




**Concrete Pavement Research at MnROAD:
Lessons Learned & The Path Forward**

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Concrete Pavement Research at MnROAD


- **MnROAD Phase 1 (1994-2007)**
 - Validation of design procedures – 5 & 10 year, LVR designs
 - Effect of base material/drainage
 - Whitetopping (concrete overlay on old asphalt pavement)



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Concrete Pavement Research at MnROAD

- **MnROAD Phase 2 (2008-2016)**
 - Unbonded Concrete Overlay (concrete on old concrete pavement)
 - Whitetopping
 - Thickness Optimization (how thin can you go?)
 - Composite pavement (concrete on concrete, asphalt on concrete)
 - Pavement preservation
 - Improved surface characteristics (noise, safety)
 - Pervious concrete pavement
 - Roller Compacted Concrete (shoulders)
 - Load transfer devices




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Phase 1 – Validation of Design Procedures

• Lesson Learned:

- AASHTO empirical based design procedures very conservative



Mainline Cell 7




LVR Cell 36

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Phase 1 – Effect of Base Materials/Drainage

• Lessons Learned:

- Stability and drainage matters



Deep base consolidation




"Bathtub"

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Phase 1 – Effect of Base Materials/Drainage

• Lesson Learned:

- Joints must drain efficiently



Slow draining base



Fast draining base

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Phase 1 – Whitetopping

• Lessons Learned:



Keep wheel loads away from joints




Fatigue cracking is primarily longitudinal

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Phase 1 – Whitetopping

• Lessons Learned:

- Large panels (< 6" thick) seek one-half lane width (i.e. 6' to 7')
- Undoweled joints can develop faulting




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Phase 2 – Unbonded Concrete Overlay

• Lesson Learned:

- Thin large panels crack



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Phase 2 – Unbonded Concrete Overlay


- Lesson Learned:
 - Small panels on fabric interlayer perform well



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Phase 2 – Whitetopping


- Lesson Learned:
 - Sealed joints do not guarantee long term performance (However, sealing prolongs bond with underlying asphalt)



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Phase 2 – Thickness Optimization

- Lesson Learned:
 - Reduced safety factor for thicknesses < 6"
 - Over 1.5 million CESALs before 1st crack
 - Over 6 million CESALs before removal



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Phase 2 – Composite Pavement

- **Lessons Learned:**
 - “Thermally insulated” pavement not as robust
 - Two-lift “wet-on-wet” concrete feasible alternative

Cell 205: 2" HMA on 5" PCC

Cell 271: 3" PCC on 6" Recycled PCC

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Phase 2 – Pavement Preservation

- **Lessons Learned:**
 - 3 year evaluation of various repair materials

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Phase 2 – Pavement Preservation

- **Lessons Learned:**
 - Precast and roller compacted concrete repairs can be successfully deployed

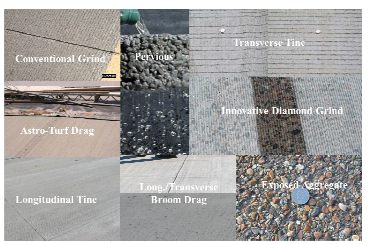
Precast concrete slab repair

Roller compacted concrete slab repair

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Phase 2 – Improved Surface Characteristics

- **Lessons Learned:**
 - Understanding characteristics of various textures
 - Refinement of next generation diamond grinding



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Phase 2 – Improved Surface Characteristics

- **Lessons Learned:**
 - Classification of rolling resistance

Surface	Rolling Resistance (PRE)
No. 39 Pervious Concrete - Pervious Overlay	0.0003
No. 31 12.5 mm Dense Graded Superpave	0.0002
No. 33 12.5 mm Dense Graded Superpave	0.0002
No. 12 PCC, Shaded base, Transverse Line	0.0002
No. 79 12.5 mm Dense Graded Superpave	0.0001
No. 13 PCC, Longitudinal Turf Drag	0.0001
No. 24 12.5 mm Dense Graded Superpave	0.0001
No. 34 12.5 mm Dense Graded Superpave	0.0001
No. 40 PCC Transverse Line	0.0001
No. 14 Thin Bonded Concrete Overlay of HMA -	0.0001
No. 71 Ultimate Diamond Grind	0.0000
No. 60 Thin Bonded Concrete Overlay of HMA - 5.	0.0000
No. 61 Thin Bonded Concrete Overlay of HMA - 5.	0.0000
No. 62 Thin Bonded Concrete Overlay of HMA - 4.	0.0000
No. 53 PCC, Transverse Broom	0.0000
No. 38 PCC Transverse Line	0.0000
No. 87 12.5 mm Dense Graded Superpave	0.0000
No. 36 PCC Transverse Line	0.0000
No. 32 PCC, Longitudinal Turf Drag	0.0000
No. 37 PCC	0.0000
No. 52 PCC, Longitudinal Turf Drag	0.0000
No. 54 PCC, Longitudinal Turf Drag	0.0000

0.000 0.001 0.002 0.003 0.004 0.005 0.006 PRE

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Phase 2 – Pervious Concrete Pavement

- **Lessons Learned:**
 - Improved performance over sand subgrade
 - Requires routine cleaning




7" Pervious concrete, sand subgrade
@ 5 years

7" Pervious concrete, silty-clay subgrade
@ 8 years

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Phase 2 – Roller Compacted Concrete

- Lesson Learned:
 - Performs well in Minnesota climate




4" roller compacted concrete shoulder @ 5 years

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Phase 2 – Joint Load Transfer Devices

- Lesson Learned:
 - Joint stabilizers tend to push slabs apart = lower load transfer (need constraint at both ends)



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Phase 2 – Joint Load Transfer Devices

- Lesson Learned:
 - Retrofit plate dowels can perform well in $\geq 6"$ thick pavements



CoVex in 6" slabs @ 6 years

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Phase 2 – Joint Load Transfer Devices

• **Lesson Learned:**

- Retrofit plate dowels do not perform well in < 6" thick pavements




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Phase 2 – Joint Load Transfer Devices

• **Lesson Learned:**

- Debonding "slip covers" create voids = loss of load transfer



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Phase 3 Concrete Pavement Research at MnROAD

• **Determined by NRRA members**

- Fiber-reinforced Concrete Pavement
- Long-Term Impacts of Early Opening of Concrete Pavements to Traffic
- Reduced Cementitious Material in Optimized Concrete Mixtures
- Long Term Effects of Diamond Grinding on PCC and the Impact of Sealers
- Compacted Concrete Pavement
- Concrete Repair Product Evaluations

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Phase 3 - Fiber Reinforced Unbonded Concrete Overlay

• MnROAD Cells 705, 805
(Mainline interstate traffic)

- Fiber content: 20% RSR (ASTM C1609)
- Non-woven geotextile interlayer
- Cell 705: 14'W x 12'L panels
- Cell 805: 6'Wx12'L & 8'Wx12'L panels



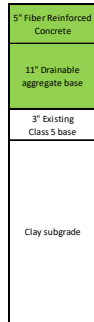
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Phase 3 - Fiber Reinforced Concrete On Grade

• MnROAD Cells 506, 606, 706, 806
(Mainline interstate traffic)

- All cells: 6' x 6' panels
- Fiber content:
 - Cell 506: No fibers (control)
 - Cell 606: 20% RSR (ASTM C1609)
 - Cell 706: 30% RSR (ASTM C1609)
 - Cell 806: 0.75% by volume



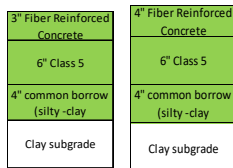
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Phase 3 - Ultra-thin Fiber Reinforced Concrete On Grade

• MnROAD Cells 139, 239
(Low Volume Road traffic)

- All cells: 6' x 6' panels
- Fiber content: 30% RSR (ASTM C1609)

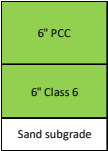


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Phase 3 - Early Opening to Traffic

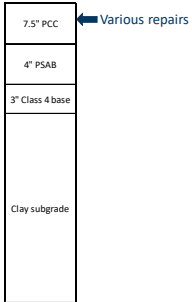
- **MnROAD Cell 124**
(Low Volume Road Traffic)
 - Standard panel size 12'W x 15'L
 - Doweled joints
 - Loaded lane: Apply sequential traffic loadings
 - 100' @ 6 hours
 - 200' @ 12 hours
 - 300' @ 18 hours
 - 400' @ 24 hours
 - Environmental lane: Drive vehicle through concrete before set to cause visible damage



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Phase 3 - Early Opening of Repairs

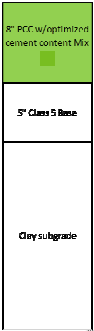
- **MnROAD Cell 8**
(Mainline interstate traffic)
 - Full panel replacements, full-depth joint repairs, and partial-depth repairs
 - Various repair materials
 - Roller compacted concrete
 - Internally cured concrete
 - Other concepts?
 - Load early
 - Similar loading scheme as Cell 124



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Phase 3 - Reduced Cementitious Content Mixes


- **MnROAD Cells 138, 238**
(Low Volume Road traffic)
 - All cells: 12'W' x 15'L panels
 - Cell 138: Cementitious content = 430 - 470 lb/cy
 - Cell 238: Cementitious content = 475 - 500 lb/cy



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Phase 3 - Effects of Diamond Grinding and Topical Sealers


- MnROAD Cells 41, 42, 43
(Low Volume Road traffic)
- Current cells 24 years old, constructed with aggregates susceptible to ASR or D-Cracking
- Diamond grind portions of each cell
- Treat portions with topical sealers
 - Both ground and non-ground sections



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Phase 3 - Compacted Concrete Pavement


- MnROAD Cells 132 - 432
(Low Volume Road traffic)
- Roller Compacted Concrete with special admixture = CCP
 - Placed with high-density asphalt type paver (>95%)
 - Smoothed with light rollers and/or riding trowel machines
 - Astro-turf drag finish
- Cell 132: 12'W x 20'L panels with fiber-reinforced CCP mix
- Cell 232: 12'W x 15'L panels with fiber-reinforced CCP mix
- Cell 332: 12'W x 15'L panels CCP mix
- Cell 432: 12'W x 20'L panels CCP mix



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Phase 3 - Concrete Repair Product Evaluations

- I-94 MnROAD Bypass (1900 ft)
(intermittent interstate traffic)
- 44 year JRCP (27' long panels)
- Partial-depth repairs
 - Standard repair pattern
- Various repair materials
 - Seeking 15 innovative materials
 - Inviting manufacturers to partner



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Phase 3 Construction Schedule

- Summer 2017




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MnROAD Tour Stops

- Cells 405 – 306
 - Large panel unbonded concrete overlay
 - 6" PCC with "stable but drainable" base
- Cells 9 & 162
 - Original 7.5" PCC (5 year design, drainable base)
 - 5" whitetopping with fiber-reinforced mix
- Cells 85 & 89
 - 7" Pervious concrete pavement
- Cells 32 & 140
 - 5" PCC with repairs
 - 3" unbonded concrete overlay with fiber-reinforced mix

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Questions?

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