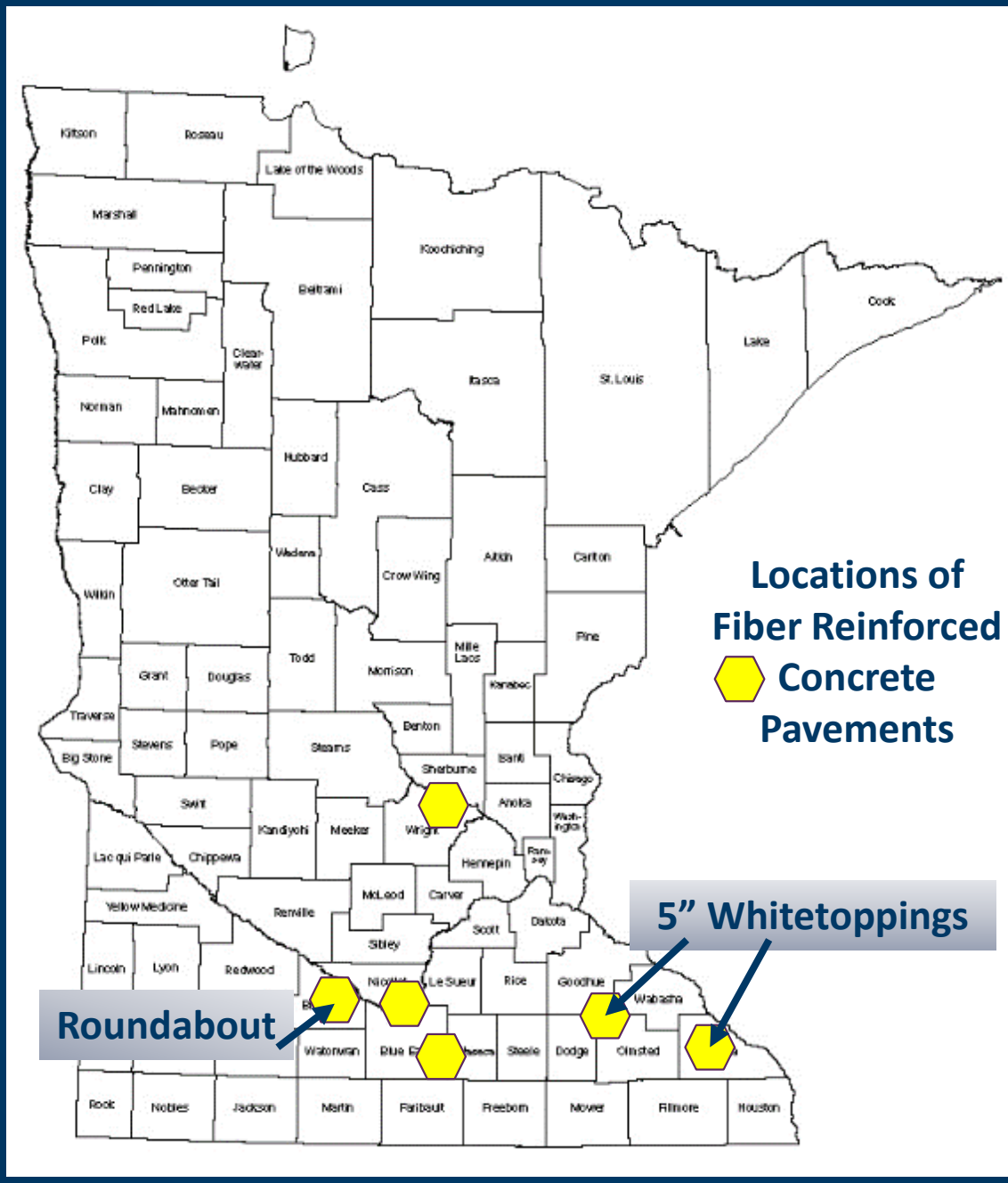
MnDOT's Fiber Reinforced Concrete Roundabout and Joint Activation of 5" FRC Whitetopping

NCC Meeting – Denver, CO

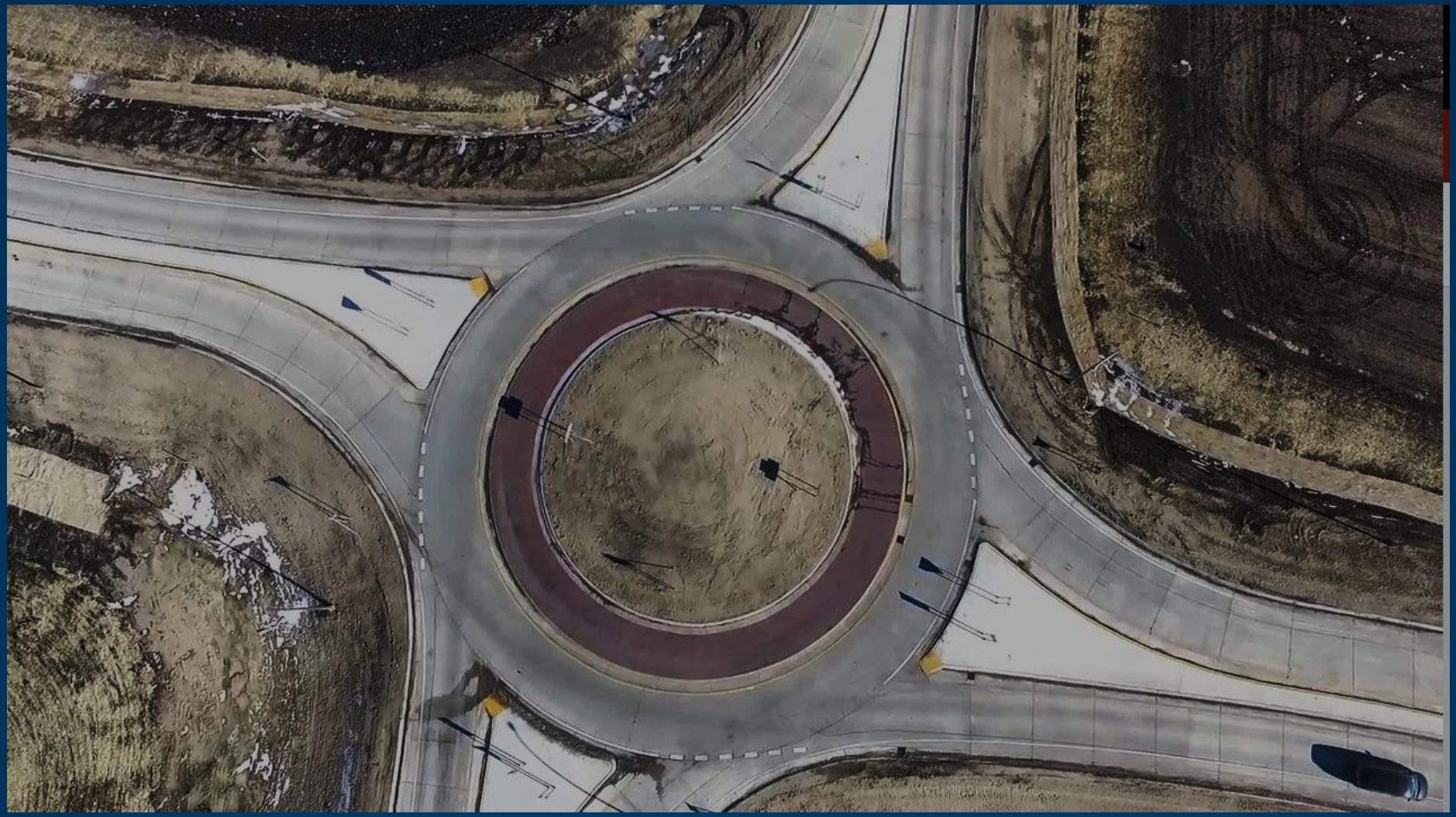
Maria Masten, MnDOT Concrete Engineer

April 2, 2019

DEPARTMENT OF TRANSPORTATION


Kittson
Roseau
Lake of the Woods
Marshall
Pennington
Red Lake
Polk
Beltrami
Koochiching
Cook
Lake
Clear-water
Itasca
St. Louis
Norman
Mahnomen
Hubbard
Clay
Becker
Cass
Wadena
Crow Wing
Aitkin
Carlton
Wilkin
Otter Tail
Pine
Todd
Morrison
Mille Lacs
Kanabec
Grant
Douglas
Traverse
Stevens
Pope
Stearns
Benton
Isanti
Chisago
Big Stone
Sherburne
Swift
Kandiyohi
Meeker
Wright
Anoka
Lac qui Parle
Chippewa
Hennepin
Yellow Medicine
Renville
McLeod
Carver
Scott
Dakota
Sibley
Lincoln
Lyon
Redwood
Nicollet
Le Sueur
Rice
Goodhue
Wabasha
Waterman
Steele
Dodge
Olmsted
Rock
Nobles
Jackson
Martin
Faribault
Freeborn
Mower
Fillmore
Houston
Locations of
Fiber Reinforced
Concrete
Pavements
5” Whitetoppings
Roundabout

Fiber Reinforced Concrete Roundabout



Snapshot from https://youtu.be/GmrP8G46_v4

Courtesy Greg Bauer, CPAM

Why build a jointless roundabout?

- District 7 Mankato Materials Engineer contacted the Concrete Office to discuss the idea of constructing a Continuously Reinforced Concrete(CRC) Roundabout
  - Goal was to not worry about jointing pattern
  - Concern about cost and constructability
  - Presentation at a NCC meeting discussing FRC roundabouts prompted the idea to build FRC roundabout without joints
- Lots and lots of discussion…

Fiber Requirements

Provide Type III structural synthetic fibers meeting the requirements of ASTM C 1116 and the following:

a. Minimum mean residual strength of 175 psi (F175), when tested in accordance with ASTM C1609
b. A monofilament or bundled monofilament with a minimum length of 1.5 in and a maximum length of 2.25 in., and
c. A maximum aspect ratio (length divided by the equivalent diameter of the fiber) of 150, and with a target aspect ratio between 50 and 100.

TH 4 Roundabout with fibers

- Cemstone/Hoffmann
  - Required Test Data and Test Pour
  - Mean residual strength of 175 psi (equivalent strength ratio)
- BASF Macro 360FF
  - Dosage Rate 6 lb/cy
  - Used for temperature and drying shrinkage control
  - a synthetic micro- and macrofibers, is manufactured from a proprietary blend of polypropylene resins

Quality Control Plan

- Identify dedicated personnel involved in introduction of synthetic fibers to mix
- Proposed method for adding the synthetic fibers into the mixer to ensure uniform distribution and random orientation of the fibers throughout the concrete mixture
- Mitigation strategies needed if unmixed fiber balls are identified after concrete mixing or during concrete placement.

Trial Batching

- Minimum 5 cubic yard trial placement with the contractor-designed mix to demonstrate slump, air loss, and workability with the Contractor's mix design.
- Any trial batching of the FRC mix designs are at the Contractor's discretion with no additional cost to the Agency.
- Ensure the manufacturer's technical representative is available by phone or in person to troubleshoot fiber inclusion into the mix during the trial batching.

Placement

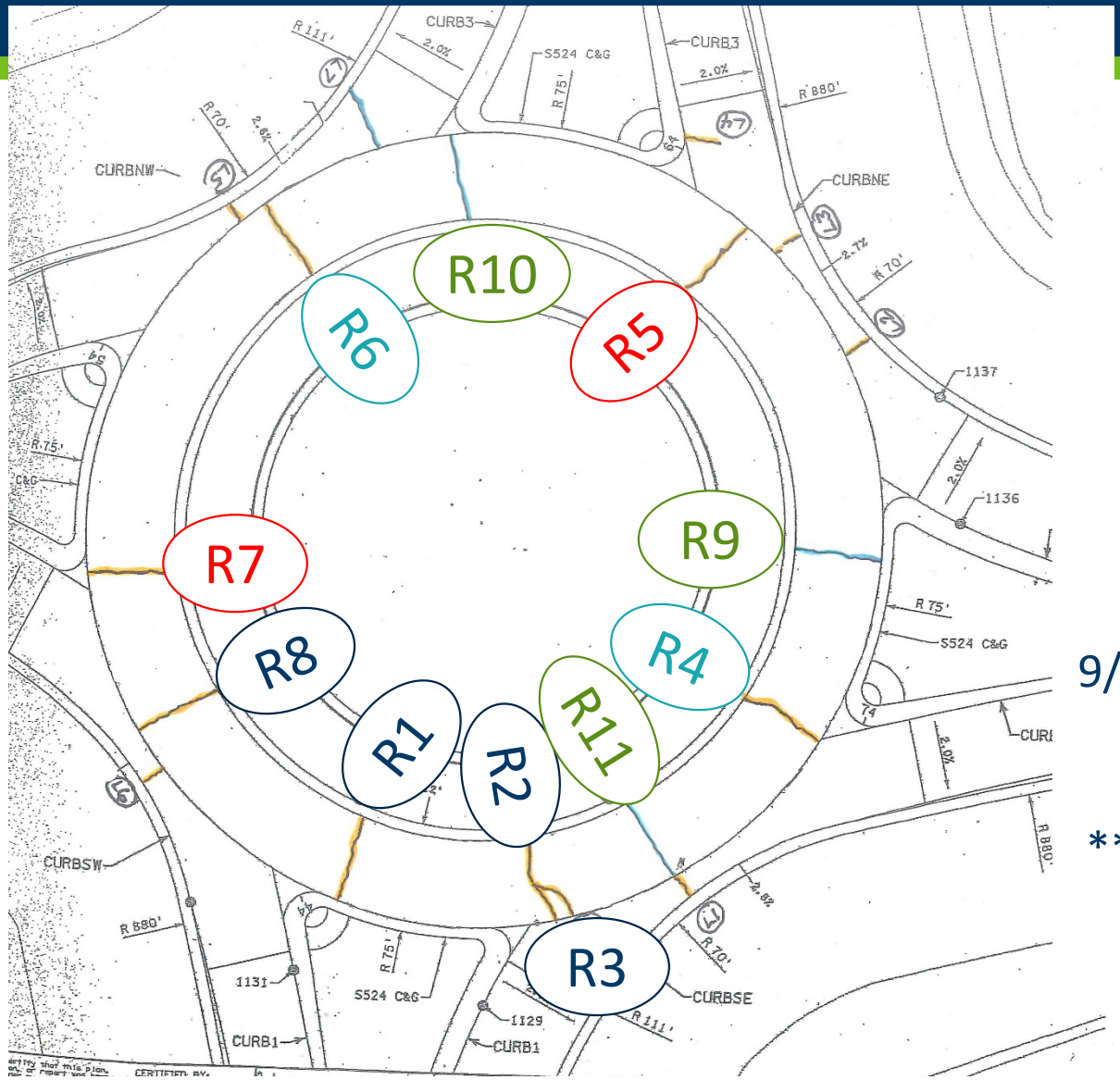
- Plan to place the FRC inside the isolated circle of the roundabout in one continuous placement.
- Provide active crack control (notch) on the outside edge of the roundabout:
  - 15 inch long saw cut,
  - At a depth of 1.5 inch, and
  - Every 4 feet on the outside edge of the roundabout.
- Seal the active crack control (notch) saw cuts using hot pour

Fiber Reinforced Concrete Roundabout

Fiber Reaction to Vibration

Aerial View of Roundabout

Fiber Reinforced Concrete Roundabout



9/10/18 - Legs Poured

9/13/18 - Roundabout Poured

Cracking Locations

9/16/18 - R5, R7**

9/17/18 - R1**, R2, R3**, R8

9/18/18 - R4, R6**

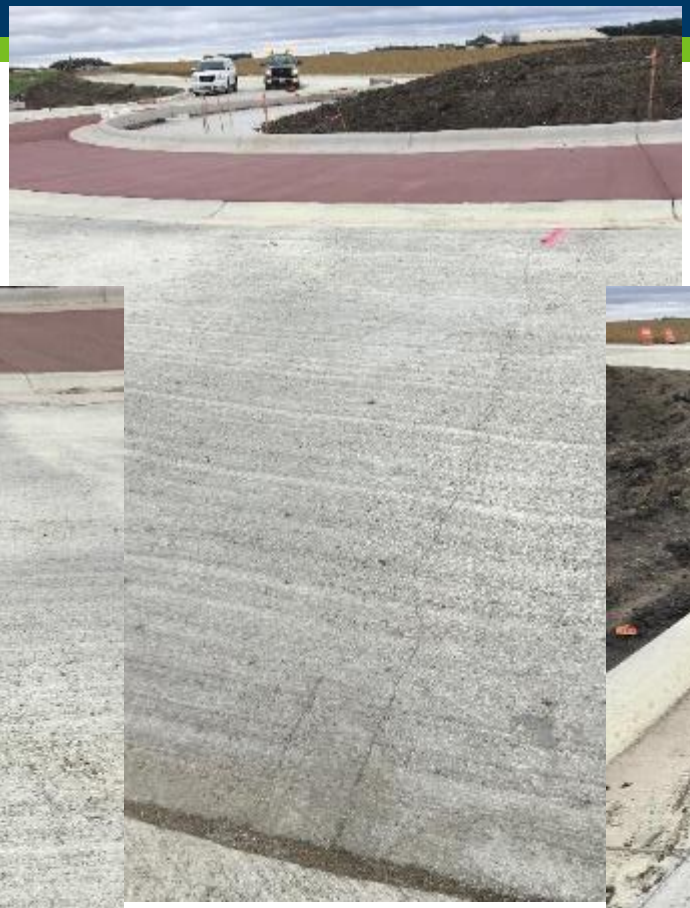
3/28/19 – R9, R10, R11

** Cracked off Sawed Notch

Cracks as of 3/28/19

Fiber Reinforced Concrete Roundabout

Fiber Reinforced Concrete Roundabout



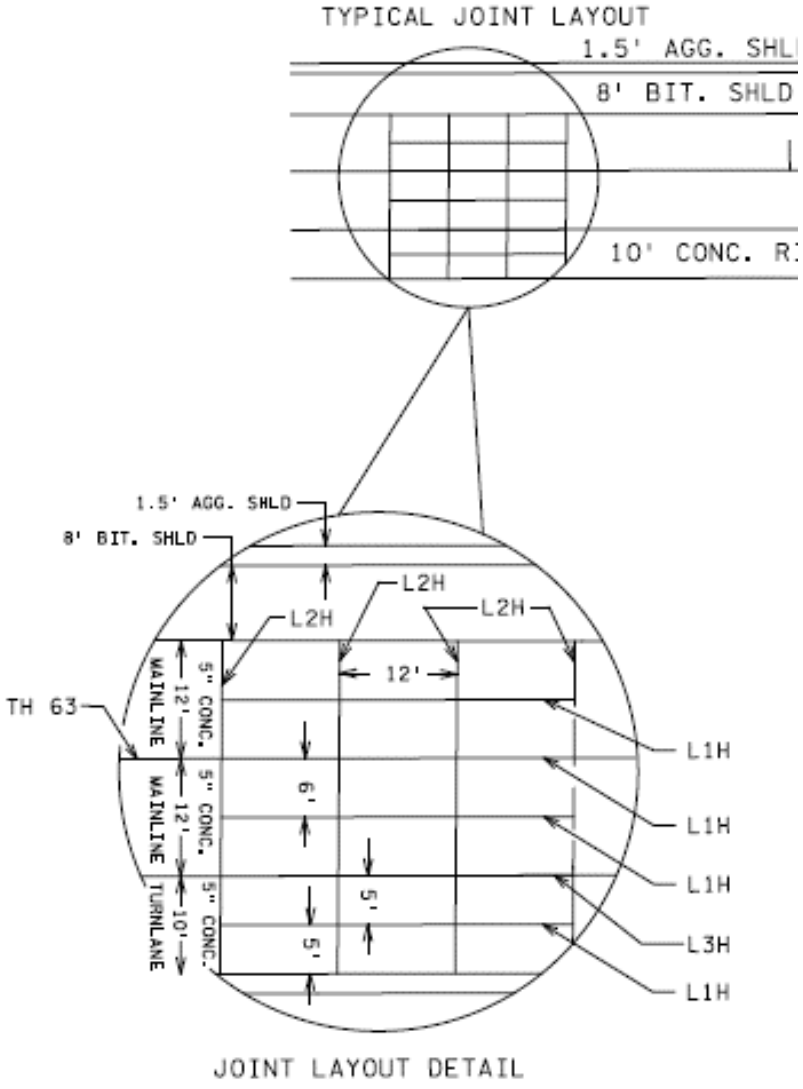
TH 63 5” Whitetopping with fibers

TH 63 5” Whitetopping with fibers

- Croell, Inc. – Iowa Contractor
  - 12.379 Miles
  - Engineer’s Estimate $6.1 Million
  - Low Bidder $6.9 Million
  - Placement (177, 319 SY) – EE $5.87, Croell $4.30
  - Structural Conc (24,900 CY) – EE $59.89, Croell $92.50
  - SP 12.5 WE (2,B) (20,863 Tons) – EE $44.22, Croell $51.50

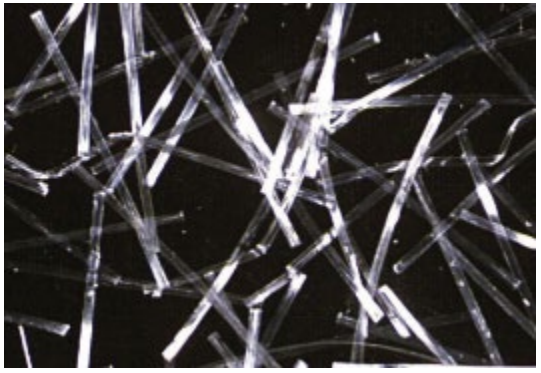
TH 63 5” Whitetopping with fibers

- Typical 6’ x 6’ panels
- ½ mile test section - 12’ long x 6’ wide panels
- 3D Profile Milling of Asphalt
- Stringless Paving



TH 63 5” Whitetopping with fibers

- Croell tried 3 different fibers
  - Forta Concrete Fiber - Forta Ferro One Macro
    - Virgin Copolymer/Polypropylene
    - Monofilament/Fibrillated Fiber System
  - Grace Construction Products - Strux 90/40 Synthetic Macrofiber
  - Mapei/GRT Advantage Macrosynthetic Fiber
    - Embossed tape fiber comprised of a blend of polypropylene and polyethylene resins



Delivery of Fibers

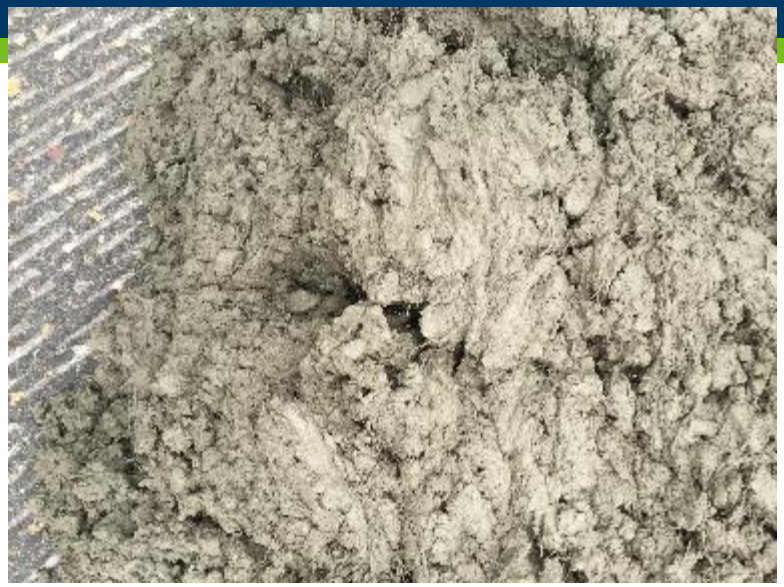
- High production paving using Fibers was major concern
- Mixing Time may need to be increased
  - Croell has batched at increased batching times (15-30 sec) – once dialed in back to about 50 – 60 secs
  - Similar experience found in trial placement in Iowa in 2017

Automated Fiber Dispensing/Conveying

- TH 63 Spec requires automated fiber dispensing or conveying system – Contractor fabricated their own
- Batched 10 cy loads – Used 8 – 5 # bags per load

Used a screw to keep bags separated – so laser eye could keep count of when to shut off belt for each load

Placing the fiber reinforced concrete



Placing the fiber reinforced concrete

DEPARTMENT OF TRANSPORTATION

Comparison of Performances of Structural Fibers and Development of a Specification for Using Them in Thin Concrete Overlays

Manik Barman, Principal Investigator
University of Minnesota Duluth
Department of Civil Engineering

August 2018

Research Project
Final Report 2018-29

LRRB

http://www.dot.state.mn.us/research/reports/2018/201829.pdf

Joint Activation of Fiber Reinforced Concrete

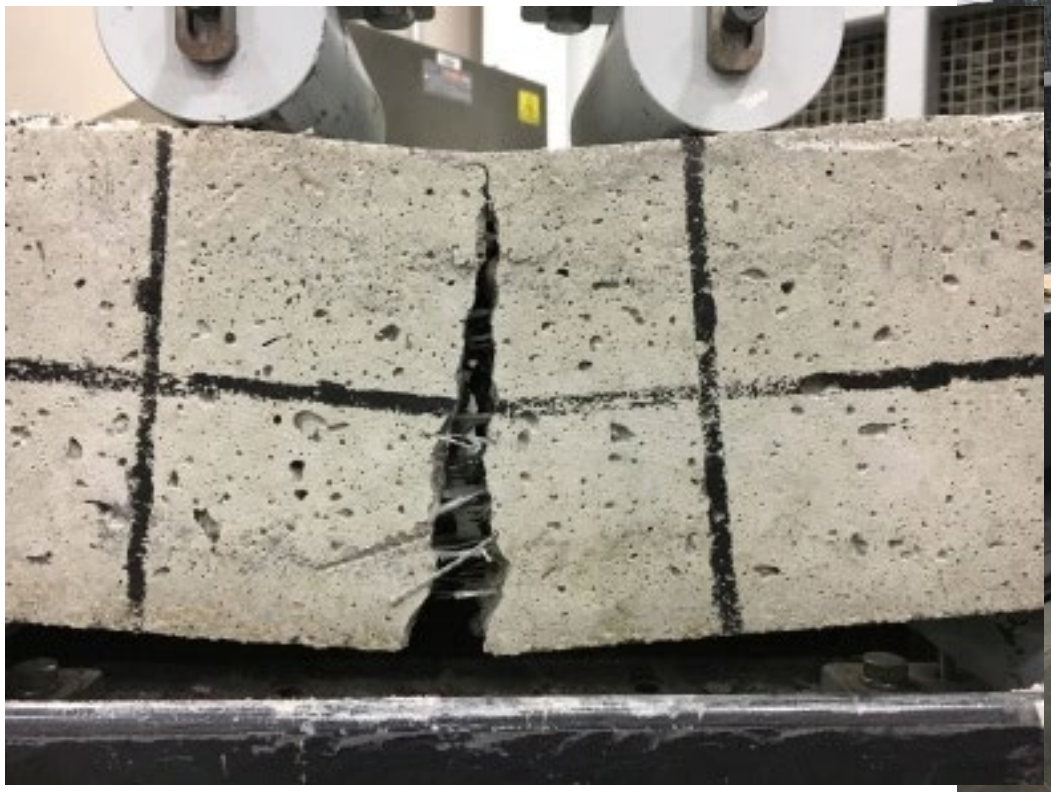


Photo courtesy of Dr. Manik Barnam, UMD

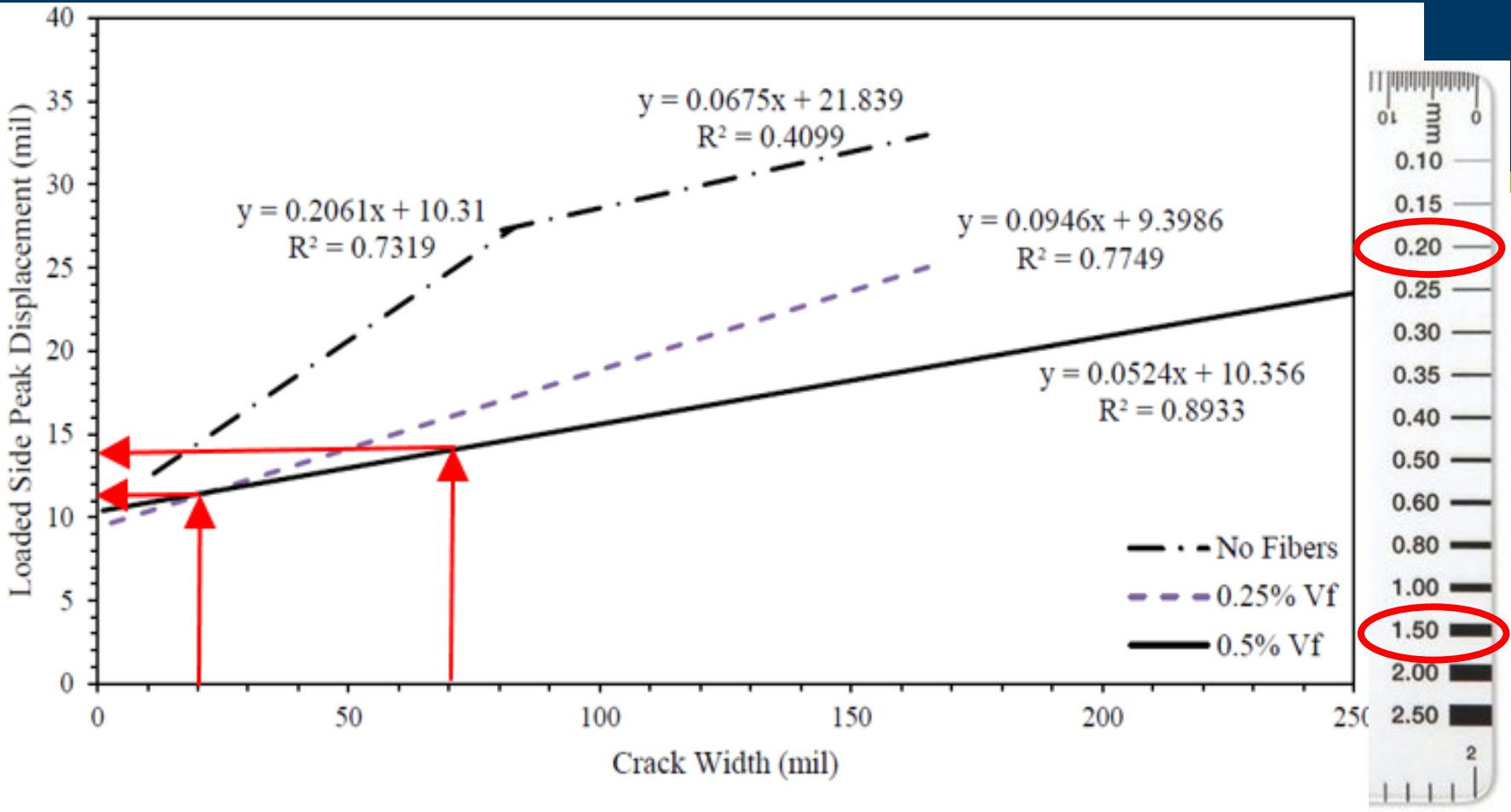


Figure 4-6. Average loaded side peak displacement as a function of crack width to compare the effect of fiber dosage on joint performance.

A 20 mils crack width has a Loaded Side Peak Displacement of 11.25 mils and at 70 mils cracked width has a Loaded Side Peak Displacement of 14 mils. A 20% difference in Loaded Side Peak Displacement just by reducing the crack width. Also, using 0.25% Vf would be cheaper that using 0.5% Vf for the same Loaded Side Peak Displacement results.

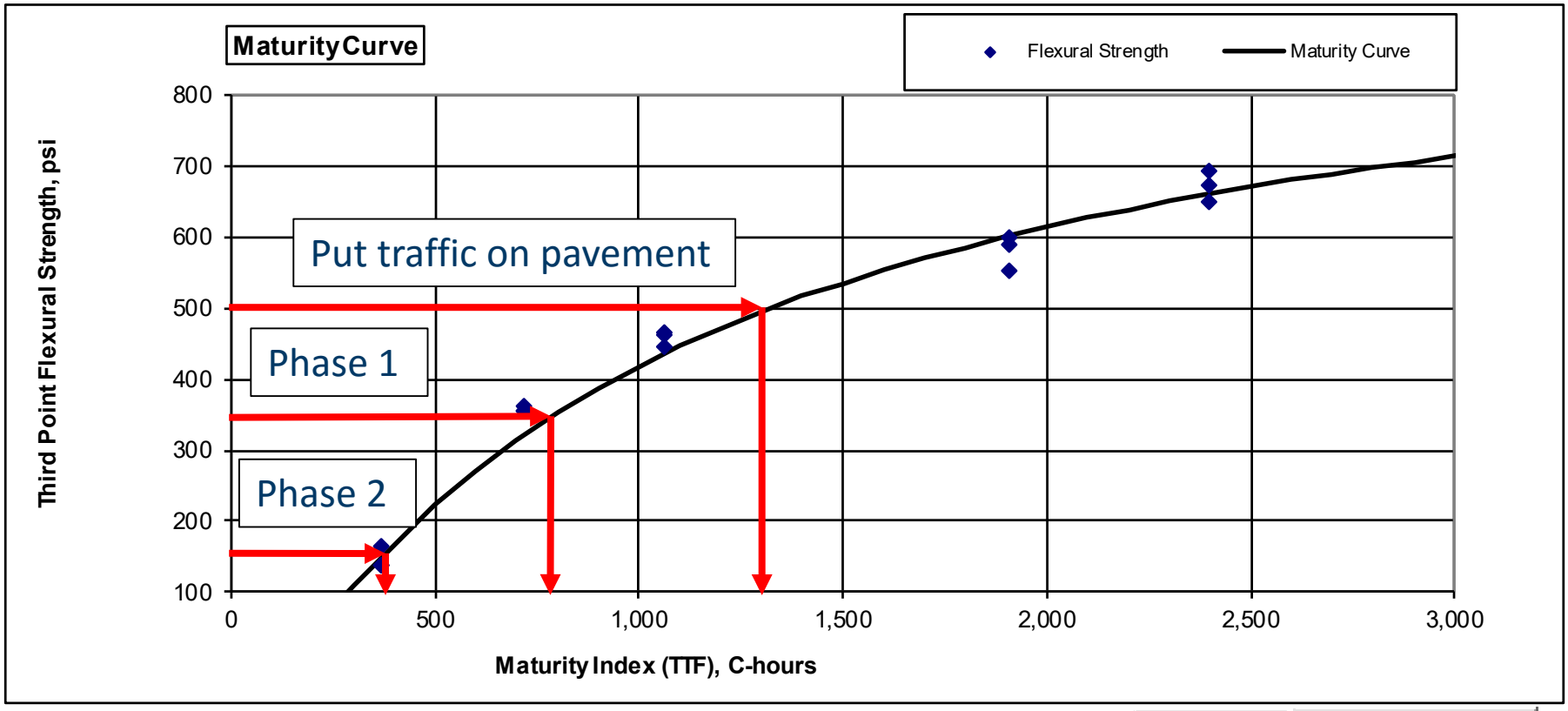
Report Conclusion

- Fibers help keep cracks and joints tight and improve load transfer across cracks and joints in thin concrete overlays.
- Synthetic fibers provide equal or better performance than steel fibers, which are expensive, heavy and difficult to mix.
- Dosages less than 0.25 percent fiber volume fraction of concrete mixture did not improve post-crack flexural or load transfer efficiency across the joint.
- Dosage levels and crack width strongly affected joint performance. Overall, it was found that fibers can increase the load transfer by 30 percent and can reduce the slab displacement by 50 percent.

TH 63 Joint Activation

- GOAL: Influence the number of working joints!
  Narrow joint widths – fibers more beneficial
- HOW: Drive on pavement to activate joints

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:

TH 63 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

Sawing Through Transverse Joints Fully

- Important to Note:
  - MN specs require sawing all the way through edge
  - IA specs do not
  - I requested Croell saw all the way through edge for TH 63 project
  - Not sure if it made a difference but I don’t think it hurt



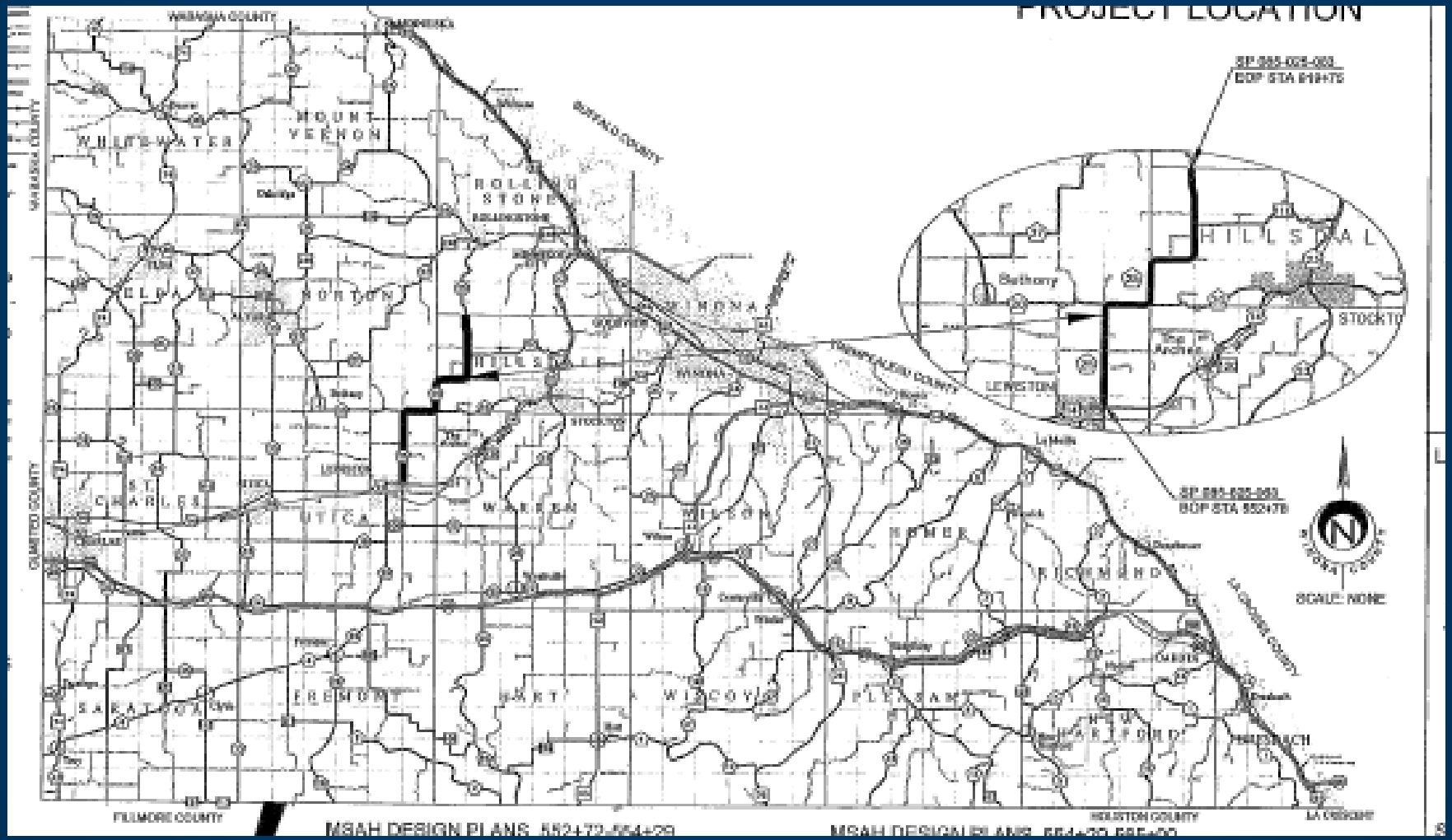

A Little Excitement

- An 800-foot stretch of Highway 63 north of Rochester is ruined after a 95-year-old man drove through wet concrete.
- Repair estimates top $100,000.


kare11.com


More Videos

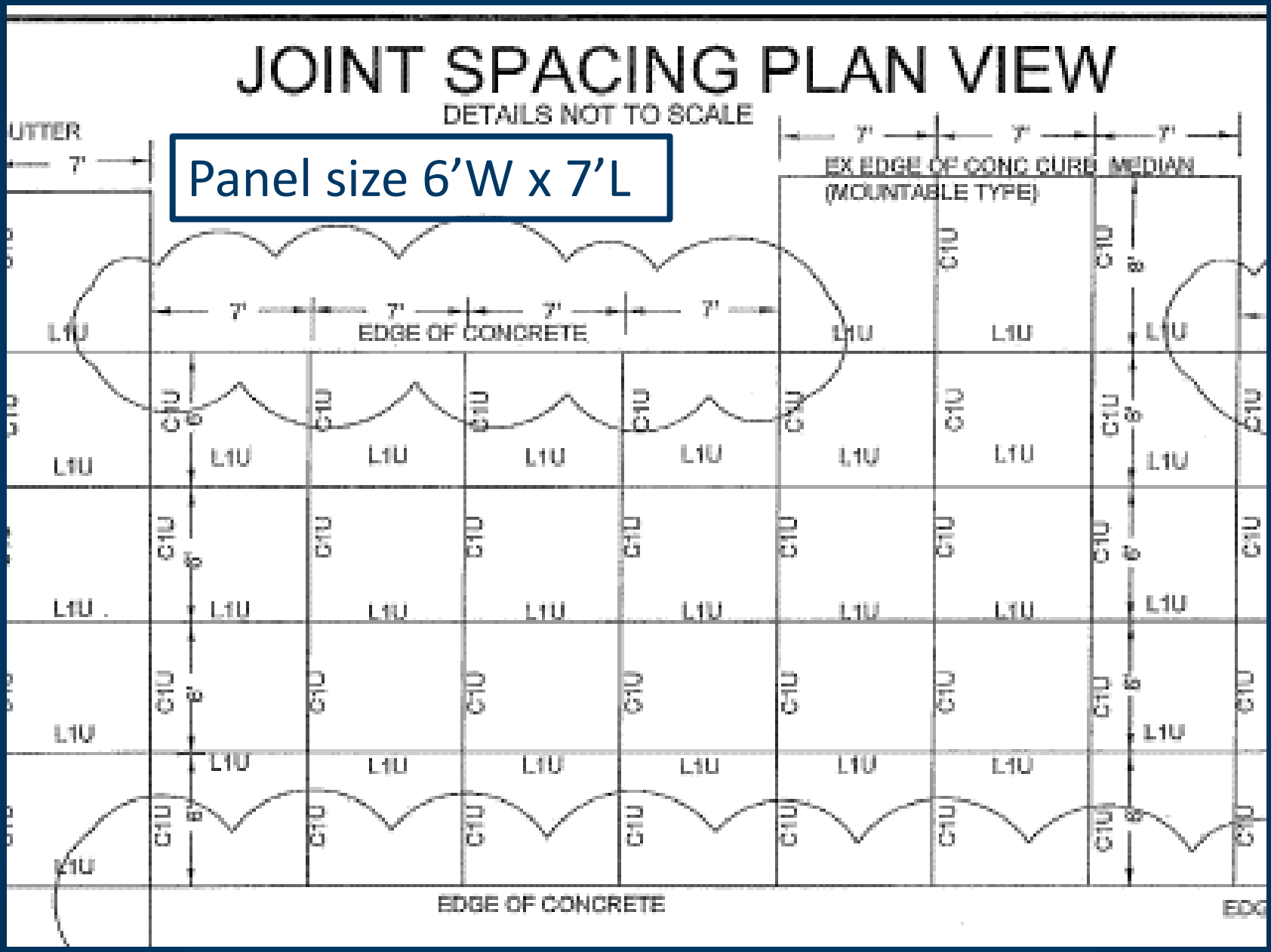
Winona County CSAH 25



CSAH 25 5” Whitetopping with fibers

- Croell, Inc. – Iowa Contractor
  - 7.0 Miles
  - Engineer’s Estimate $3.8 Million
  - Low Bidder $3.26 Million
  - Placement (94,677 SY) – EE $6.11, Croell $4.54
  - Structural Conc (15,188 CY) – EE $92.25, Croell $92.00
- Supplemental Agreement to add fibers
  - Dosage rate of 4 lbs/cy at $21.00/cy
  - Total Additional Cost = $329,910.00

JOINT SPACING PLAN VIEW



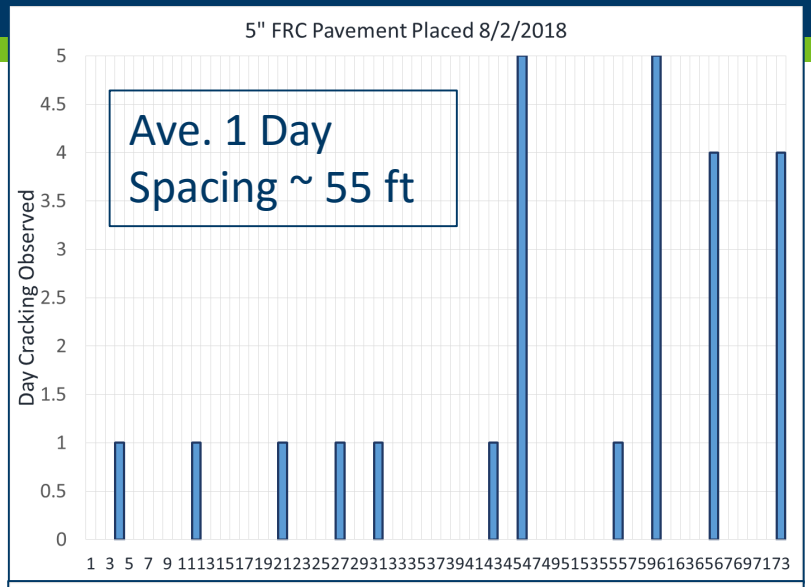

7-42

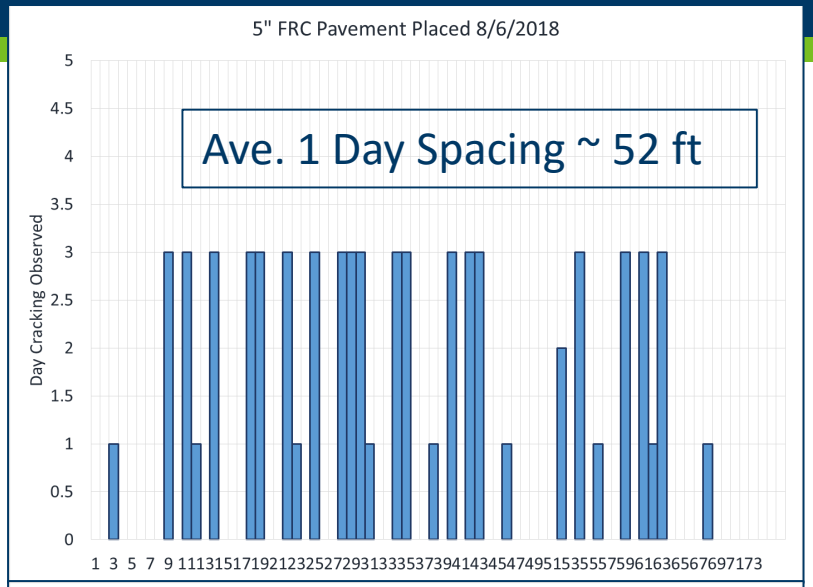

E L A N
Field Book
E 64-8x4 W

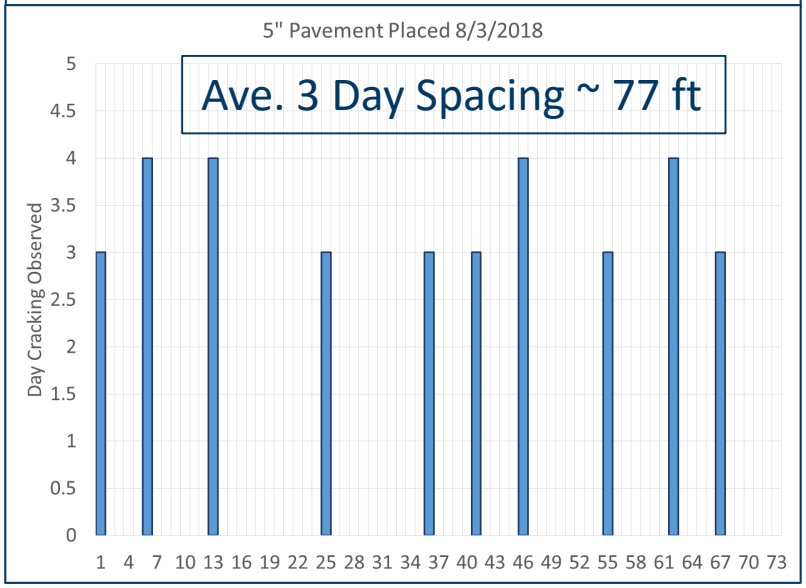
Joint Activation Plan on Winona CSAH 25

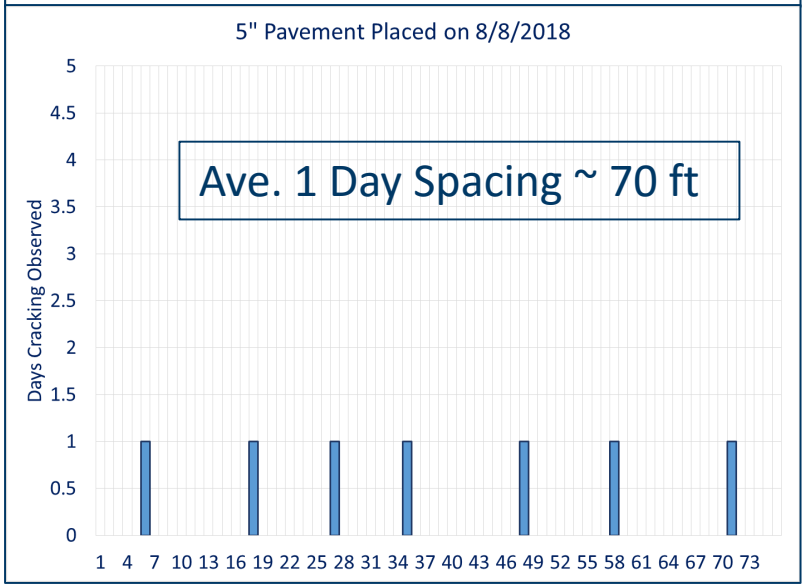
1) Select a 500-foot section for each day of paving or per mile of pavement, whichever is greater.
   - Perform daily inspection of any new cracks that have developed.
   - Mark/spray paint the new cracks on the side of the pavement.
2) Note the relative spacing and location of new cracks.
3) Document the timing of the water truck loading relative to the paving date and time.
   - Fully loaded water truck on the pavement
   - 12 hours and then 24 hours after placement

Early Transverse Joint Deployment









Observation (pavement edge) age range: 1 to 5 days

MnDOT DRAFT Language
Local traffic on the concrete early?

- The Contractor may at their own risk allow passenger vehicles (total gross vehicle weight not to exceed 10,000 lbs) to drive on the concrete pavement no earlier than 12 hours after pavement placement and after satisfactory completion of all initial joint establishment in accordance with 2301.3.N.2, *"Joint Establishment."*
- Prior to placement of any concrete pavement, provide a Quality Control Plan to the Engineer for acceptance which provides the Contractor's plan for management of local traffic during concrete pavement placement.

Thank you!

Any Questions?