

Introduction to Concrete Pavements

Dan Labo, P.E. – CPAM Director of Engineering Services



Class Goals

- MnDOT Concrete Pavement Repair (CPR) Boiler Plates
- Estimate Concrete Repair Quantities
- Complete Field Review of Distressed Pavement
- Compare field review quantity estimates from teams

Concrete Pavement Types

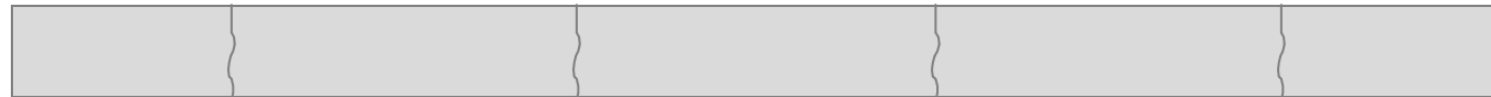
- Jointed Plain
 - Undoweled
 - Doweled
- Jointed Reinforced
- Continuously Reinforced

Jointed Plain

Plan



Profile

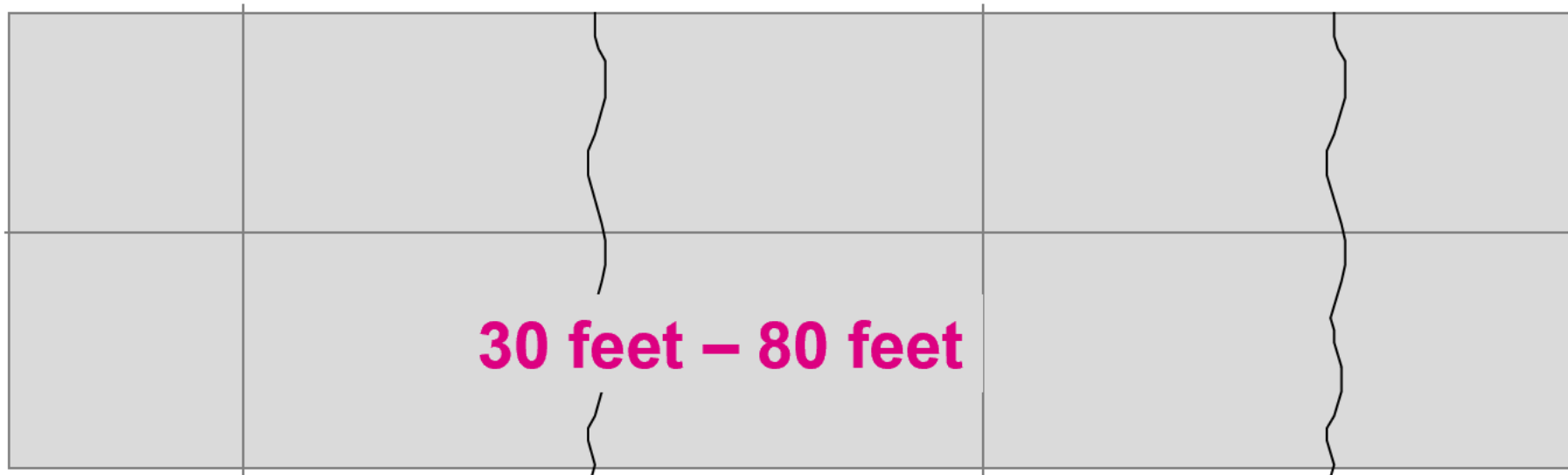


or

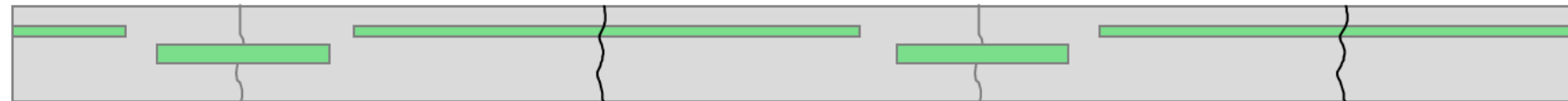


Jointed Reinforced

Plan

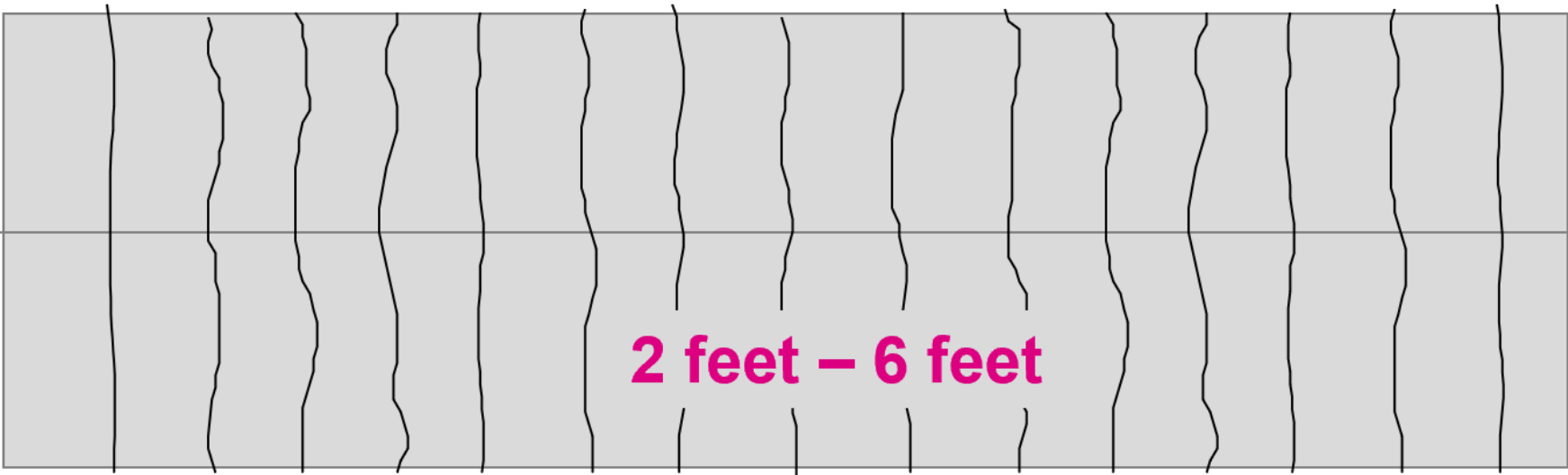


Profile

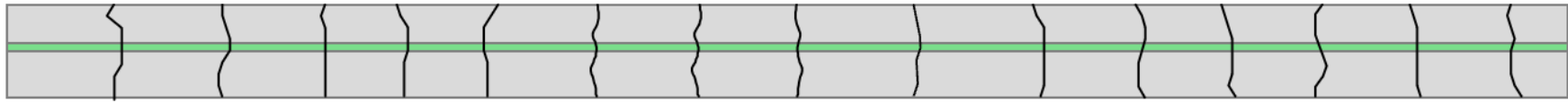


Continuously Reinforced

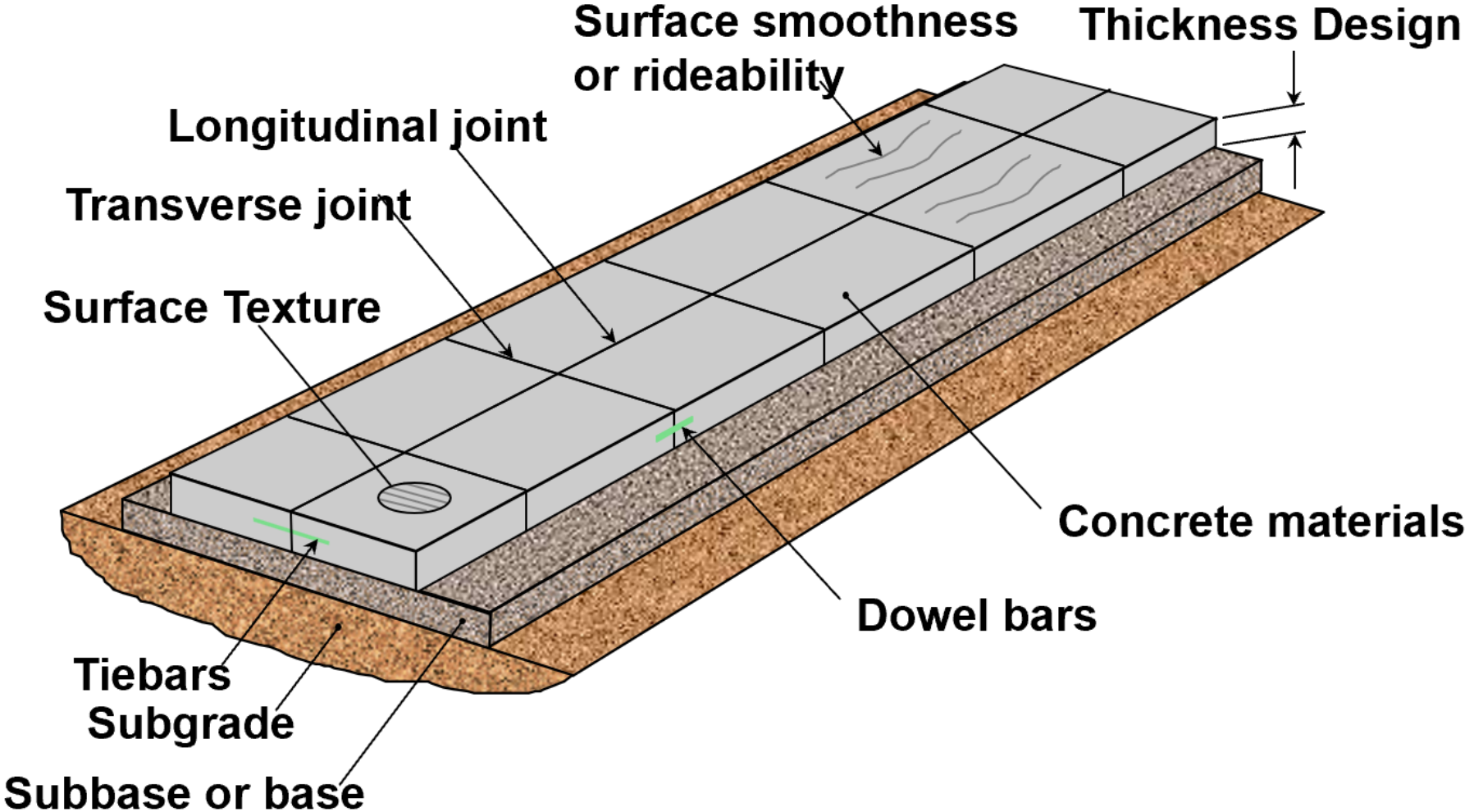
Plan



Profile

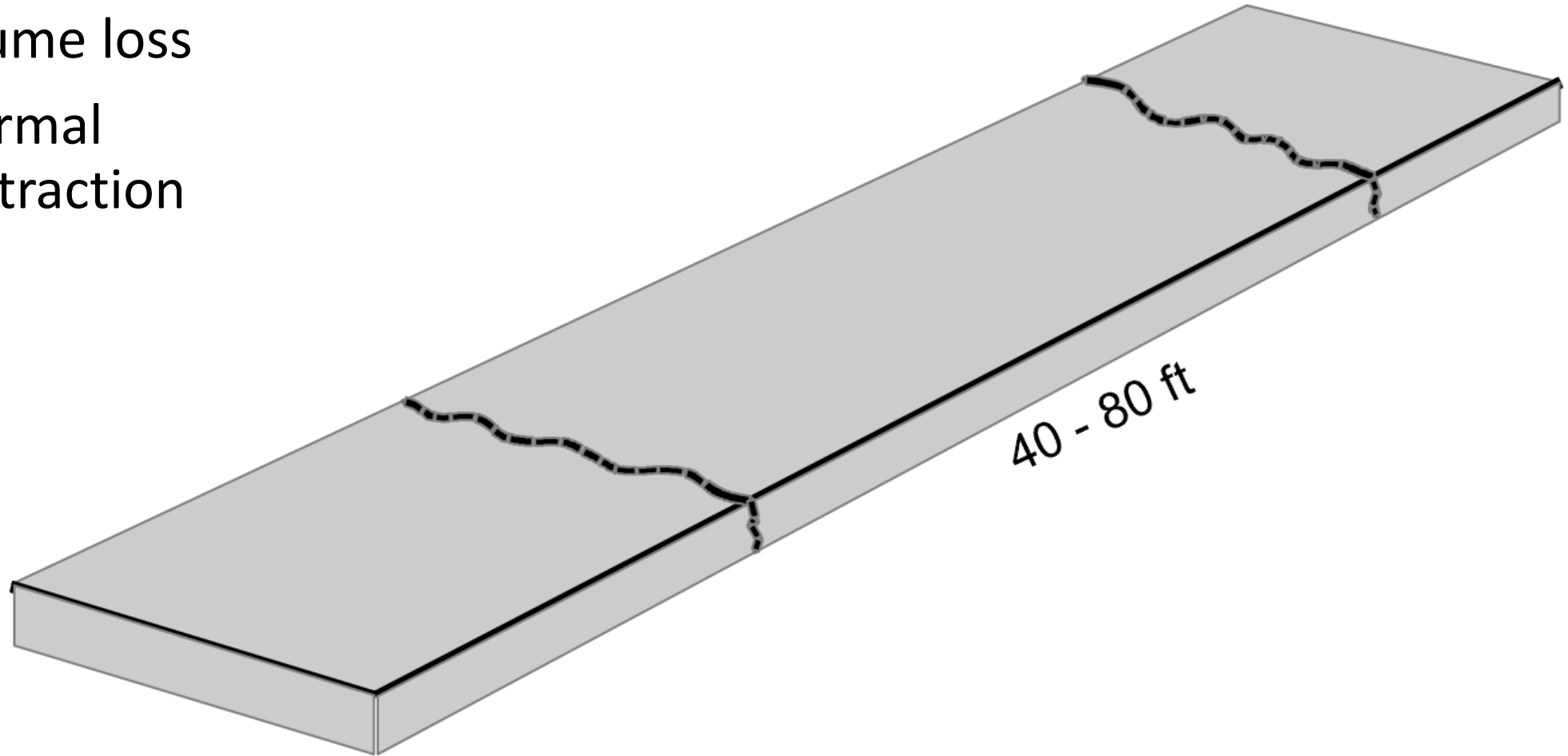


Basic Components of a Concrete Pavement



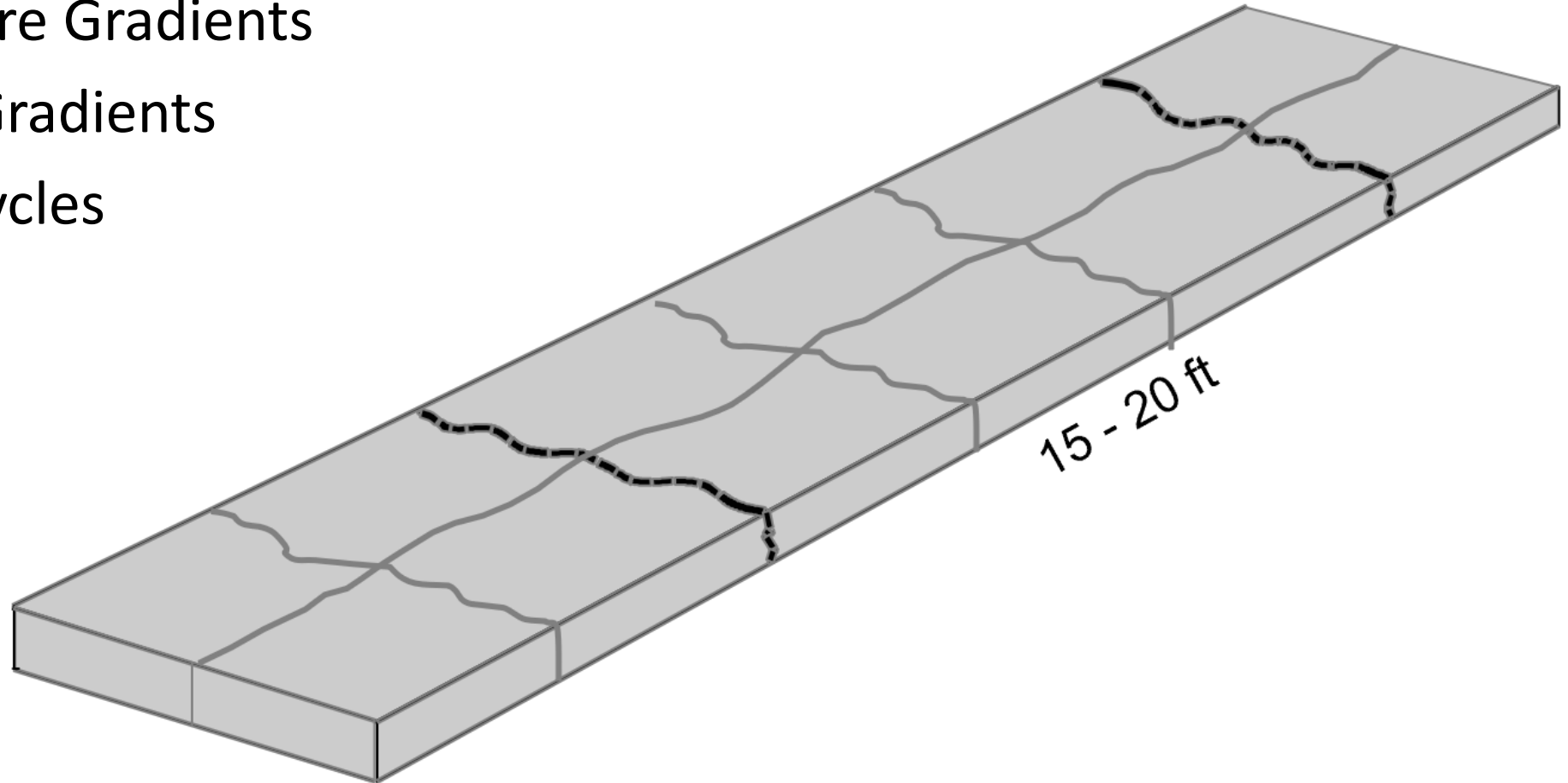
Natural Crack Development

- Volume loss
- Thermal Contraction



Natural Crack Development

- Temperature Gradients
- Moisture Gradients
- Thermal Cycles
- Loading



Erratic Crack Patterns

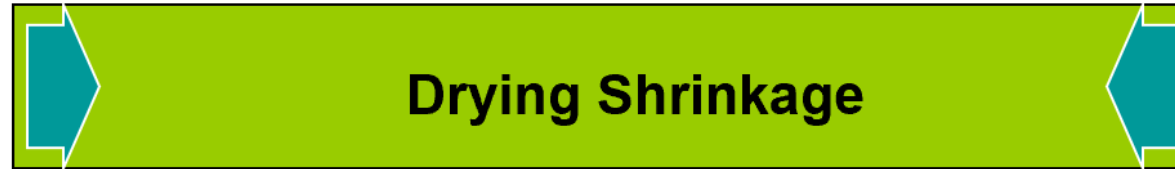


Erratic Crack Patterns



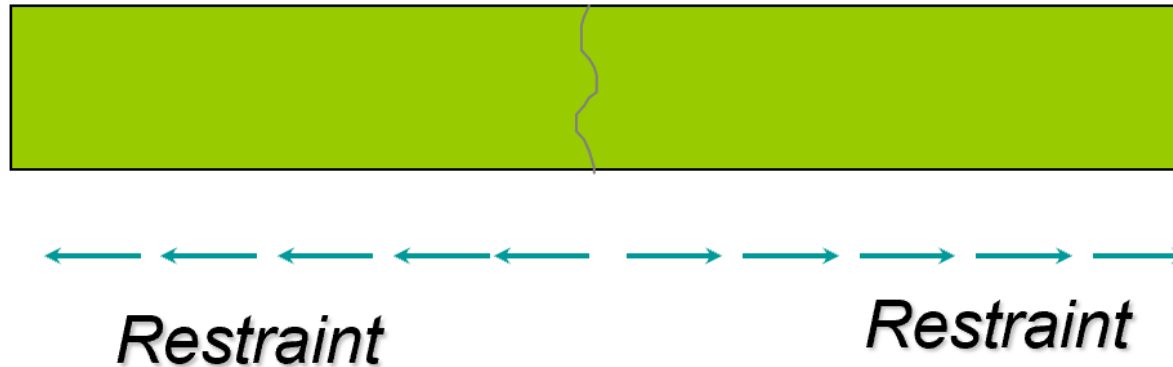
Old US 20 Woodbury 1921

Crack Formation



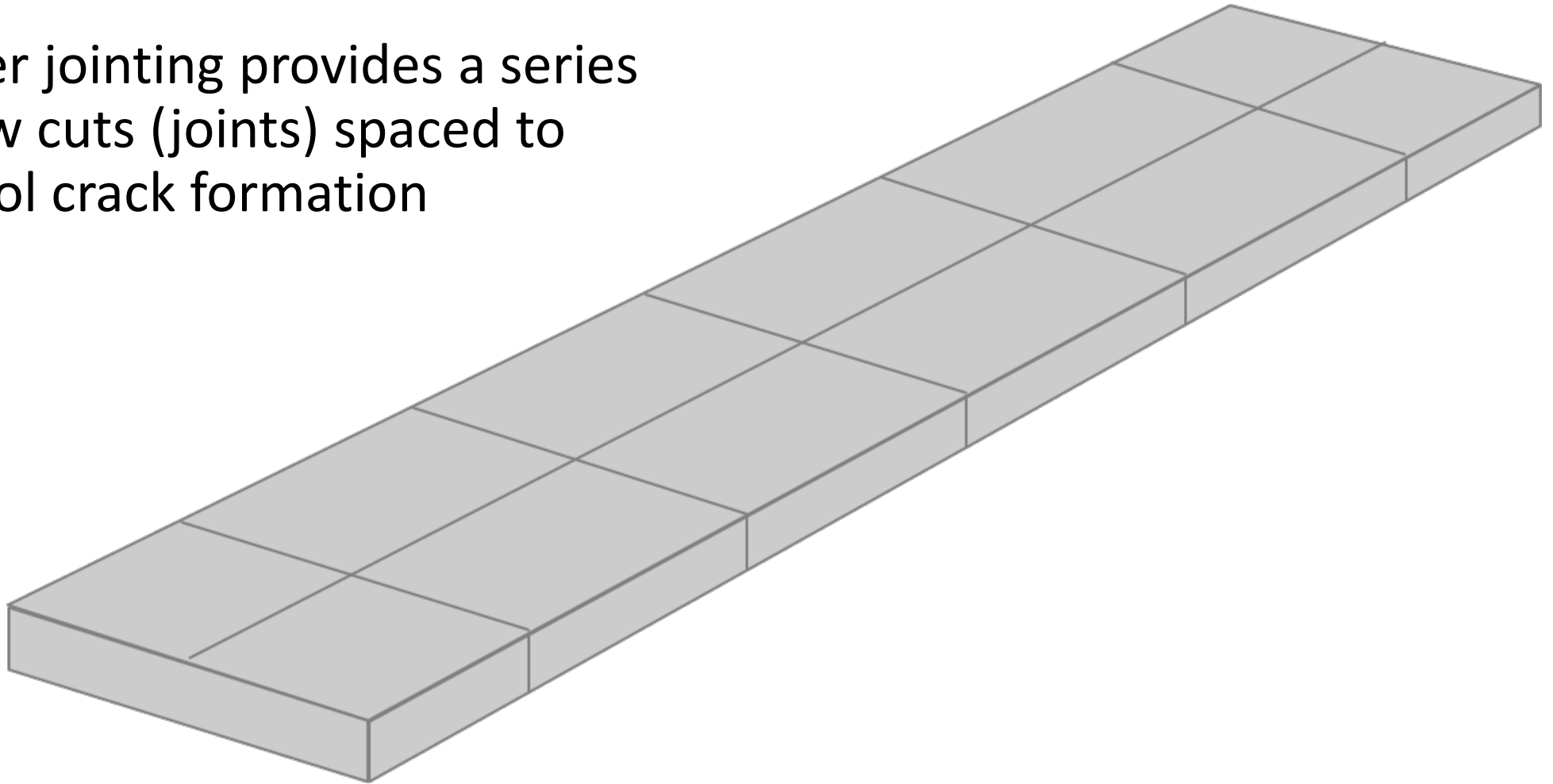
Approximately $1/16$ inch per 10 feet = $5/8$ in/100'

Thermal Contraction



Natural Crack Development

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



Joint Types

- Transverse contraction
 - Undoweled
 - Doweled
- Transverse construction – Beginning and end of daily paving operations
- Longitudinal contraction – Sawed joint
- Longitudinal construction – Butt joint
- Isolation/Expansion



Transverse Contraction Joints

No Difference between Expansion and Isolation Joints

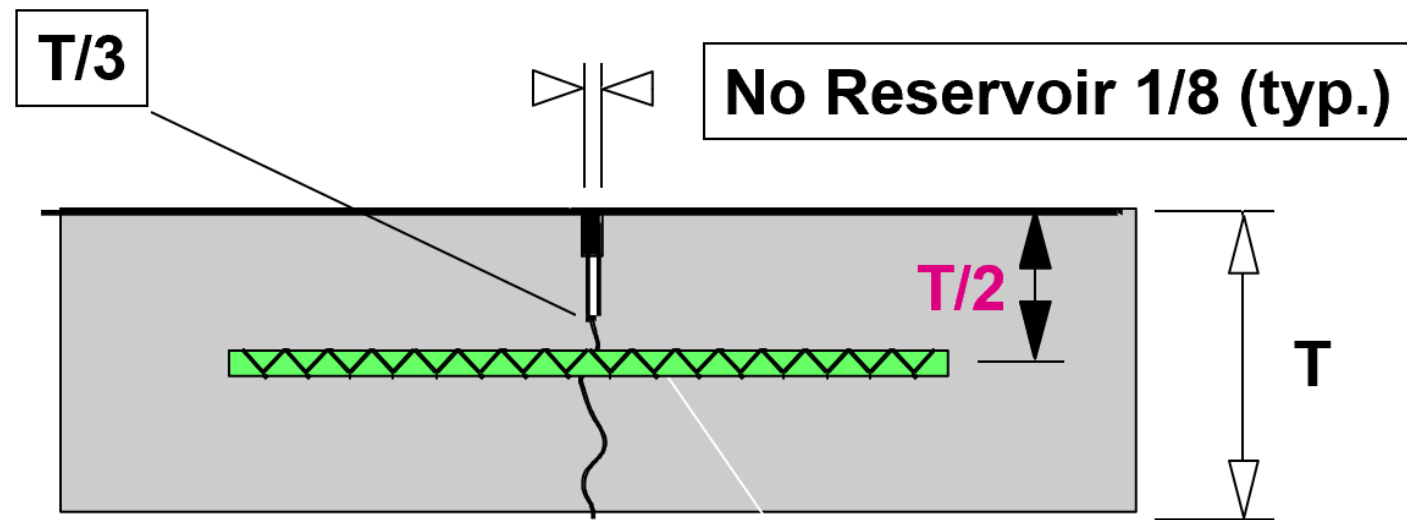
- Isolation/Expansion Joints
 - For Frost Protected structures within the pavement (E8 joints at bridges)
 - Not needed in the mainline pavement at regular intervals
 - At intersections between old and new
 - Small in-pavement objects, water valve
 - For structures adjacent to the pavement

Types of Joints

- Contraction Joints
 - Control formation of cracks
- Construction Joints
 - For joining lanes paved in separate passes (long. Jt.)
 - At end of daily production (transverse joint)
- Isolation-Expansion Joints
 - For structures adjacent to the pavement
 - For pavement adjacent to the pavement

Longitudinal Contraction Joint

- New construction designs may not have joint sealant if speed limit is > 45 mph.
- CPR rule is to use hot pour and smallest possible width.



Use keyway or Drill & Grout to replace Reinforcing bars for a Full Depth Repair of both travel lanes.

Ensure the Following

- Match existing joints or cracks or provide isolation material
- Reduce/eliminate crack risks
 - Develop a jointing plan
 - Watch timing
 - Understand joint location
(make adjustments!)
- Consider non-obvious factors

Traffic Control Schemes

- Standard Specification 2302
- Establish traffic control 1-day in advance of the Contractor operation for marking of repair locations.
 - This is a good item to include in your special provisions / traffic control plan.

Center Lane Closed



One half Roadway Closed With Pilot Car



Note: DBR backfill cures in 2-4 hours, flagging is not recommended on a general CPR project.



One Half Roadway Closed,
One-way traffic or Place Both Direction on Same Side Separated by Double Yellow or “Pogo Stick” Delineators



Roadway Closed with Marked Detour...
Every other (staged) cross road closures

CPR – Data collection

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CPR Data collection – Pavement History

- When was the pavement constructed?
- Did the pavement have W/C Ratio requirements?
- How long do you want the rehab to last?
- Get MnDOT Concrete Engineering Unit Advice
 - MnDOT: Gordy Bruhn – Gordon.bruhn@state.mn.us
- Know how long the types of repairs should last

Types of Concrete Repair

- Type A – Joint Repairs – [3-5 years*]
- Type B – Partial Depth Repairs (PDR) – [7-10 years*]
- Type C – Full Depth Repairs (FDR) – [15-20 years*]
- Dowel Bar Retrofit (DBR) – [15-20 years*]
- Diamond Grinding – Smoothness & Friction

*Life of repair assumes the repairs are used and constructed properly

Concrete Pavement Rehab Website

www.dot.state.mn.us/materials/concretepavementrehabilitation.html

Concrete Pavement Rehabilitation

[Materials Home](#) [Concrete Home](#) [Contacts](#)

Pavement Rehabilitation Program

Investigation

Prior to undertaking a concrete repair project, the Concrete Engineering Unit recommends an investigation into the soundness of the proposed concrete pavement. One – two years prior to letting, the pavement should be cored at various locations on and adjacent to some of the joints. Based on the visual results of the extracted cores, other testing may be needed including compressive strength testing, hardened air content testing, petrographic analysis, etc. Contact the Concrete Engineering Unit for further information.

New - Concrete Pavement Rehabilitation (CPR) Guide

The [CPR Guide](#) is a web-based interactive resource detailing the MnDOT processes and materials utilized to repair portland cement concrete pavements. The CPR Guide's target audience is Inspectors, Contractors, Materials Engineers, Maintenance Engineers, Consultants and Designers who are involved in the CPR process.

Revisions and Modifications

CD-HV and CX repair details have been revised to include 11 dowel bars per lane instead of the previously published 8 dowel bars per lane. CPR details and State Aid repair details have been modified and combined as of August 2015. Review the CPR memo and boiler plates for details about specific revisions and modifications.

CPR memo and boiler plates

Forms

Concrete mix designs

- [Mix designs](#)

Field

- [Concrete pavement repair \(CPR\) workbook](#) (Last revised 12/17/18)

Prepackaged dry concrete (3U18 and 3U58M)

- [Contact report 2022 - prepackaged dry concrete](#)
- [Bagged mix quality control worksheet](#) (Last revised 4/22/21)

Determine if PDR's are a Feasible Repair

- You need to do your homework!
 - PDR's perform best when used correctly... meaning that they should remain (mostly partial depth).
 - Take cores to determine the extent (depth) of deterioration.

SP. 4712 -18 TH55 5-6-13
MP. 117.5 (S)2 RT EB
117.5.D ML



1 2 3 4 5 6 7 8 9 10 11 12 13 14

117.5D
○

SP. 4712 -18 TH55 5-6-13
MP. 117.5 (S)2 RT EB
117.5.D ML

Not a good candidate for a PDR



Coring the Project is ESSENTIAL!

- Typical Minnesota Bottom-Up Deterioration



Structural Crack at Mid-Depth

- Dowel Bar Fatigue



No Brainers – (1/3)

- Typically, a FDR is recommended if a contraction joint has been previously repaired.



No Brainers – (2/3)

- Cracks like these extend down the full slab thickness.
- Random cracks like this should be repaired with a FDR.



No Brainers – (3/3)

- Unless you are suspecting a material durability issue, no need to core this location.
- Random cracks like this should be repaired with a FDR.



No Brainers – Conclusion

- The proceeding three examples should all be removed and replaced with a FDR, regardless of what the cores show.
- Taking cores in other locations should have been time better spent.

Material Durability Issues...

- Compromised Air Entrainment System
- We did “rehab” this by removing the first 300 feet of the ramp...



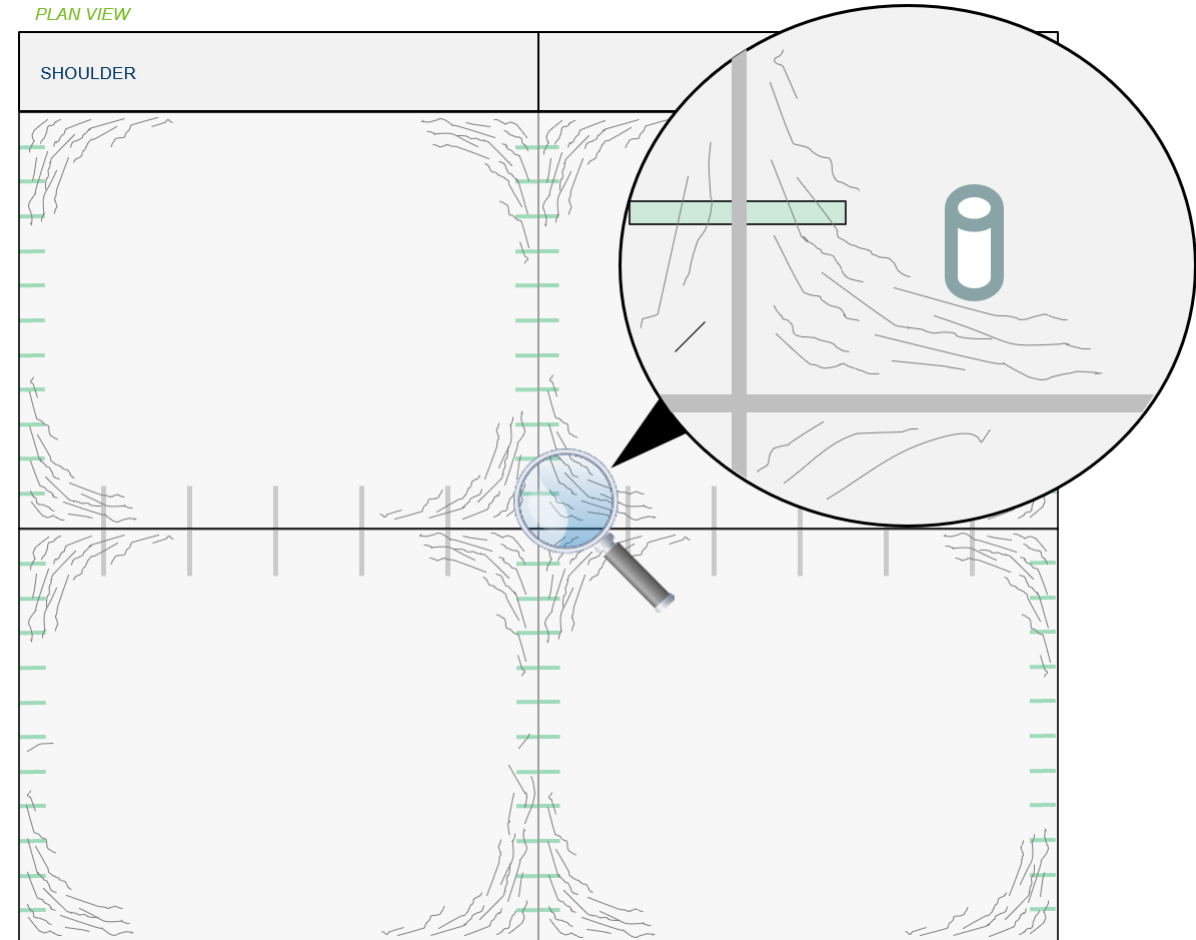
Pavements with Expansive Aggregates

- D-Cracked Pavement



Material Durability: D-Cracking

- We take cores whenever we see D-cracking at the surface (D-cracking starts in the corners and propagates along the joints; it can generate slightly different patterns).
- Beware that D-cracking and ASR cracks can sometimes have the same appearance on the surface which means that we need a Petrographic analysis of a core to know what we are really facing.
- Take a core where we believe that the sample will have a chance to remain as a whole; in fact, the best practice consists of taking a core at the limit of the first cracks. It does not really matter if the core is not very close to the corner because the anomaly is everywhere in the concrete.



Alkali Silica Reaction (ASR)

- Looks similar to D-Cracking
- ASR usually stains the adjacent pavement.
- This would be a good location to core.





Alkali-Silica Reactivity (ASR)



Faulting of Previously Placed FDR's



Pathway Services Inc. Digital Images (Ver. 10.53 MnDOT)

Image Help

Pathway Services Inc. 3D Camera Longit...

Longitudinal Profile

Pathway Services Inc. Pavement Surface. Intensity

Pathway Services Inc. Pavement Surface. 3D Elevation.

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Microsoft Word 2010, Firefox, RICOH, 2012 Winter Pictorials, GOPUS, Data for GPM projects m...

ProjectWise Explorer, 1094.rpt, Road Logn Webcams, @graphisoft, Embarcador, October Reviews, 3-9-12 g...

start

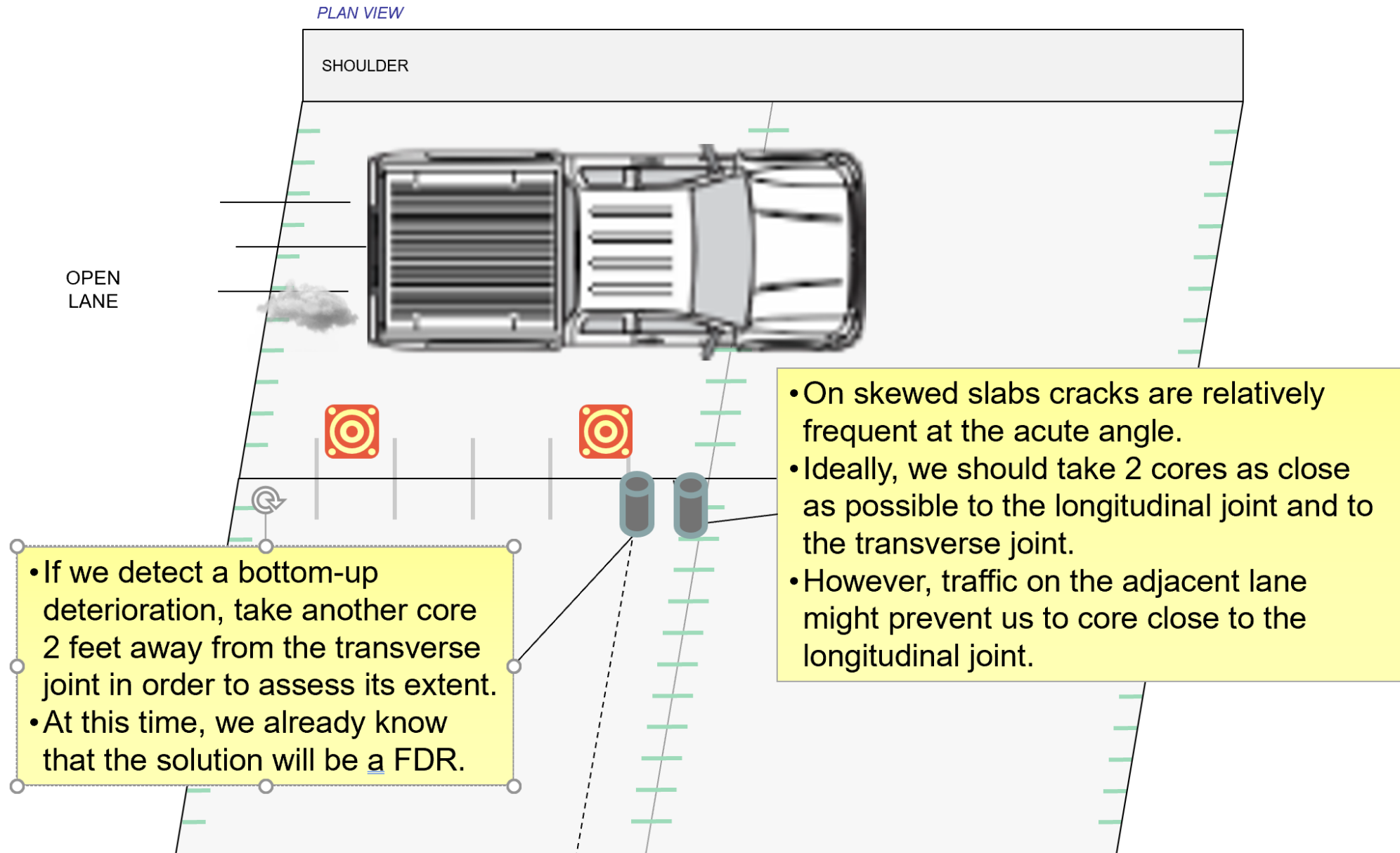
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Previously Placed FDR's are Faulted – Socketed Voids Around Dowel Bars

- Take a core over the previously drilled and grouted dowl bar on the in-place concrete (not the previous FDR concrete).
- Example: The adhesive coverage of the dowel bar was not complete at the time of the rehab.
 - This resulted in the socketing of the dowel bar and thus causing faulting/sinking of the FDR at the saw cut interface.



Contraction Joints



Transverse Joints are Contraction Joints

Windom: April 16-18, 2007

- TH 71 Cores North of Windom
- Built in 1965
- Plain Pavement
- Project CPR, DBR, & Diamond Grinding
- Previous CPR around 1988



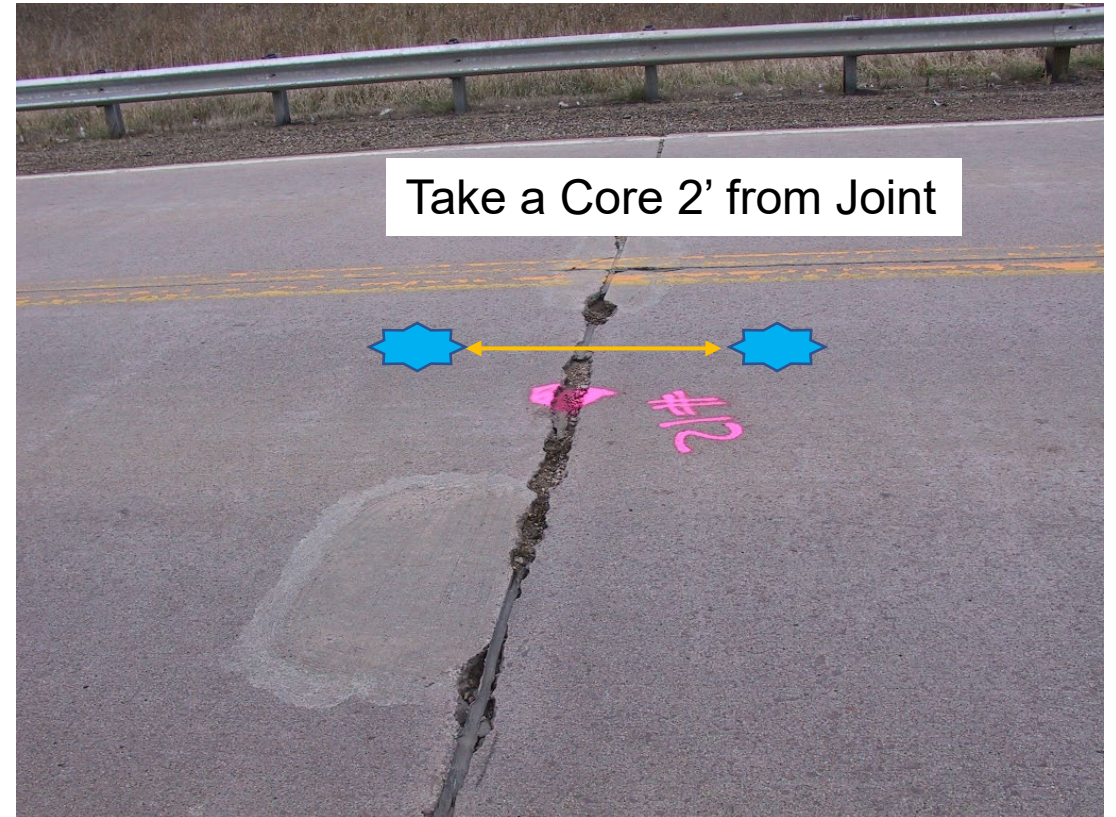






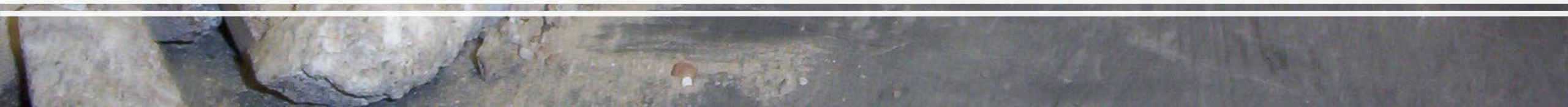
Good Candidate?

- Pavement constructed in 1962
- PDR was placed in 1986 (19 years old)
- Core Taken in 2005
- 2nd CPR in 2007
- This joint has been repaired w/PDR once, recommend an FDR on the 2nd Rehab.





Bad Candidate!







1707-19

T# 71

CORE #

8



Pavement split horizontally – may have socketed dowel bars
Further Investigation recommended.



CPR Quantity Collection

The Cardinal Rule in Concrete Rehab Design:

**“There is no such thing as a
representative mile or segment.”**

Noting that this cardinal rule is broken most of the
time...

CPR Quantity Collection

- 1. Chain Entire Project** – This will give the most accurate quantities. Will likely require a much smaller “fudge factor.”
- 2. Windshield Survey of the Entire Project** – Can be somewhat accurate if a proper investigation is done. Will likely require a larger “fudge factor.”
- 3. Highly recommend having construction personnel help with quantity acquisition** – you are more likely to be close to estimates when the people marking the repairs also scoped the repairs.



CPR Data Collection – Example

- Examples from the Annual CPR Meeting held in St. Cloud on Nov. 3 & 4, 1999
- US 10 EBL between Big Lake & Elk River



Red Team

4 Sq. Ft. B-2A at Centerline

1 Sq. Ft. B-2E Right Lane

Blue Team

9 Sq. Ft. C1-LV at Centerline

11/3/1999

Orange Team

24 Lin. Ft. CD-HV

Green Team

24 Lin. Ft. B-3

5

11/3/1999

Red Team

24 Lin. Ft. CD-HV

5.5 Sq. Yd. CX

Blue Team

24 Lin. Ft. B3

11/3/1999



Red Team

24 Lin. Ft. CD-HV

5.33 Sq. Yd. CX

Blue Team

24 Lin. Ft. CD-HV

11/3/1999

Red Team

24 Lin. Ft. CD-HV

8 Sq. Yd. CX

Blue Team

24 Lin. Ft. CD-HV

10.7 Sq. Yd. CX

67

11/3/1999

Questions & Comments?