MnDOT Concrete Pavement Research – Recent Implementation and Ongoing Studies

NCC Spring 2014 Meeting
Jacksonville, FL
April 22nd, 2014

Tom Burnham, P.E.
Minnesota Department of Transportation

Office of Materials and Road Research

NCC Survey on Research

- 37 Projects
- FHWA Sponsored: 1
- Pooled Funds: 6
- Minnesota DOT: 19
- Local Road Research Board: 2
- MnROAD: 9

Will highlight 7 implemented products and
6 recently completed or ongoing studies

Implemented Research

Implementation of an International Roughness Index for Mn/DOT Pavement Construction and Rehabilitation

- MnDOT funding
- P.I. Jim Wilde, Minnesota State University- Mankato
- Completed in 2007
- CP Road Map tracks: 4, 8

Implementation of an International Roughness Index for Mn/DOT Pavement Construction and Rehabilitation

- Objectives: Develop an implementable specification for the use of the International Roughness Index (IRI) for smoothness incentives and disincentives on concrete pavements in Minnesota (switch from Profile Index)

- Product(s): Recommendations for modifying the 2006 pilot specification for using International Roughness Index for concrete pavements in Minnesota.

Implementation of an International Roughness Index for Mn/DOT Pavement Construction and Rehabilitation

D.1.b Concrete Pavements

For concrete pavements, the Engineer will use equation PCC-A.

Table 2399-5
Smoothness Pay Adjustments and Corrective Work for Concrete Pavements

Equation	Smoothness in/mi [m/km]	Pay Adjustment $/0.1 mi [0.16 km]
PCC-A	< 50.0 [0.79]	890.00
	50.0 – 90.0 [0.79 – 1.42]	2940.00 − 41.000 × Smoothness [2940.00 − 2597.800 × Smoothness]
	> 90.0 [1.42]	Corrective Work to ≤ 71.7 in/mi [1.13 m/km]

Study of Surface Characteristics for Rehabilitating Existing Concrete Pavements

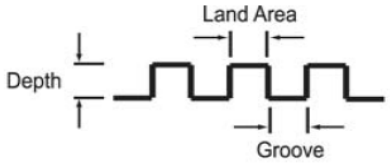
- Pooled funds: MN, TX, FHWA
- P.I.s: Bernard Izevbekhai, MnDOT
  Jim Wilde, Minnesota State University- Mankato
- Completed in 2010
- CP Road Map track: 4

Study of Surface Characteristics for Rehabilitating Existing Concrete Pavements

- Objectives:
  1) To evaluate the initial effects of various diamond grinds on concrete pavement surfaces
  2) To observe the changes in surface characteristics during the first several years after grinding

- Findings: (Conventional Diamond Grinding)
  1) Immediate increase in mean texture depth, with a quickly declining value over the first year after grinding
  2) Texture measurements then leveled off with little further change, but in most cases greater than the pre-grind texture
  3) Ride quality measurements indicated generally constant performance

Study of Surface Characteristics for Rehabilitating Existing Concrete Pavements



a) General Configuration

Conventional Grind Cell 8

c)Innovative Grind Cell 7

d)Ultimate Grind Cell 71 & Duluth

- Conventional diamond grinding used frequently in conjunction with CPR
- Specification for Next Generation Concrete Surface (NGCS)

Evaluation of Skid Resistance of Turf Drag Textured Concrete Pavements

- MnDOT funding
- P.I. Tim Nelson, MnDOT
- Completed in 2011
- CP Road Map track: 4

Evaluation of Skid Resistance of Turf Drag Textured Concrete Pavements

- Objectives:
  1) Examine performance of concrete pavements with Astro-Turf drag texture
  2) Develop friction degradation models

- Findings:
  1) 3 friction degradation models were developed and validated
  2) Rate of friction degradation was proportional to the FN value
  3) Turf drag provides sufficient texture if the proper mix design, construction and maintenance practices are followed

Use of Non-woven Fabric Interlayer for Unbonded Concrete Overlays

- MnDOT funding
- P.I. Lev Khazanovich, University of Minnesota
- Completed in 2012
- CP Road Map tracks: 2, 8

Use of Non-woven Fabric Interlayer for Unbonded Concrete Overlays

- Objectives:
  1) Evaluate performance of thin unbonded concrete overlays placed on top of fabric interlayers
  2) Characterize drainage of fabric interlayers

- Findings:
  1) Fabric interlayers provided sufficient stress relief for the experimental slabs
  2) Drainage provided by the fabric interlayer more than adequate

Use of Non-woven Fabric Interlayer for Unbonded Concrete Overlays

- Implementation:
  1) 4 thin UBOL cells at MnROAD
  2) Several standard (thick) UBOL projects, up to 10 miles in length, placed in greater Minnesota

Development of a Concrete Maturity Test Protocol

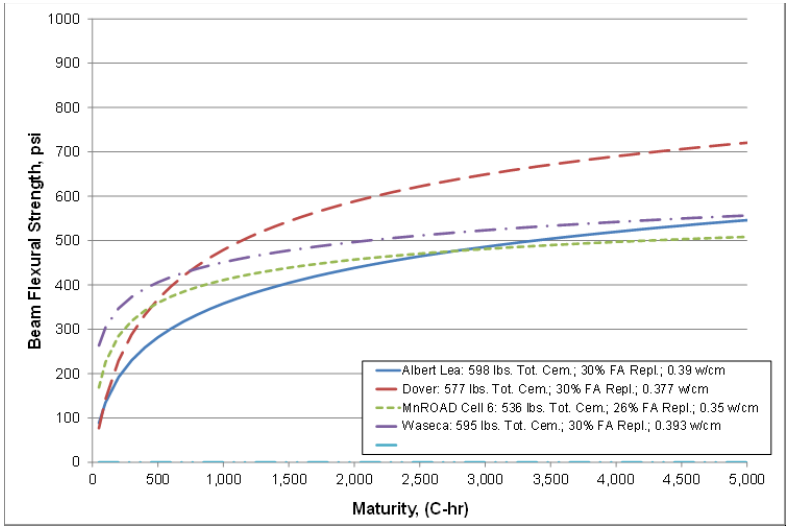
- MnDOT funding
- P.I. Jim Wilde, Minnesota State University- Mankato
- Completed in 2013
- CP Road Map track: 7

Development of a Concrete Maturity Test Protocol

- Objective:
  1) Develop strength-maturity relationships for various high-SCM and low w/c mixes often utilized by MnDOT
  2) Visit 18 concrete paving projects on interstate, state and county highways, establishing the viability of using flexural beams as specimens

- Products:
  1) Exponential model of very early age strength development suitable for most cases
  2) Maturity curve database, where different mixes and their associated maturity curves can be entered and stored for future reference
  3) Recommended future construction specifications utilizing maturity method

Development of a Concrete Maturity Test Protocol



Add New Maturity Data

Project / Mix Name	US-14
MnDOT Project / SP Number	8101-44
Mix Designation	3A21-5
Beam Casting Date	8 /16/2010
Mix Data	
Cement Content, lb/cy	417
Cement Type / Manufacturer	Holcim
Fly Ash Content, lb/cy	179
Fly Ash Type / Manufacturer	CCREEK
w/cm	0.39

Concrete Maturity Data

Approx. Age, days	Maturity at Time of Testing, C-hrs	Beam Flexural Strength, psi
1	944	444
2	1747	494
3	2571	510
7	5952	564
28	22351	653

Cancel OK

MnROAD PCC Thickness Optimization

- MnDOT funding
- P.I. Tom Burnham, MnDOT
- Completed in 2013
- CP Road Map tracks: 9, 13

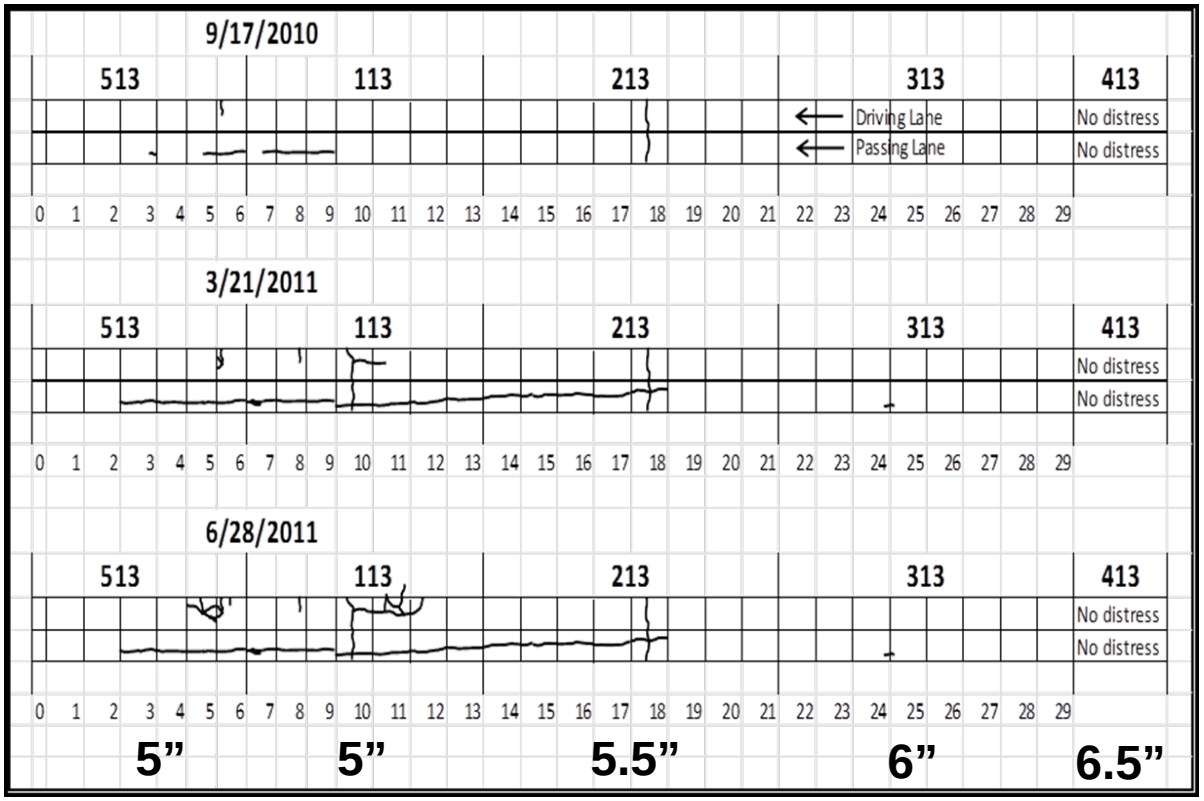
MnROAD PCC Thickness Optimization

- Objective:
  Determine how “thin can you go” and still maintain reliable performance under heavy traffic

  Thin = 5”, 5.5”, 6”, 6.5” (interstate traffic)

- Findings:
  1) Thin concrete sections can withstand substantially more traffic than AASHTO designs predict (over 4+ million CESALS on 6”)
  2) Thin slabs are much more sensitive to loss of support and curling effects
  3) Thin slabs are very difficult to repair

MnROAD PCC Thickness Optimization



Note: Design thicknesses shown, as-built = typically thicker

- Implementation: MnDOT lowered minimum thickness for concrete pavements to 6”

Development of Improved Design Procedure for Bonded Concrete Overlays of Existing Asphalt Pavement [BCOA-ME]

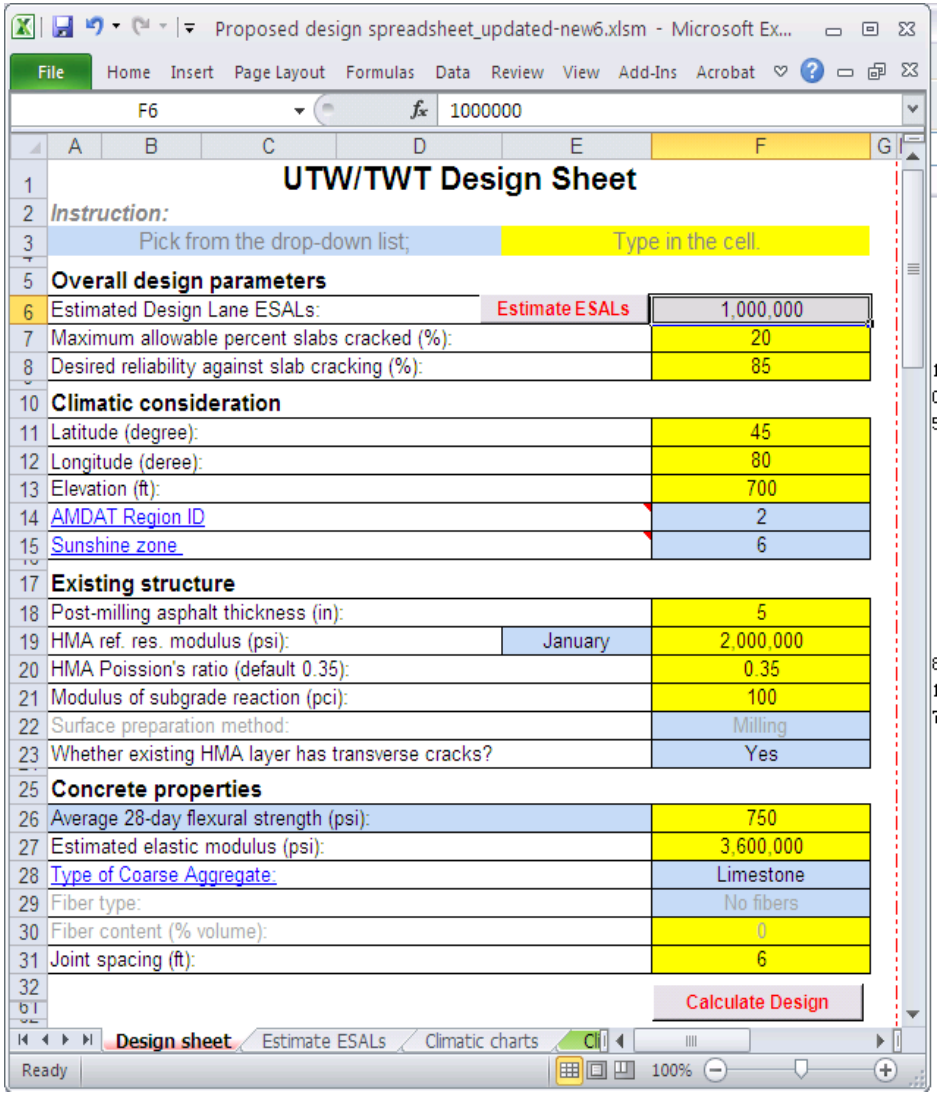
- Pooled Funds
- P.I. Julie Vandenbossche, University of Pittsburgh
- Completed in 2013
- CP Road Map tracks: 2, 8

Development of Improved Design Procedure for Bonded Concrete Overlays of Existing Asphalt Pavement [BCOA-ME]

- Objective:
  Develop stand alone, rational mechanistic-empirical based design procedure for thin bonded concrete overlays of existing asphalt pavements

- Product:
  BCOA-ME
  - Accounts for effect of climate on both overlay and underlying HMA modulus
  - Structural fatigue models based on panel size

BCOA-ME Procedure



MnDOT has adopted as standard design procedure for BCOAs

Recently Completed or Ongoing Research

MnDOT PCC Thickness Variation

- MnDOT funding
- P.I.s Lev Khazanovich, Kyle Hoegh, Randal Barnes, University of Minnesota
- Projected Completion: 2016
- CP Road Map track: 2

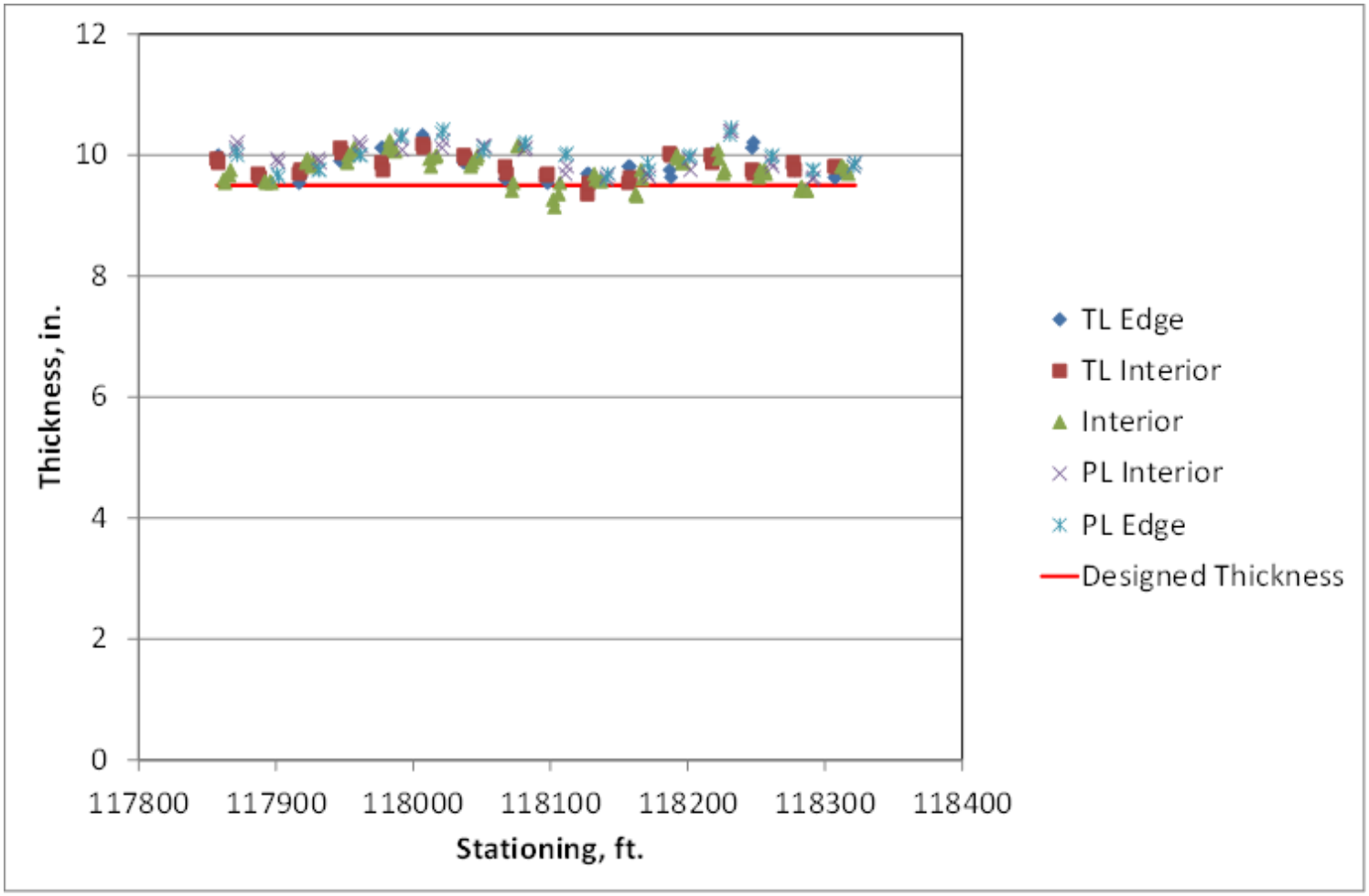
MnDOT PCC Thickness Variation

- Objective:
  1) Characterize variation in as-built thickness of concrete pavements
  2) Determine correlation with observed distresses

Notes:

- A similar project was completed in 2013 for MnROAD test cells
- This study extends to pavement sections throughout Minnesota
- Findings could influence MnDOT pavement design procedures

MnROAD PCC Thickness Variation



Development of Improved Design Procedure for Unbonded Concrete Overlays of Existing Concrete and Composite Pavements

- Pooled Funds
- P.I.s Lev Khazanovich, University of Minnesota
  Julie Vandenbossche, University of Pittsburgh
  Mark Snyder, Consultant
- Projected Completion: 2016
- CP Road Map tracks: 2, 8

Development of Improved Design Procedure for Unbonded Concrete Overlays of Existing Concrete and Composite Pavements

- Objective:

  Develop stand alone, rational mechanistic-empirical based design procedure for unbonded concrete overlays of existing concrete and composite pavements

Notes:

- Applicable to all UBOL thicknesses
- Main task to characterize interlayer systems and materials
- Likely to be combined with BCOA-ME

Investigation and Assessment of Colored Concrete Pavement

- LRRB funding
- P.I.s Tom Burnham, (Ally Akkari), MnDOT
- Completion: 2014
- CP Road Map track: 1

Investigation and Assessment of Colored Concrete Pavement

Investigation and Assessment of Colored Concrete Pavement

- Objective:

  Determine cause for observed early distresses in colored concrete crosswalks, medians and sidewalks

- Findings:
  - Compromised freeze/thaw durability
  - Chemical attack of paste and fine aggregates (ASR)
  - Thermal compatibility issues

Use of Plate Dowels in Concrete Pavements

- MnDOT funding
- P.I. Tom Burnham, MnDOT
- Completion: 2016
- CP Road Map track: 6

Use of Plate Dowels in Concrete Pavements

- Objectives:
  1) Determine performance of plate dowels in thin concrete pavements
  2) Determine feasibility of using plate dowels in concrete repairs

Current and past installations at MnROAD:

- Basket installations in 5” PCC (interstate traffic)
- Basket installations in 6’ W x 12’L whitetopping panels
- Retrofit dowels in 5” UBOL
- Full-depth panel replacements in 5” PCC
- Full-depth joint replacements in 6” PCC
- Full-depth joint replacement in 9.5” PCC (interstate traffic)

Use of Plate Dowels in Concrete Pavements

Use of Plate Dowels in Concrete Pavements

6 to 7 CoVex across joint

5 CoVex across joint

Benefit of Fibers in Thin PCC Pavements

- MnDOT funding
- P.I. Tom Burnham, MnDOT
- Completion: 2018
- CP Road Map tracks: 1, 2

Benefit of Fibers in Thin PCC Pavements

- Objectives:
  1) Determine performance of thin structural fiber-reinforced concrete overlays and other PCC repairs
  2) Determine cost effectiveness

Current installations at MnROAD:

- 4” and 5” thick BCOA
- 3” UBOL
- Full-depth joint repairs

Sealing Joints in BCOA

- MnDOT funding
- P.I.s Tom Burnham, MnDOT
- Completion: 2013
- CP Road Map tracks: 6, 8

Sealing Joints in BCOA

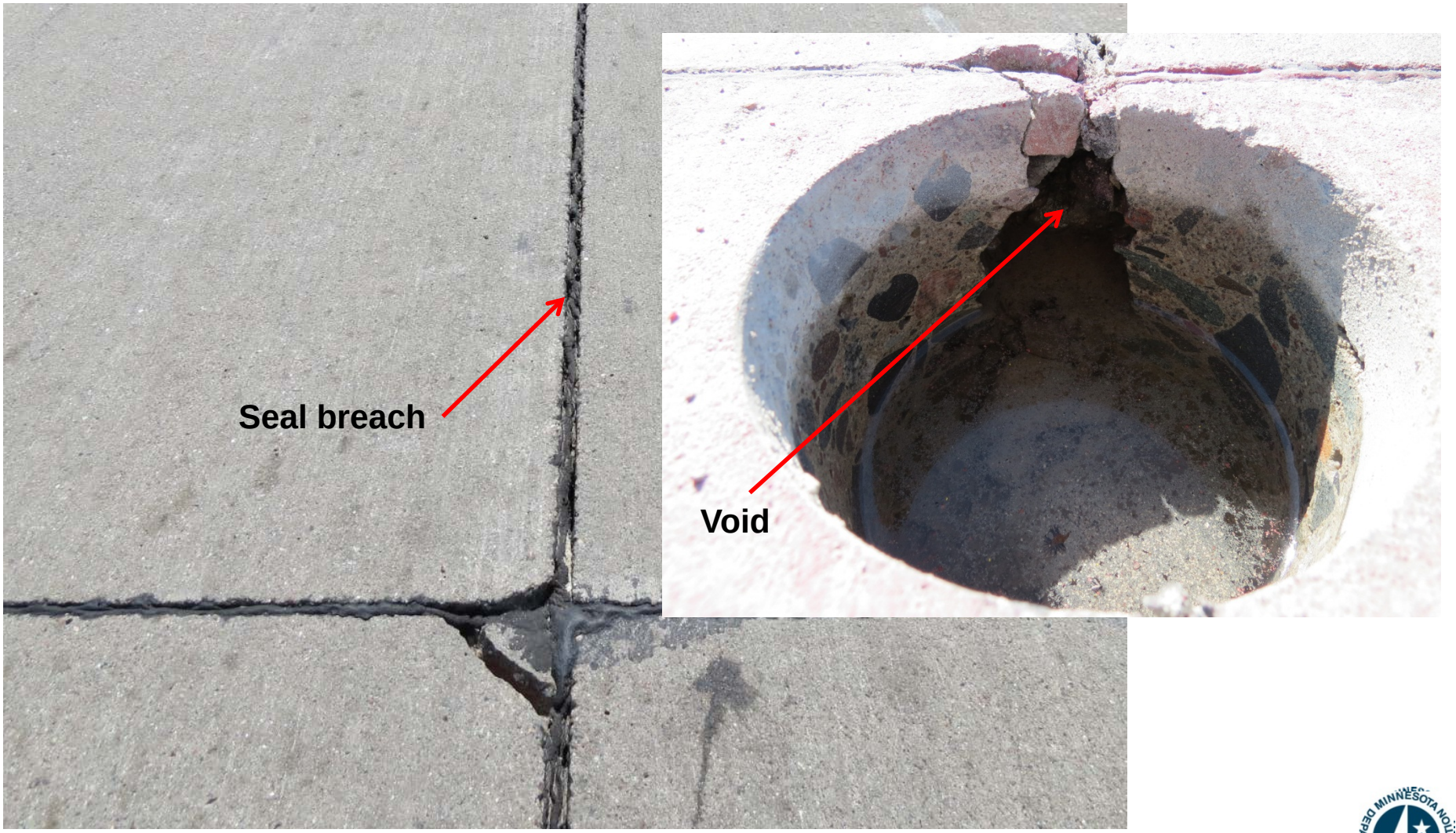
- Objectives:

  Determine performance sealed/filled versus unsealed/unfilled joints in BCOA (single saw-cut joints with hot pour asphalt sealant)

Recent findings based on MnROAD BCOA test cells:

- For PCC overlay < 4.5”
  - Layer bonding is more critical than joint deterioration
  - Recommend sealing joints
  - Once placed, important to maintain seal
- For PCC overlay > 4.5”
  - Joint condition more critical than layer bonding
  - Sealing optional
  - If sealed, must be maintained

Sealing Joints in BCOA



Questions????