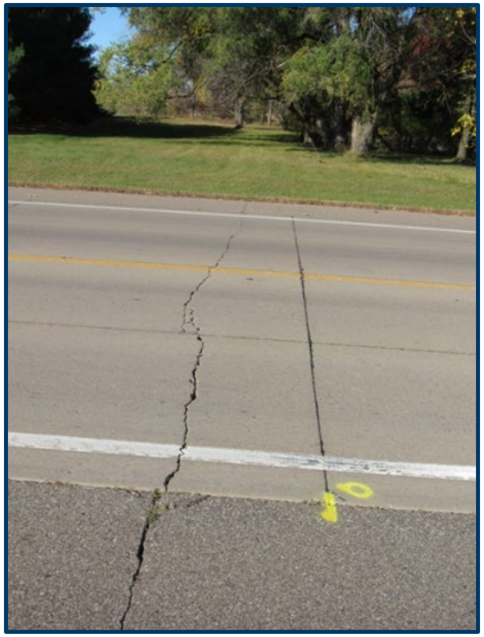
Lessons Learned

- **Need minimum of 3” of <u>good</u> condition remaining HMA**
  - **Survive paving process**
  - **Reduced tensile forces as long as layer bonding is available**

- **Heavy truck loadings = faulted joints**
  - **Physics: relatively “light” panels get pushed around by momentum forces**
  - **Hydraulic forces in joints strip HMA, leading to loss of support**
  - **Viscoelastic deformation of HMA in high temperatures**
  - **Currently specified fibers unable to mitigate transverse joint faulting**
  - ★ **Structural fibers do mitigate panel migration**

Lessons Learned

- **Northern climates can lead to reflective cracking**
  - **Even >6” inch thick COA can be breached**



- **Not all transverse saw-cut joints will deploy (in short panels)**
  - **Leads to dominant (wide) joints**
  - **Uneven curling affects ride quality**
  - **Intermittent faulting patterns**

Lessons Learned

- **Joint sealing performance = mixed results**
  - **Sealing extends layer bonding**
    - **Necessary for ultrathin COA performance**
  - **Sealing/filling necessary to keep out incompressibles**
    - **Especially need with gravel shoulders to prevent panel buckling**
  - **Current sealing practices are short-lived**
    - **1 to 2 years with hot pour asphalt materials in 1/8” wide saw-cuts**
  - **Seals must be maintained**
    - **Partially sealed joints shown to perform worse than non-sealed joints**

“More Research is Needed”

- **Fibers (synthetic)**
  - **Can they maintain tight cracks?**
  - **Can they aid in joint load transfer (delay or mitigate faulting)?**

- **Joint sealing**
  - **Improved materials (more elastic, shape memory)?**
  - **Improved reservoir geometry (easier to clean during installation)?**
  - **Improved drainage design to mitigate water stacking up in joints?**
    - **Still need to keep incompressibles out**

- **Joint deployment**
  - **Is it possible to deploy more 6’x6’ joints with very early loadings?**

Questions?

Tom Burnham

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Today's Panelists

#TRBWebinar

Moderator: Julie Vandenbossche, *University of Pittsburgh*

Moinul Mahdi, *Louisiana State University*

Angel Mateos, *University of California, Berkeley*

Tom Burnham, *Minnesota DOT*

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