



NRRA Concrete Pavement Research Update

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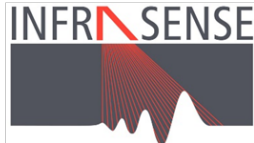
Spring 2019 NCC Meeting, Denver, CO

4/2/2019

State DOT Members



Associate Members



MnROAD Facility

MnROAD

- Full-scale, cold climate pavement test facility near Albertville, MN
- 3.5 mile (5.6 km) “Mainline” section with diverted interstate I-94 traffic
- 2.5 mile (4 km) “Low Volume Road” closed loop test track
- Multiple pavement test sections
 - Asphalt
 - Concrete
 - Overlays
- Operation began in 1994
 - Current conducting Phase 3 experiments (2016 -)



Provides opportunities for BOLD ideas!

Outline

- **Impacts of Early Loading on Concrete Pavement Performance**
 - New pavements
 - Repairs
- **Fiber-Reinforced Concrete Pavement**
 - Thin slabs on grade
- **Compacted Concrete Pavement**
 - RCC with a surface texture

Early loading!



Impact of Early Opening to Traffic

Study Objectives

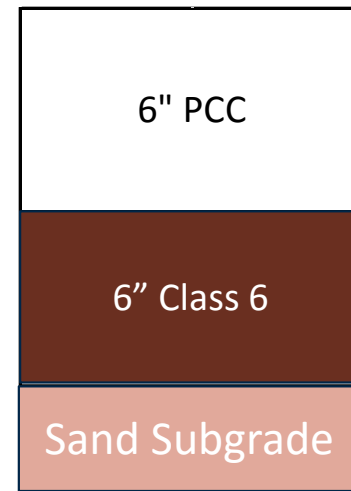
- Evaluate visible and non-visible immediate damage caused by early age loading
- Quantify the effect of early loading damage on long-term performance
- Determine minimum strength at opening or other measurable variables associated with this parameter
- Recommend strategies for minimizing or avoiding early loading damage detrimental to long-term performance

Early Opening to Traffic

- **MnROAD Cells 124-624**

(Low Volume Road Traffic)

- **Standard panel size 12'W x 15'L**
- **Standard concrete mix**
- **Doweled joints**
- **Early sequential traffic loadings**
 - **Based on maturity**
- **Vehicle driven across concrete before full set to cause visible damage**



Early loading of Cells 124-424



(a)



(b)



(c)



(d)

4,000 lb axle vs 14,000 lb axle loads

Early loading of Cells 124-424



Early loading of Cells 124-424

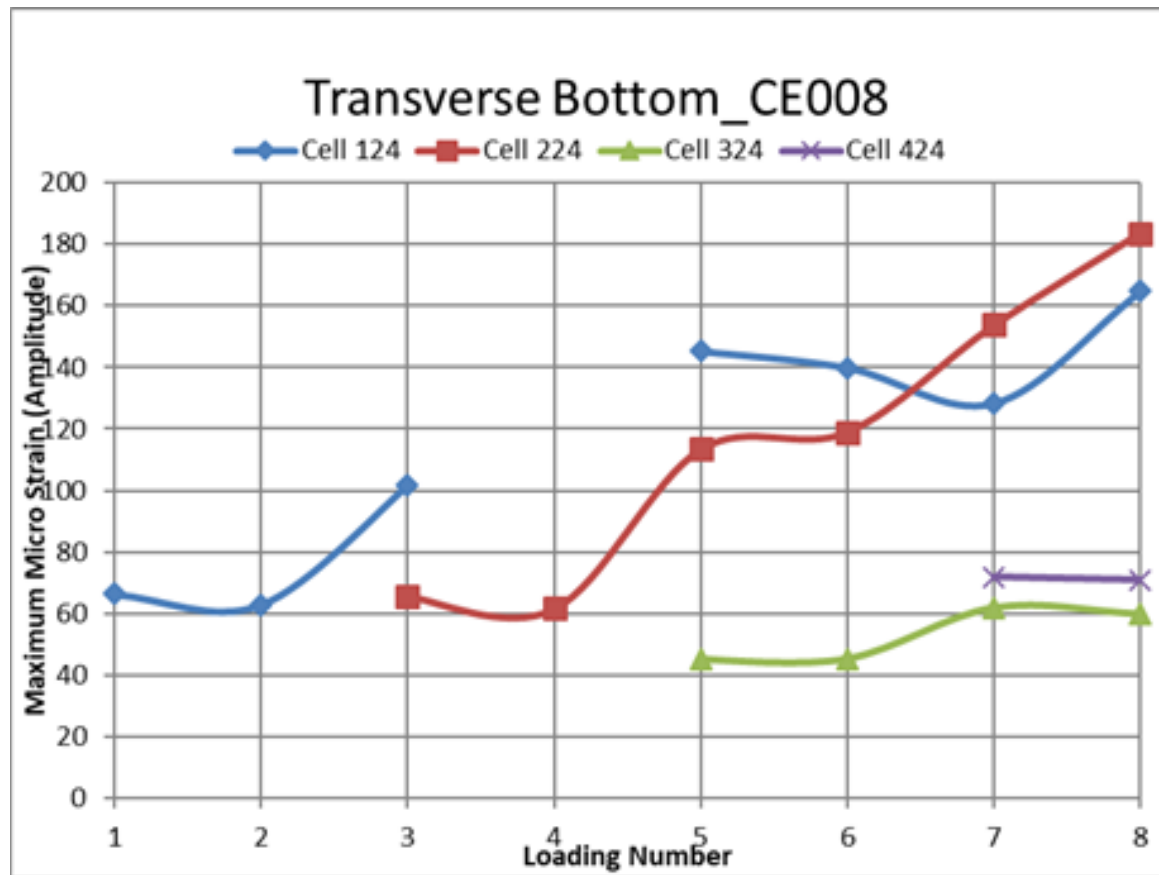
Loading Plan

Cell x24 Early Loading Sequence		
Maturity (Deg-Hr)	Flexural (psi)	Loads applied to lanes
100	73	1st Load on Cell 124 (forward and back)
200	196	1st Load on Cell 224, 2nd load on Cell 124
300	267	1st Load on Cell 324, 2nd load on Cell 224, 3rd load on Cell 124
400	318	1st Load on Cell 424, 2nd load on Cell 324, 3rd load on Cell 224, 4th load on Cell 124

Actual Loading

Age at Loading (HRS)						
Paving Time	Loaded Cells				Control	Tire Rut
	124 IL	224 IL	324 IL	424 IL	524 IL	624 IL
	124 OL	224 OL	324 OL	424 OL	524 OL	624 OL
	12:15	11:15	10:40	9:50		
Paired Repetition 1	3.00	4.00	4.55	5.40		2 Hr
Paired Repetition 2	4.25	5.25	5.80	6.65		
Paired Repetition 3	6.55	7.55	8.10	8.95		
Paired Repetition 4	8.15	9.15	9.70	10.55		

Early loading of Cells 124-424

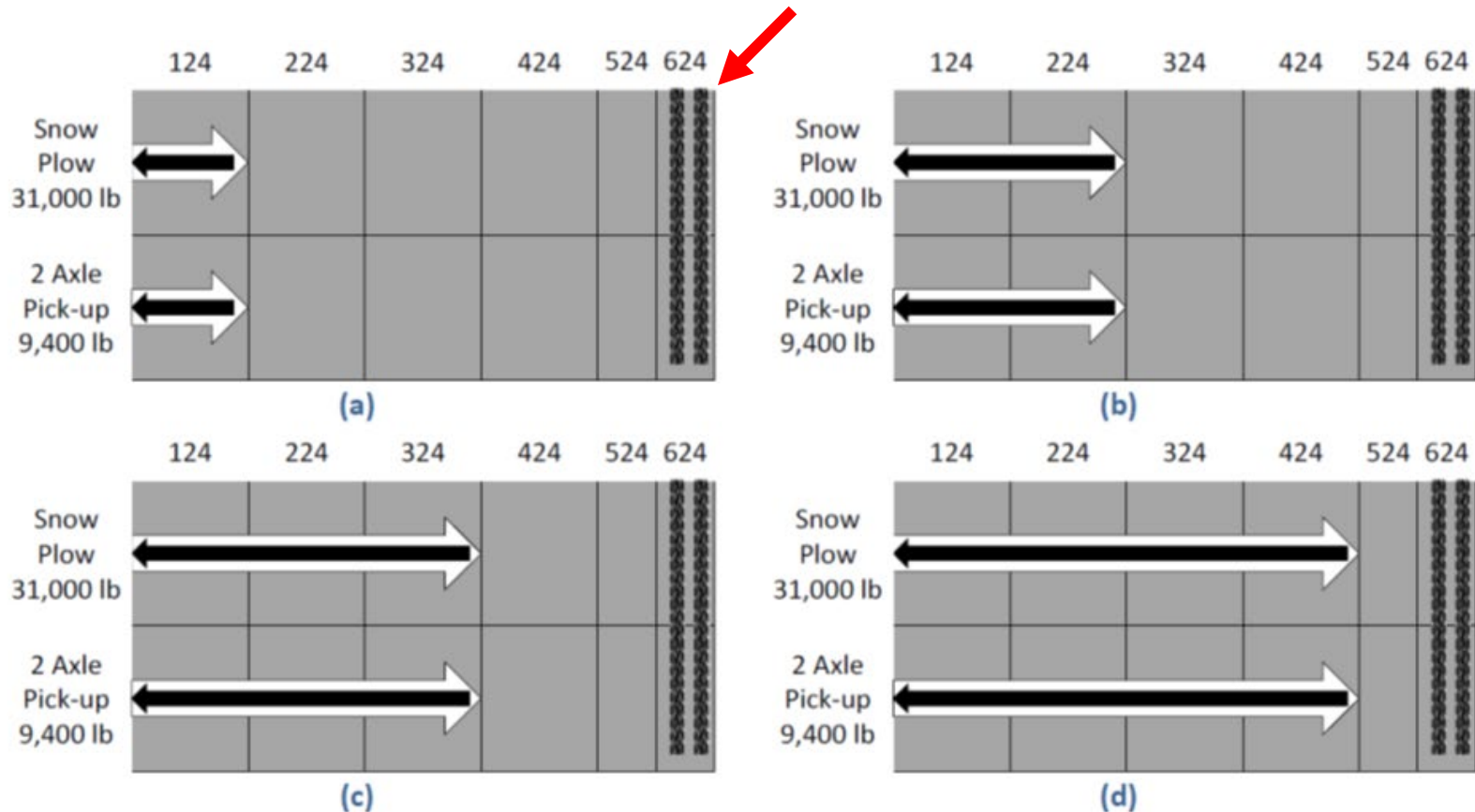


Dynamic Strain Sensor Data

Spring 2019 Cell 124 Condition



Early loading of Cells 124-424



Damage from 4,000 lb axle

Early Loading of Cell 624



Video of damage loading at 2 hours?

4,000 lb axles @ 2 hrs (very warm day!)

Early Loading of Cell 624



Inside lane

Outside lane



Spring 2019 Cell 624 Condition



Impact of Early Opening on Repairs

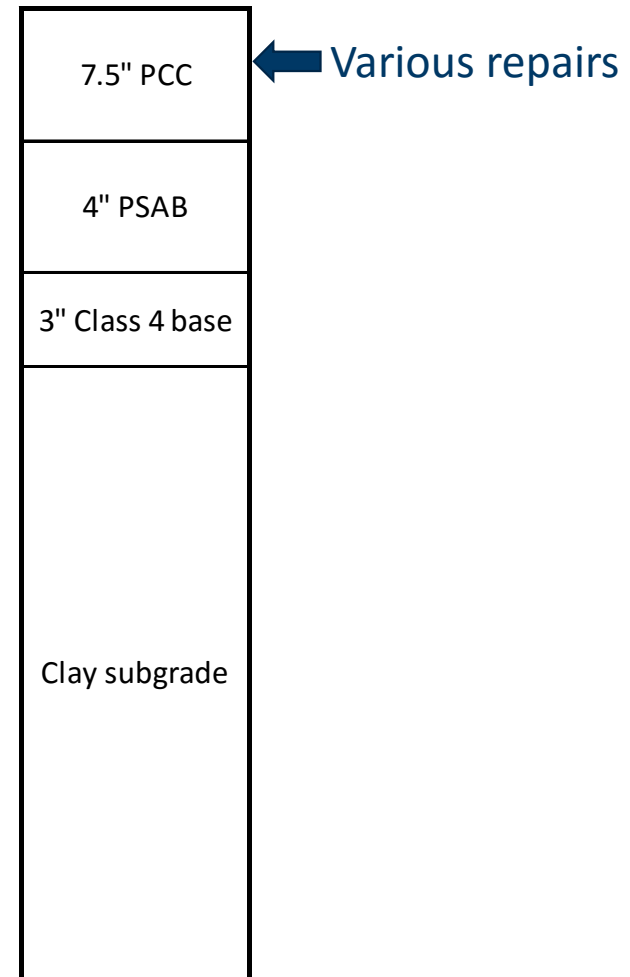
- **MnROAD Cells 7 & 8 [Constructed 1993]**
(Mainline interstate traffic)

- Full panel replacements, full-depth joint repairs, and partial-depth repairs

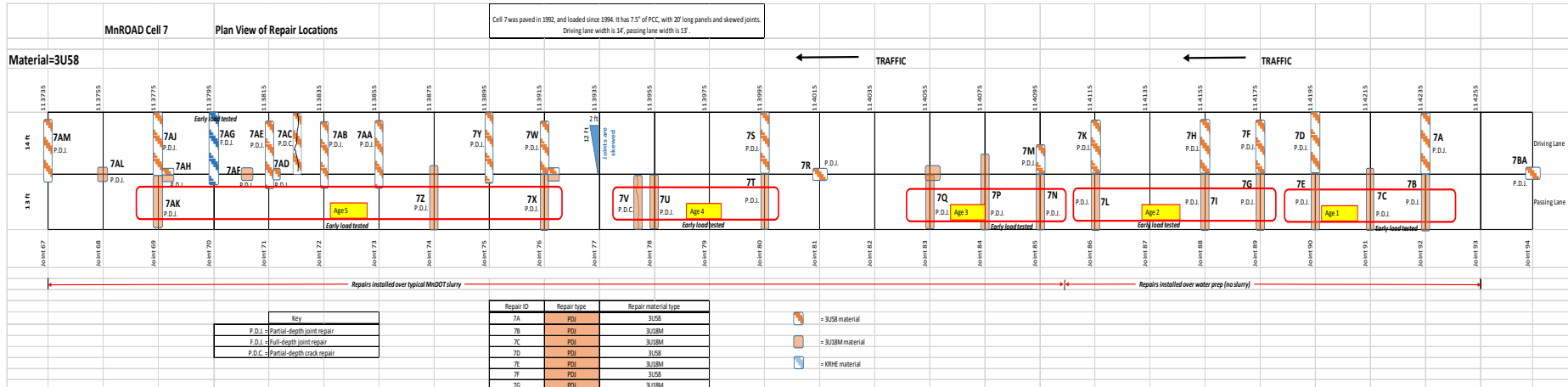
- Various repair materials

- MnDOT spec. 3U18M
- MnDOT spec. 3U58
- Contractor design high early mix
- Internal cure mix
- Roller Compacted Concrete
 - 1 and 2 lifts

- Early sequential traffic loadings



Cell 7 & 8 Repairs



Repair locations and loading scheme

Cell 7 & 8 Repairs



Partial Depth Repairs

Cell 7 & 8 Repairs



Full Depth Repairs

Cell 7 & 8 Repairs



Internal Cure Mix - High Early Strength

Cell 7 & 8 Repairs



1 and 2 lift RCC (with dowel bars)

Cell 7 & 8 Repairs



Small roller compaction

Cell 7 & 8 Repairs



Early Age Loading

Cell 8 RCC Repair



RCC repair condition - March 2019

Cell 8 Internal Cure Mix Repair

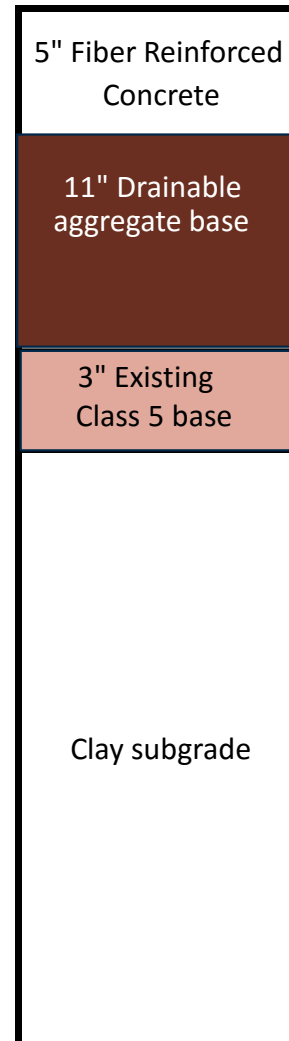


Internal cure mix repair condition - March 2019

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

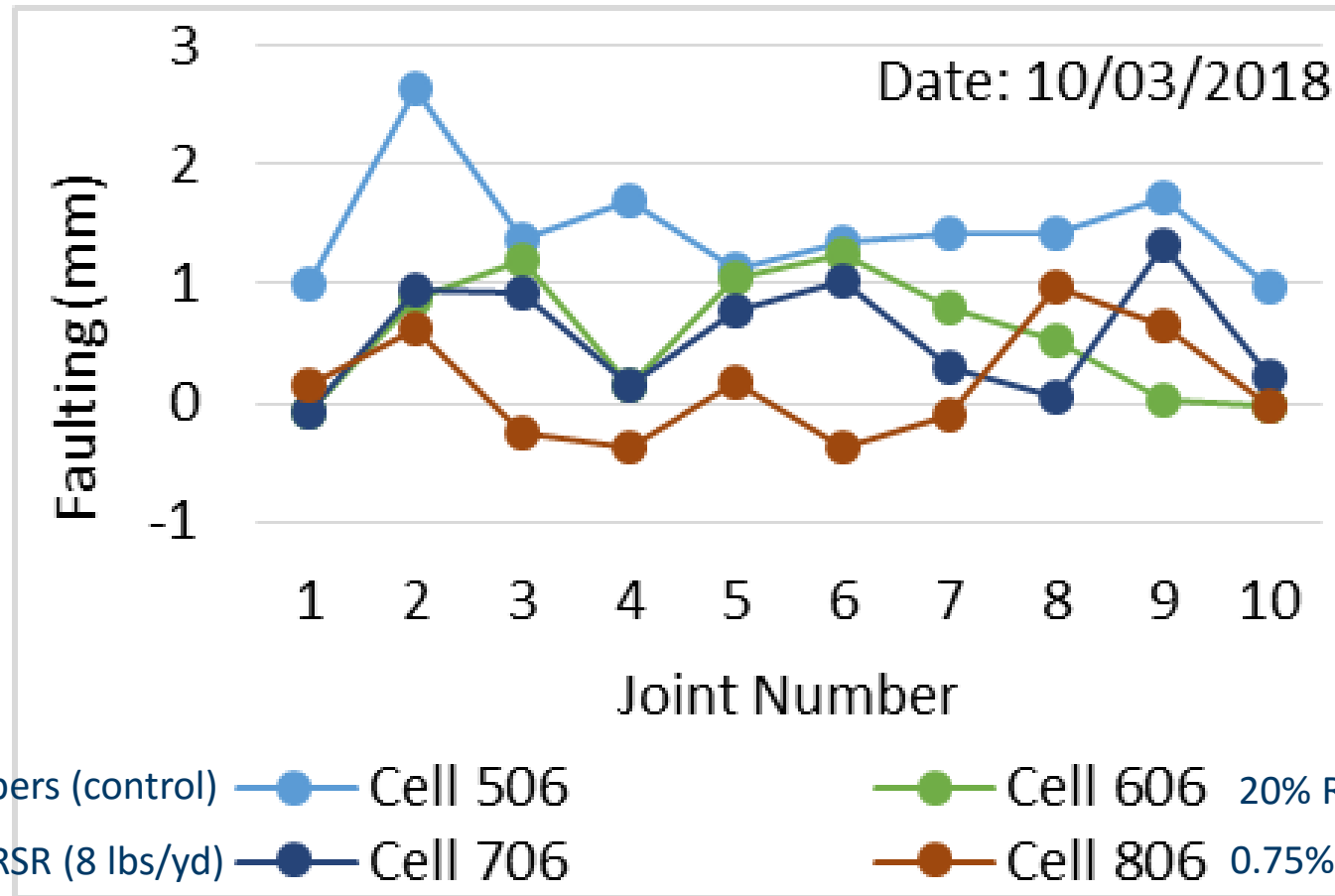


Cell 506 Control (No fibers)

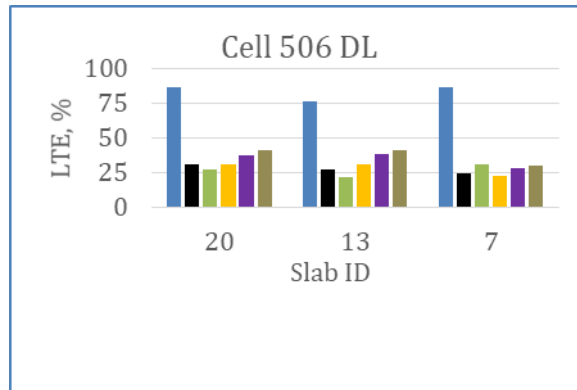


March 2019 condition: Faulted joints

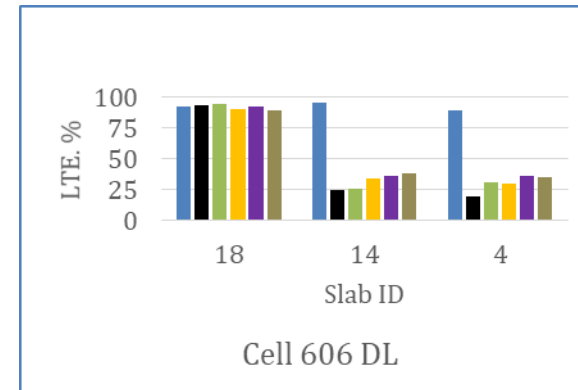
FRC Cells 506 – 806: Transverse Joint Faulting



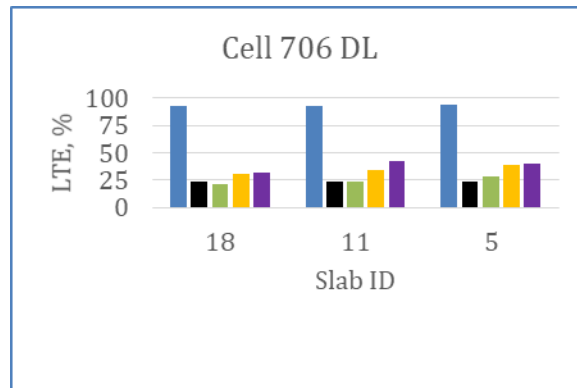
FRC Cells 506 – 806: Joint Load Transfer Efficiency



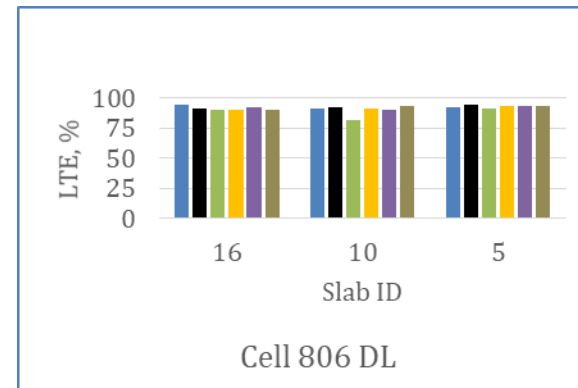
No fibers



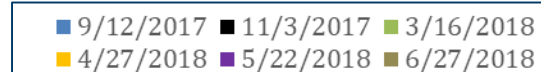
20% RSR (5 lbs/yd)



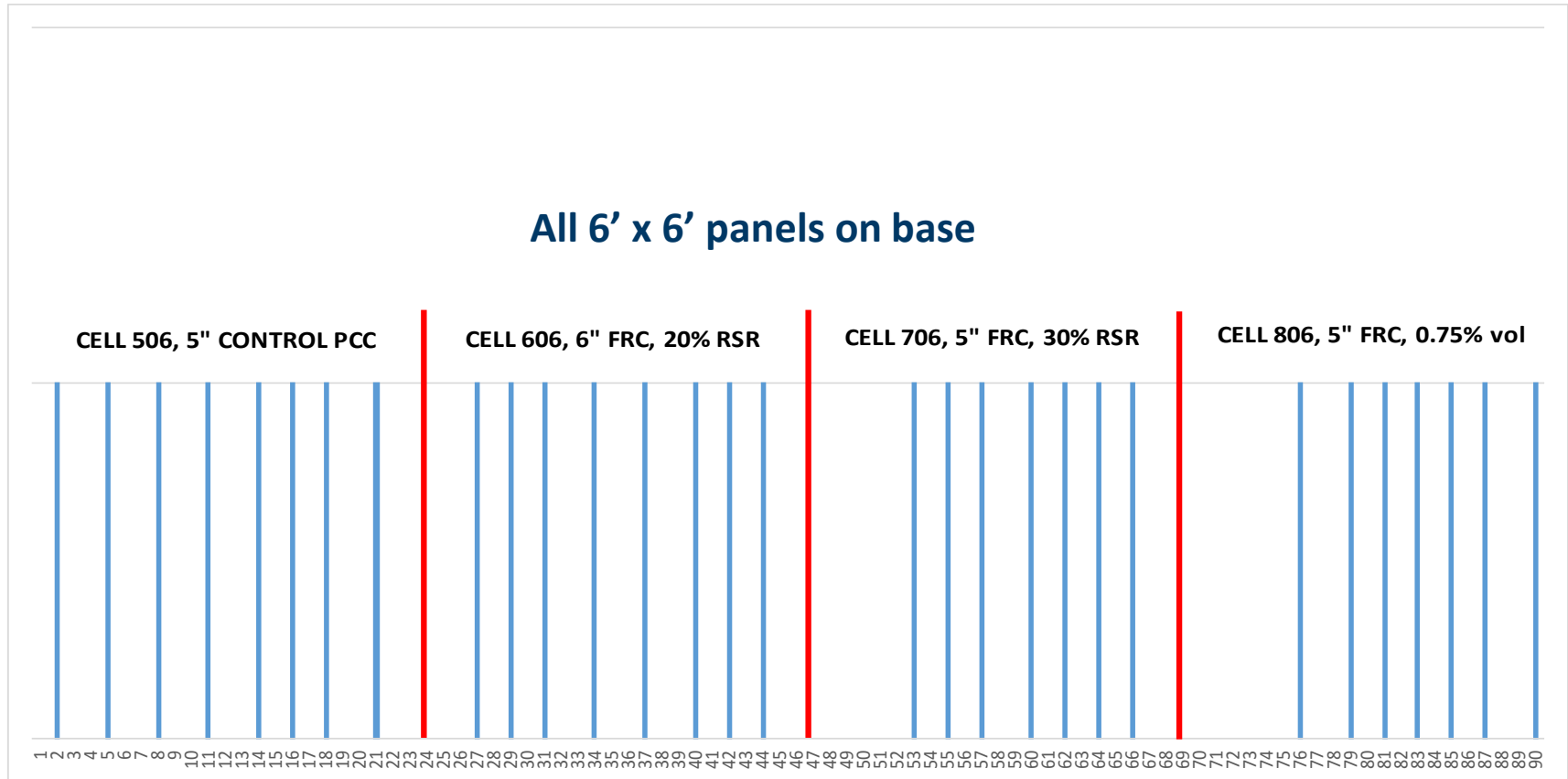
30% RSR (8 lbs/yd)



0.75% volume (11.7 lbs/yd)



Early Transverse Joint Deployment



Observation (pavement edge) on 7-5-17, age range: 5 to 9 days, no traffic loads

Compacted Concrete Pavement

- **Scott City, Missouri : Cells 551 – 553**

(Low volume traffic)

- **Cell 551: Control, 550', 15'Lx12'W panels**
- **Cell 552: Short panel, 555', 12'Lx12'W panels**
- **Cell 553: Fiber-reinforced, 280', 15'Lx12'W panels**

- **Instrumented by MnROAD staff**

- **Southbound - Paved 2018**
- **Northbound – Spring 2019**

Broom Finish

6" RCC
4" Base
12" Lime Treated Subbase

Missouri CCP Test Sections



Missouri CCP Test Sections



Missouri CCP Test Sections



Missouri CCP Test Sections



Missouri CCP Test Sections



Broomed Surface

Missouri CCP Test Sections



Questions?

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