

Concrete Pavement Joint Activation in Minnesota



**The 19th Arizona
Pavements/Materials
Conference**

**ASU, Tempe AZ
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Outline/topics

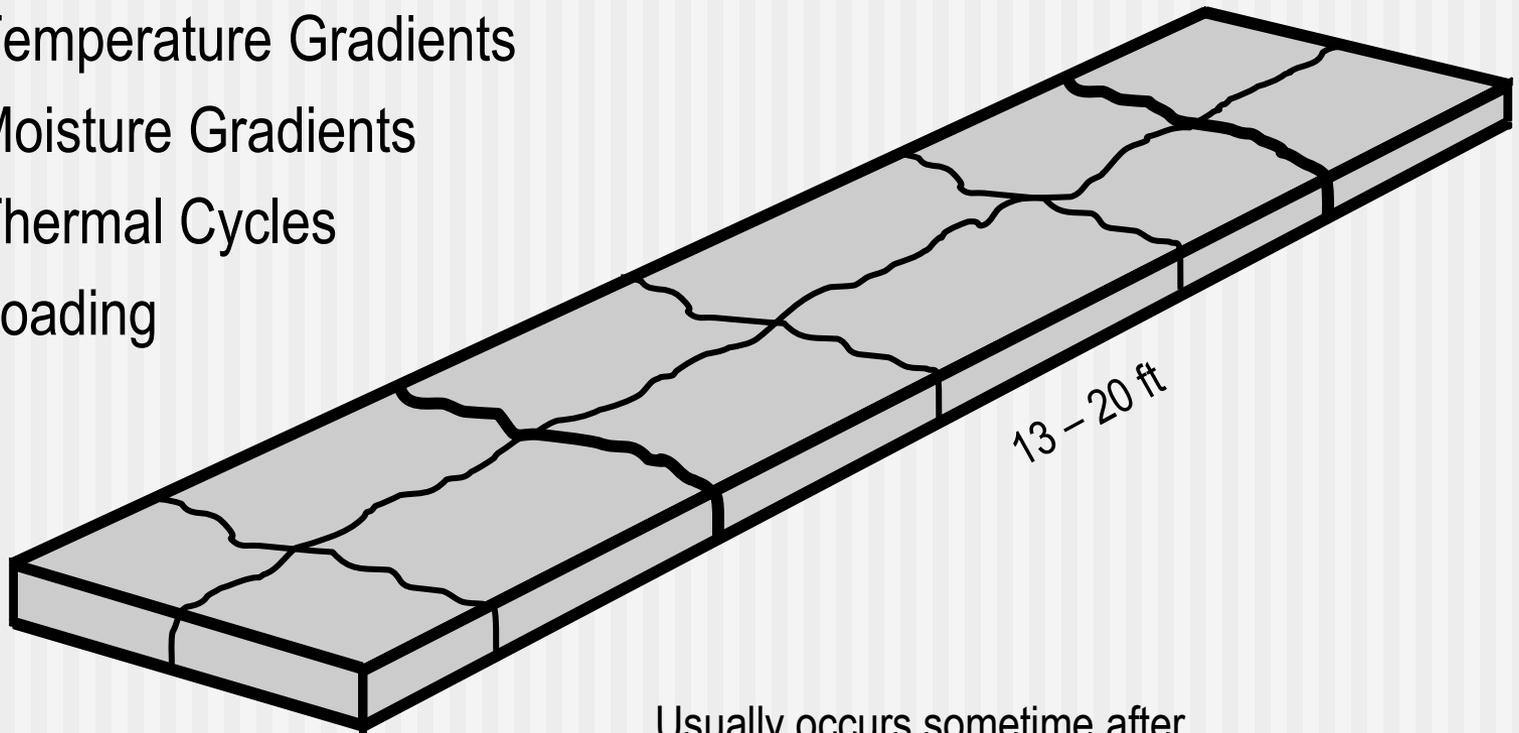
- Joint Design/Movement
- The Problem
- The Solution?

Rule Number 1

- CONCRETE CRACKS!!!

Natural Crack Development

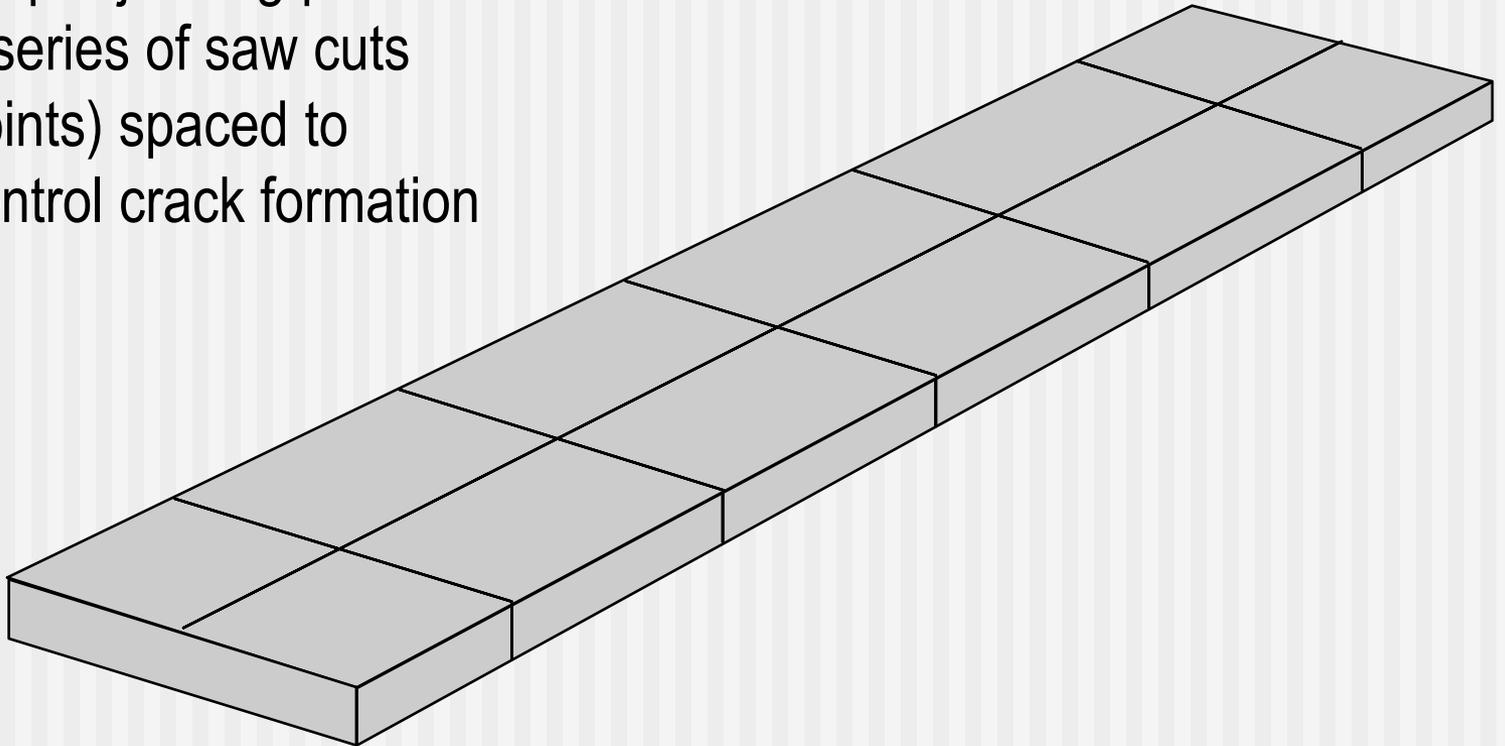
- Temperature Gradients
- Moisture Gradients
- Thermal Cycles
- Loading



Usually occurs sometime after
12 hours and may take months

Natural Crack Development

- Proper jointing provides a series of saw cuts (joints) spaced to control crack formation



Joint Activation

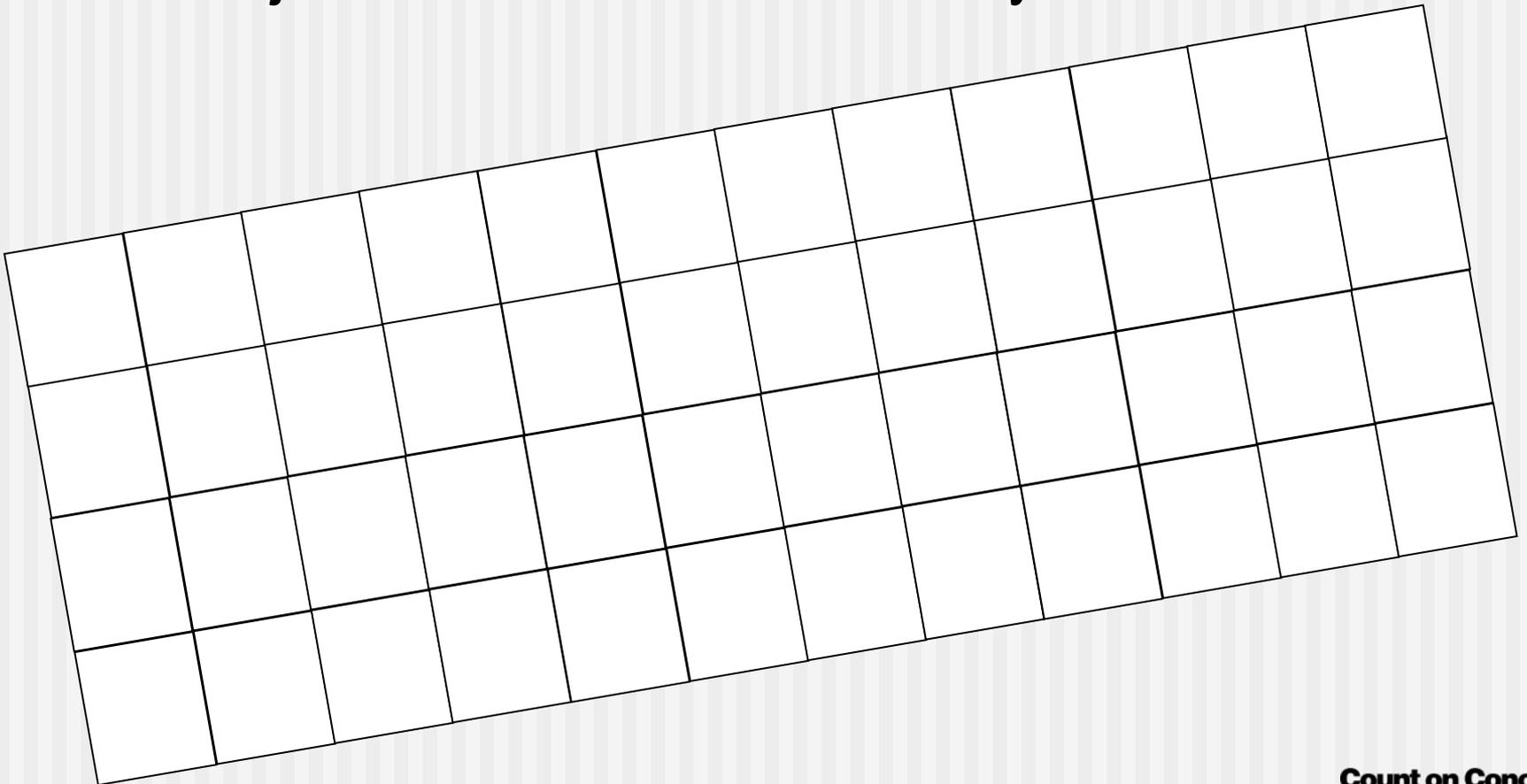
- As concrete sets it shrinks about $\frac{1}{2}$ " to $\frac{3}{4}$ " per 100' of length.
- So, a 15' panel will shrink about $\frac{1}{8}$ " and a 6' panel will shrink about 0.05"
- A 100' slab will expand/shrink by about $\frac{2}{3}$ " when subjected to a 100-degree temperature difference.
- So, a 15 slab will expand/shrink 0.1" and a 6' slab 0.04"

Joint Activation

- 15' panel length vs 6' panel length
 - Thick vs thin pavement
 - Curl/warp much worse for thin panels with long joint spacing

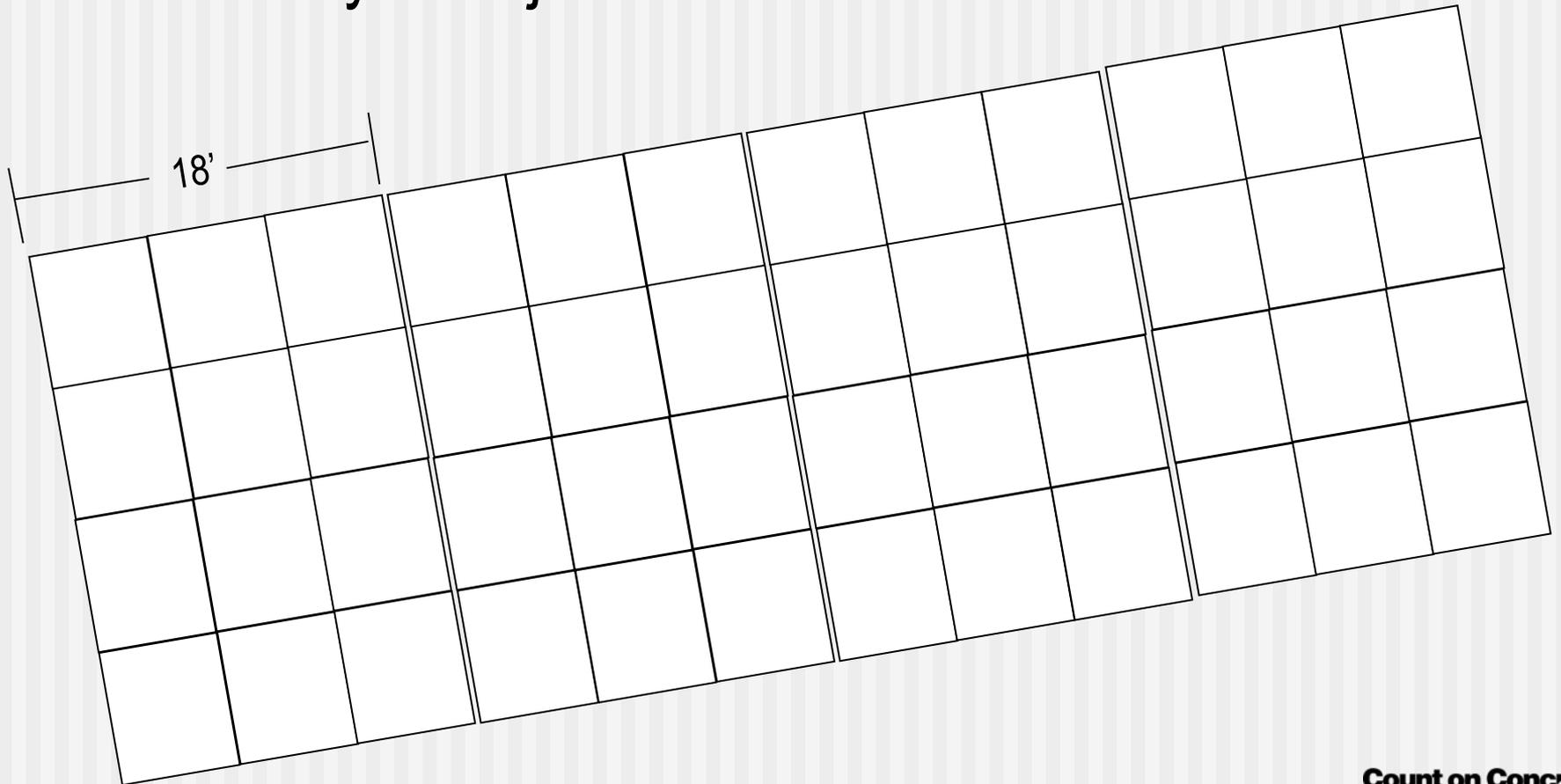
6' x 6' Joints

- If all joints activate should barely move



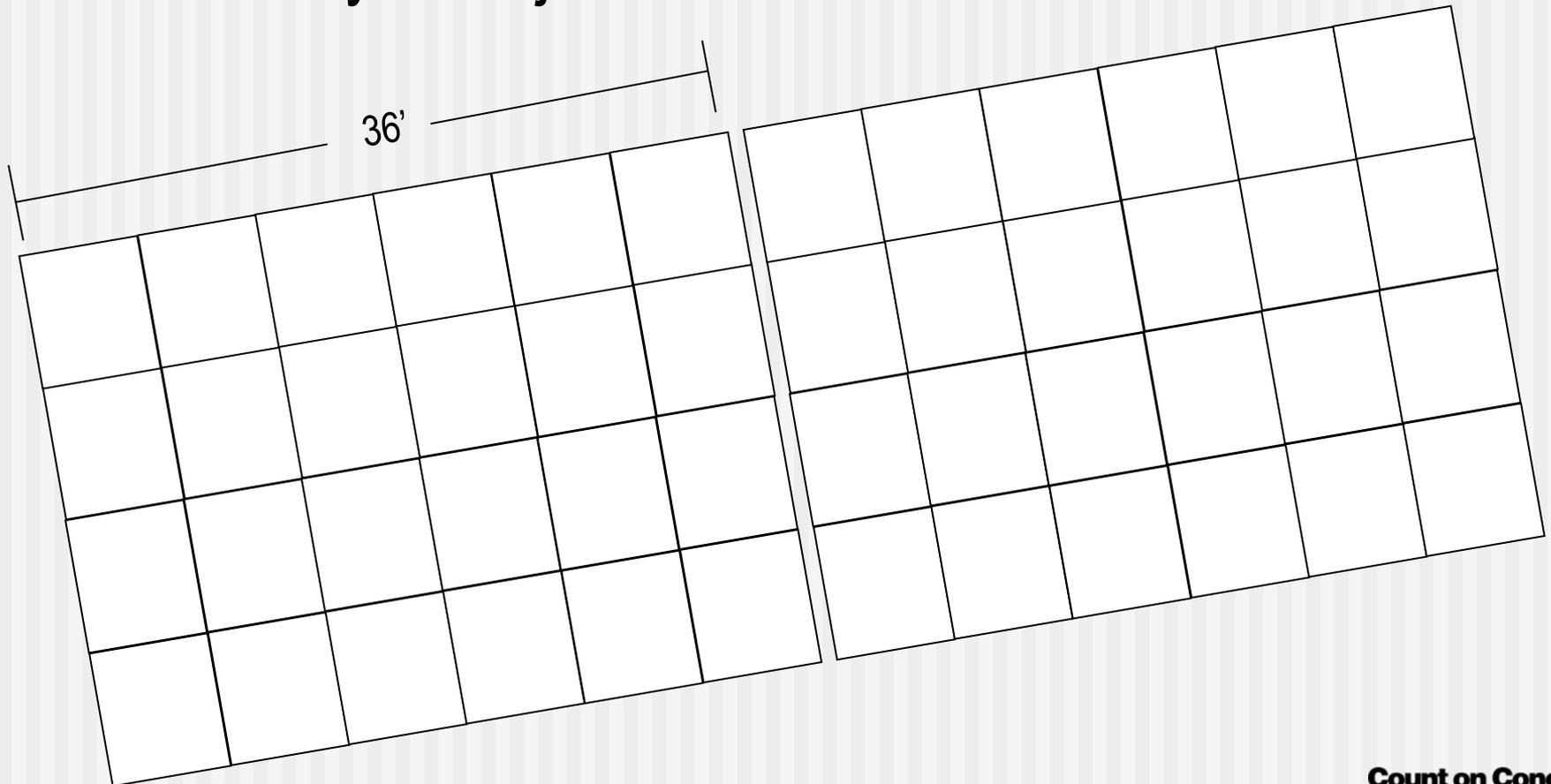
6' x 6' Joints

- If every third joint activates...



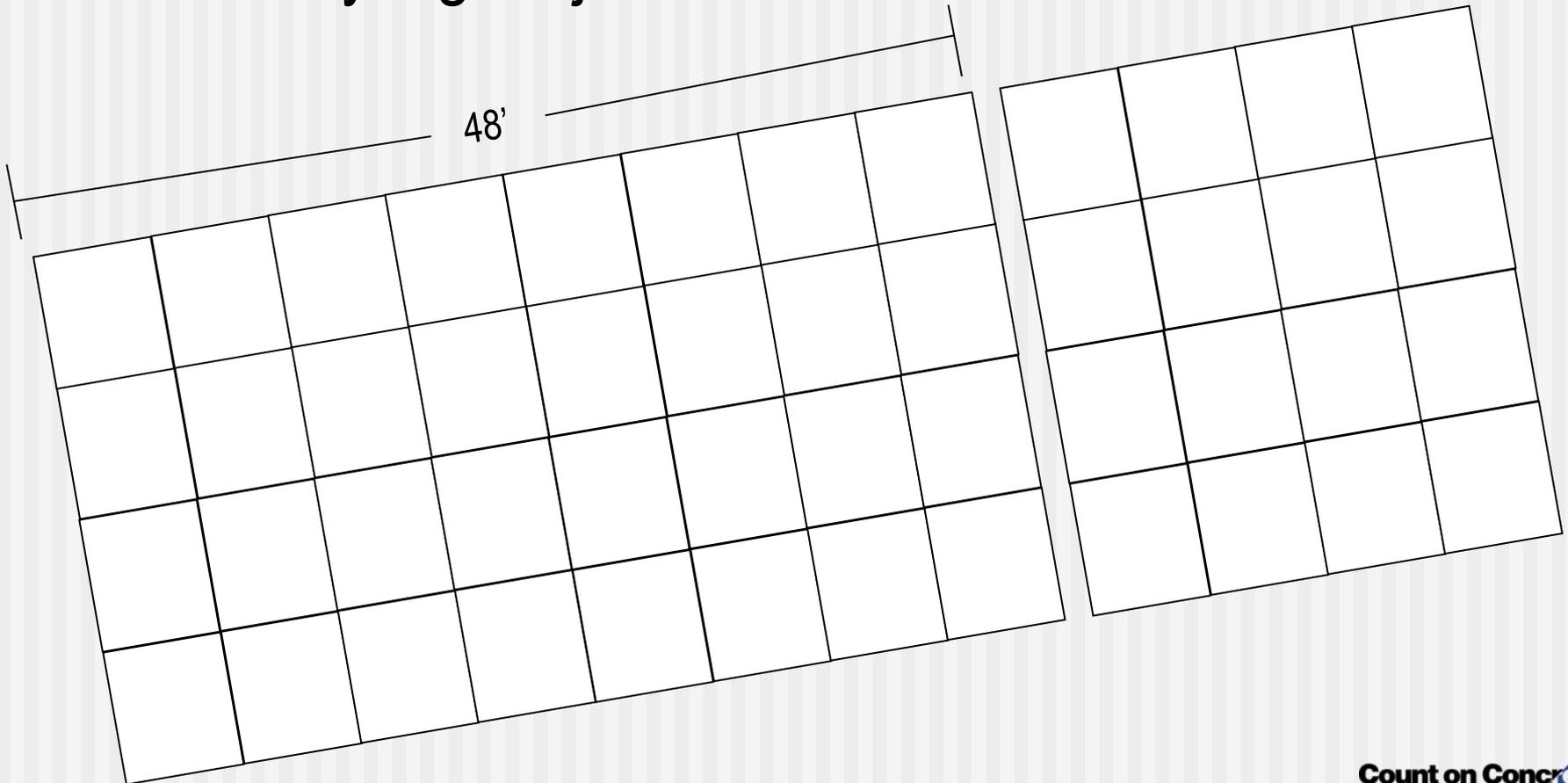
6' x 6' Joints

- If every sixth joint activates...



6' x 6' Joints

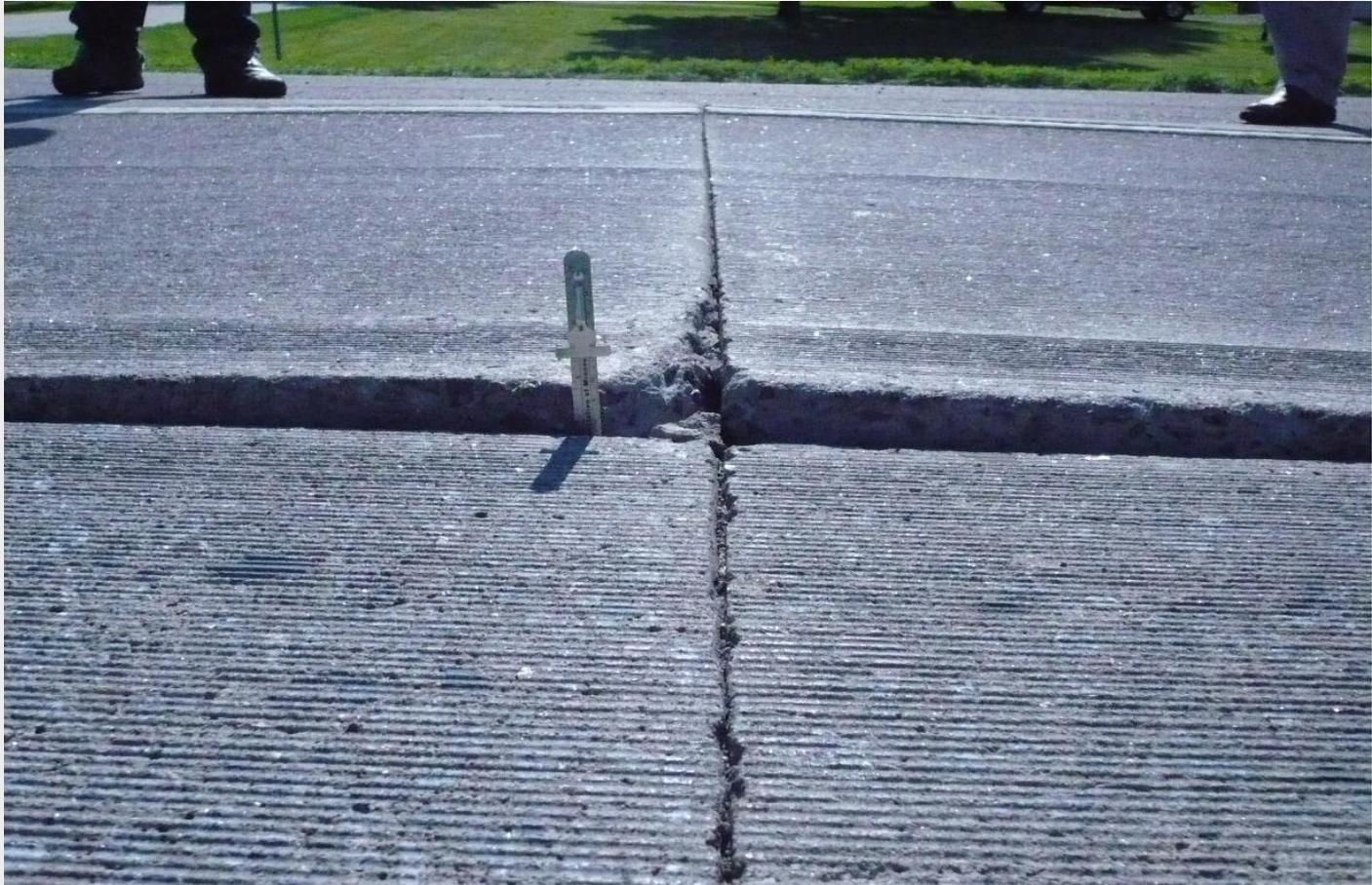
- If every eighth joint activates...



The Problem

- All Our Joints are Not Working/Moving/Activating
 - Larger panels have more curl and warp
 - More joints = smaller joint opening = better aggregate interlock
 - Smaller joint opening = less opportunity for incompressible material to infiltrate = less opportunity for pavement buckle

8-10 Year-Old 5" Overlay of Asphalt



Single lane buckle in a location that was ground when first constructed

8–10 Year-Old 5" Overlay of Asphalt



- Dominant joint. Is joint infilling causing the problem?













The Solution (maybe)

- Get All the Joints to Activate
- How?
 - Saw deeper – Lose aggregate interlock
 - Saw sooner – Spalling and/or damage around joint
 - Early loading – Long-term damage

Joint Activation/Early Loading



TH 12 Dassel - 25+ year old tracks from vehicle driving on concrete early.

MnDOT TH 12 (Paved 1994, photos taken 2016)

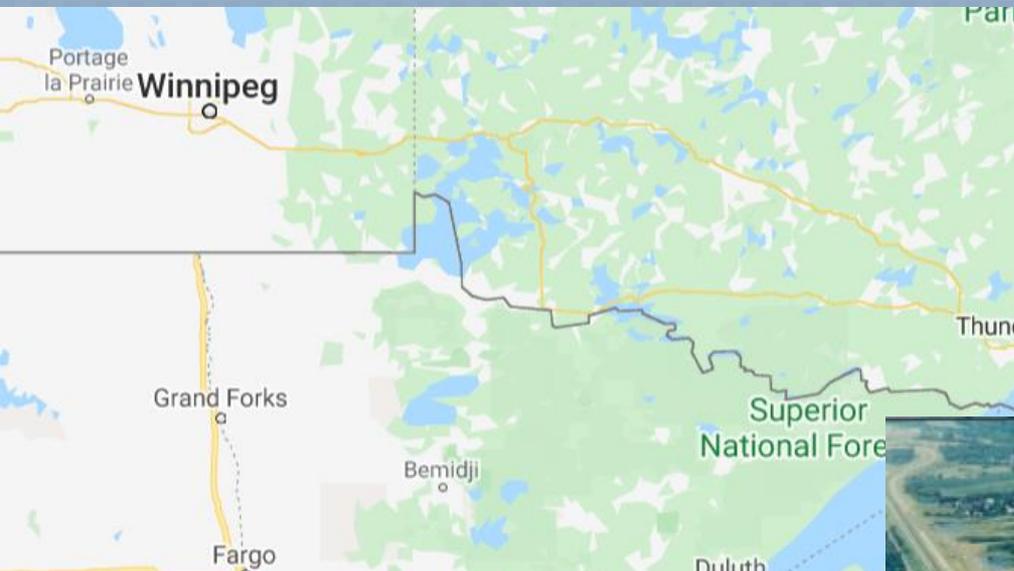


So, When Can We Allow traffic on New Concrete?

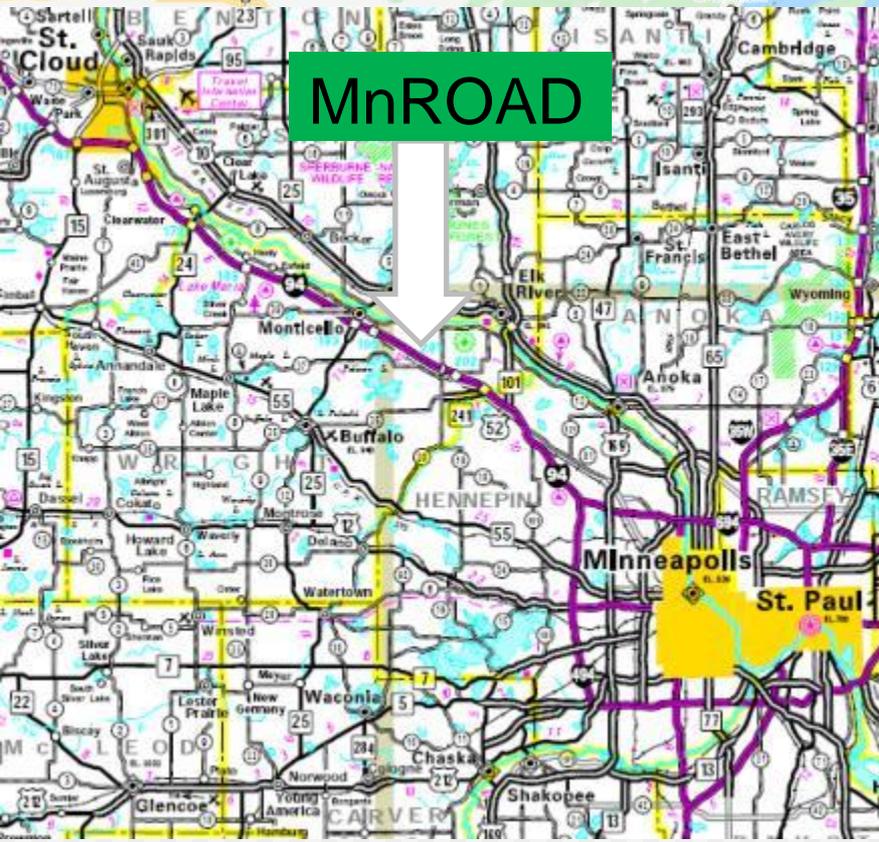
- 1/3/7 Days?
- 2000/3000/4000 psi Compressive?
- 150/300/500 psi Flex?

Opening Strength

- Why 3000 psi?
 - Where did that come from?
- Vehicle Tire Pressure
 - Car 35 psi +/-
 - Pickup truck 35 psi – 80 psi
 - Semi truck/trailer 75 psi – 135 psi+
- Quote from MnDOT rep regarding MnROAD
 - “... where Matt gets to try out his crazy ideas”



MnROAD



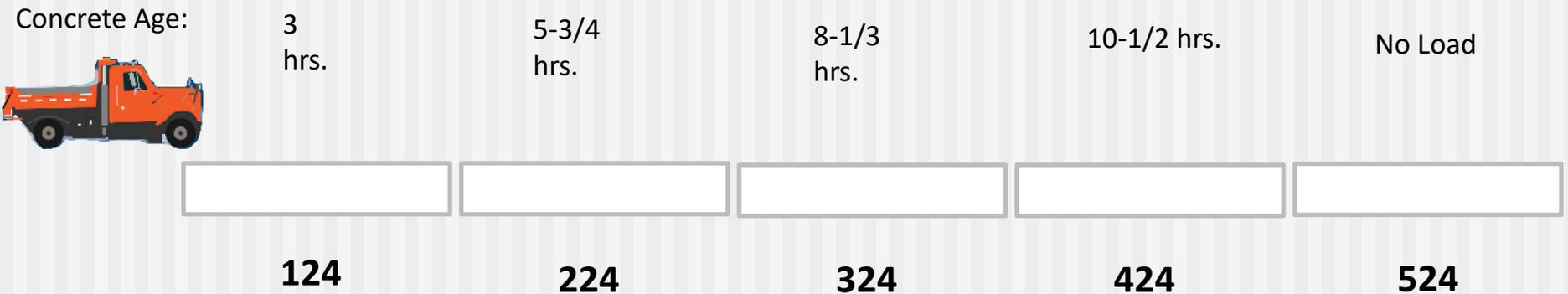
Opening Strength Test (July 2017)

Early loading of Cells 124-424



4,000 lb axle vs 14,000 lb axle loads (1st Cell @ 3hrs)

The Experiment



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

Starting Day 2, 5 passes per day for first week

Burnham - NCC 2017

3 hours



- https://www.youtube.com/watch?v=A7n-CaONlwU&ab_channel=NRRA



Future Joint





2 hours

- https://www.youtube.com/watch?v=ZyNy2UA9mSs&ab_channel=NationalRoadResearchAllianceNationalRoadResearchAlliance

MnROAD – Early Opening (rut)



MnROAD Early Opening Conclusions

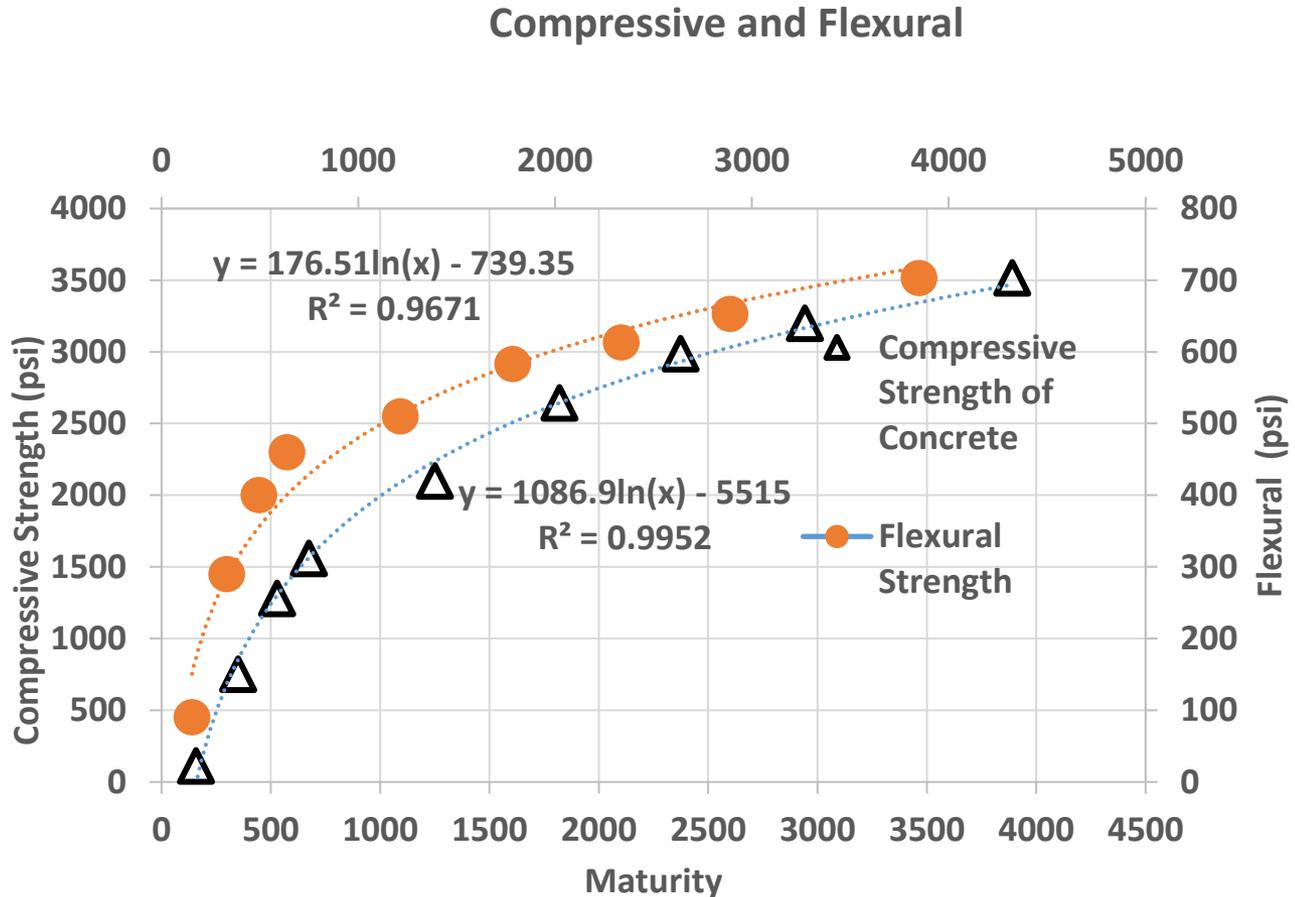
- Strain gauges picked up first pass only of the snowplow
- No visible damage
- No damage seen in cores
- 80,000 lb. truck, 80 times per day since day 6
- Ruts not fixed; no additional damage visible (until now, 2022)

Concrete Maturity Method

- Non-destructive test
- Measures strength of in-place concrete
- Early age test
- Not a 28-day strength test
- Works well with opening strength & joint activation efforts

MnROAD Maturity Curve

<u>Hours</u>	<u>TTF</u>
3.0	= 100
5.75	= 200
8.33	= 300
10.5	= 400



Indiana SR 3 - 4.5" FRC (2018)



Indiana SR 3 - 4.5" FRC (2018)



Indiana SR 3 - 4.5" FRC (2018)



Activating Joints on TH 63



TH 63 Joint Activation



TH 63 Joint Activation



TH 63 Joint Activation



Concrete Maturity - Flexural Beam Strength Development

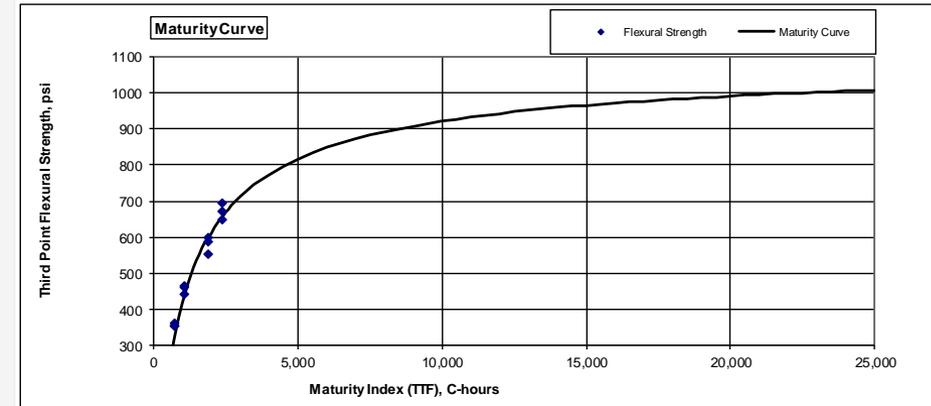
Project No.: 5510-84
 Location: HAMMOND QUARRY
 Curve #: 1

Tester: JEFF BOLSINGER
 Contractor: CROELL, INC.
 Engineer: PAUL SCHAUER

Report Date: 6/11/18
 Casting Date: 6/7/18
 Casting Time: 18:30
 Slab Thickness: 5

Beam Breaker Type: Hydraulic Beam Breaker

Beam No.	Age at Break (hours or days)	Ave. Width "B" (in)	Ave. Depth "D" (in)	Total Test Load, lb	Corrected Load, lb	Broken in Center Third? (Y/N)	Modulus of Rupture (psi)	TTF Sensor 1 (C-Hours)	TTF Sensor 2 (C-Hours)	Ave. TTF (C-Hours)
1	12	6.06	6.00	1000	1120	Y	139	363	374	370
2		6.12	5.94	1200	1310	Y	164			
3		6.12	6.00	1000	1120	Y	137			
4	24	6.12	5.94	2800	2830	Y	354	711	729	720
5		6.12	5.94	2800	2830	Y	361			
6	36	6.00	5.94	2800	2830	Y	361	1046	1069	1060
7		6.06	6.00	3600	3590	Y	444			
8		6.00	6.00	3700	3690	Y	461			
9	66.6	6.06	5.94	3700	3690	Y	466	1888	1920	1905
10		6.06	6.00	4500	4460	Y	552			
11		6.06	6.00	4900	4850	Y	600			
12	84	6.06	6.00	4800	4750	Y	588	2378	2417	2400
13		6.12	5.88	5500	5440	Y	694			
14		6.06	6.00	5300	5240	Y	649			
15		6.12	5.97	5500	5440	Y	673			



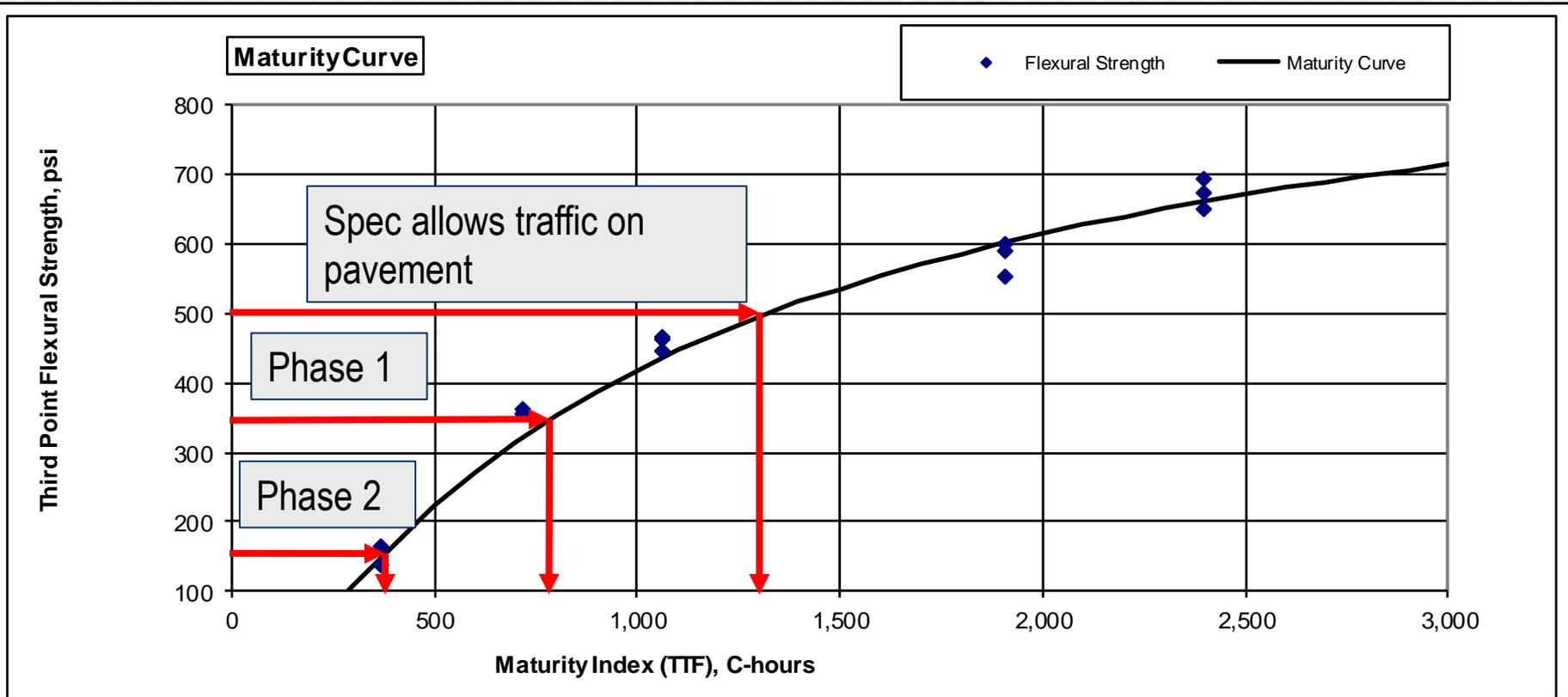
Curve Coefficients: $S_u = 1108.79$, $t = 965.85$, $a = 0.7210586$ Solve Maturity Curve

Required Strength for Opening: 500 psi
 Required TTF for Opening: 1320 C-hours

Comments:

Mix Information		Certified Contractor Representative: JEFF BOLSINGER
Mix No.	3A21-1	
Truck No.		
Air, %	6.6	
Slump, in.	2	
W/C Ratio	0.36	Maturity Curve Review ed by:

Concrete Maturity



Curve Coefficients:

Su= 1108.79
 t= 965.85
 a= 0.7210586

Solve Maturity Curve

Required Strength for Opening

500

 psi
 Required TTF for Opening

1320

 C-hours

Comments:

Joint Activation - Results

- No loading 1 day – every 24 joints
- Phase 1 (24 hours old) – 350 psi flexural (maturity)
 - Didn't see much change
 - Felt concrete too strong
 - Did see increased activation when heavier construction traffic started driving on concrete
- Phase 2 (14 hours old) – 150 psi flexural (maturity)
 - 3800 ft section
 - First 1000 ft – 17 joints working
 - Next 2800 ft – 5 joints working
 - Per District – Cracking every 4 to 6 joints more quickly

TH 63 Joint Activation



Joint Activation/Early Loading

- I think we can & should load BCOA early to activate joints
- First project TH 63 in 2018
- 10+/- projects since – mostly thin overlays
- I believe we should do this on traditional concrete pavements as well.
- Optimum timing appears to be shortly after sawing or about 12 hours.

Joint Activation/Early Loading

- Maturity test of TTF = 350 (150 psi flex) seems to be a good target to load
- Most likely need to continue to load for several days.
- Open to construction traffic or batch trucks?
- May have to ensure sawing gets through edge of pavement
- Indiana joint activation was encouraging

Joint Activation/Early Loading

- MnDOT research report notes:
 - The number of joints deployed at each location shortly after loading varied quite significantly
 - It is true that several of the projects had an increased number of joints deployed due to the application of early loading, but not to the extent desired
 - An important observation, however, is the fact that there appears to be no observable damage to the concrete overlay using the techniques utilized in this study

Joint Activation/Early Loading

- MnDOT research report notes:
 - ... it will be critical to their long-term performance to have as many deployed transverse joints as possible
 - Current early loading methods and timing would need further adaptation and monitoring to increase their success. With the number of variables that go into such a task, it may be too difficult to obtain reliable results

Joint Activation/Early Loading

- MnDOT/NRRA research supports allowing traffic on concrete pavements earlier
 - Final report published 10/12/2021
 - Conclusions:
 - The current strength criteria for opening concrete pavements to traffic are empirical and conservative.
 - Extensive analysis of pavement performance, non-destructive testing, and embedded sensors could not identify any long-term damage associated with those early loadings
 - Current criteria for traffic opening is overly conservative and that modern concrete pavements can safely open to traffic earlier than currently allowed.

What's Next

- Continue to try variations of loading
 - Many variables: weather, mix design, cement, loading (magnitude, repetitions, timing, duration, axles)
 - Some have shown encouraging results, some have not shown much

Joint Activation/Early Loading

■ Final thoughts

- This scares most people. We have been well trained to be very conservative.
- We have to work hard to change the norm and gain acceptance for allowing vehicles on concrete pavements earlier.
- We all have stories of concrete that has been driven on and rutted and left in place with no issues after decades.

What the \$\$\$ does this have to do with Pavement Preservation

- We believe that ensuring our joints are activated will:
 - Minimize the opportunity for incompressible material to infill the joint
 - Minimize the overall curl/warp
 - Minimizing the joint opening ensures aggregate interlock for better load transfer
 - Minimize the cost of preserving our concrete pavements

Thank You - Questions?



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www.concreteisbetter.com