LONGITUDINAL CRACKING IN WIDENED PCC PAVEMENTS

2020 ICPA Annual Workshop

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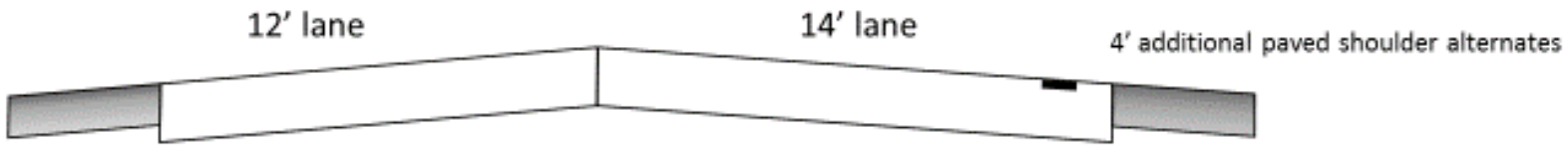
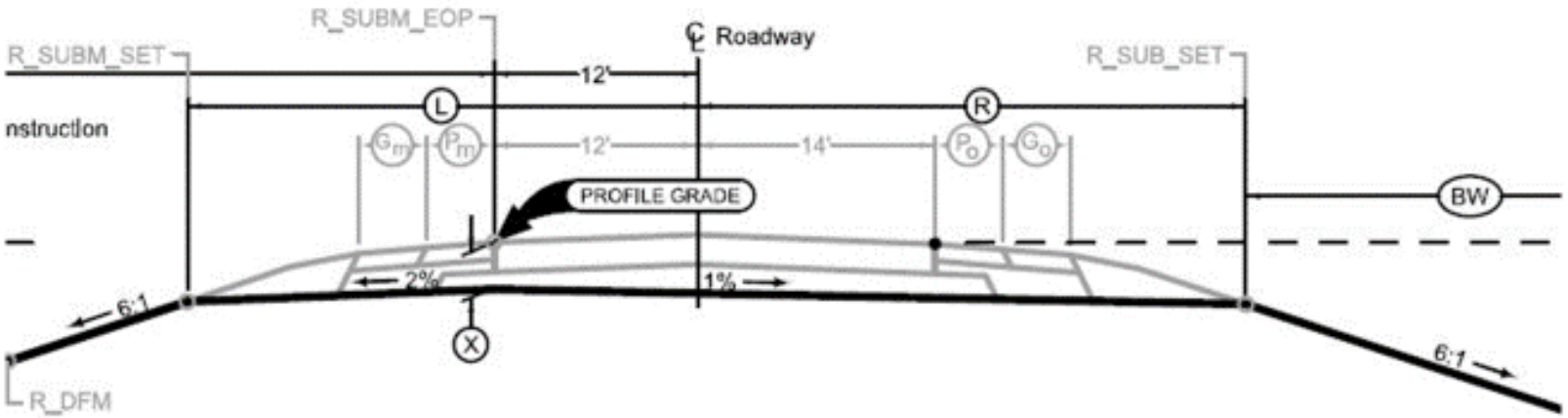
Widened Lane Concrete Pavements

- Initiated in the late 1980's and early 1990's.
  - *13' to 15' driving lane (instead of 12')*
- Most of the structural benefit of a full depth, tied concrete shoulder could be achieved by widening the outside slab 2'-3'. (Without the cost of a full depth shoulder)
  - *Reduced edge stress by creating interior loads*
- Maximum bending stresses in a PCC slab occurs with wheel loads at slab midpoint at the edge.
  - *The widened lane results in the axle loadings being interior loads.*
  - *Result is that the same thickness can carry more traffic loads.*
- Many states adopted this design.
- Added benefit of moving the edge rut away from the traveled lane

Existing 4-lane Pavement Typical for Widened Lane w/alternate paved shoulders

(since 1988 Interstate/1990 Primary)





The initial problem

Transverse cracking on I-80 Adair County

The only pavement we identified with extensive transverse cracking

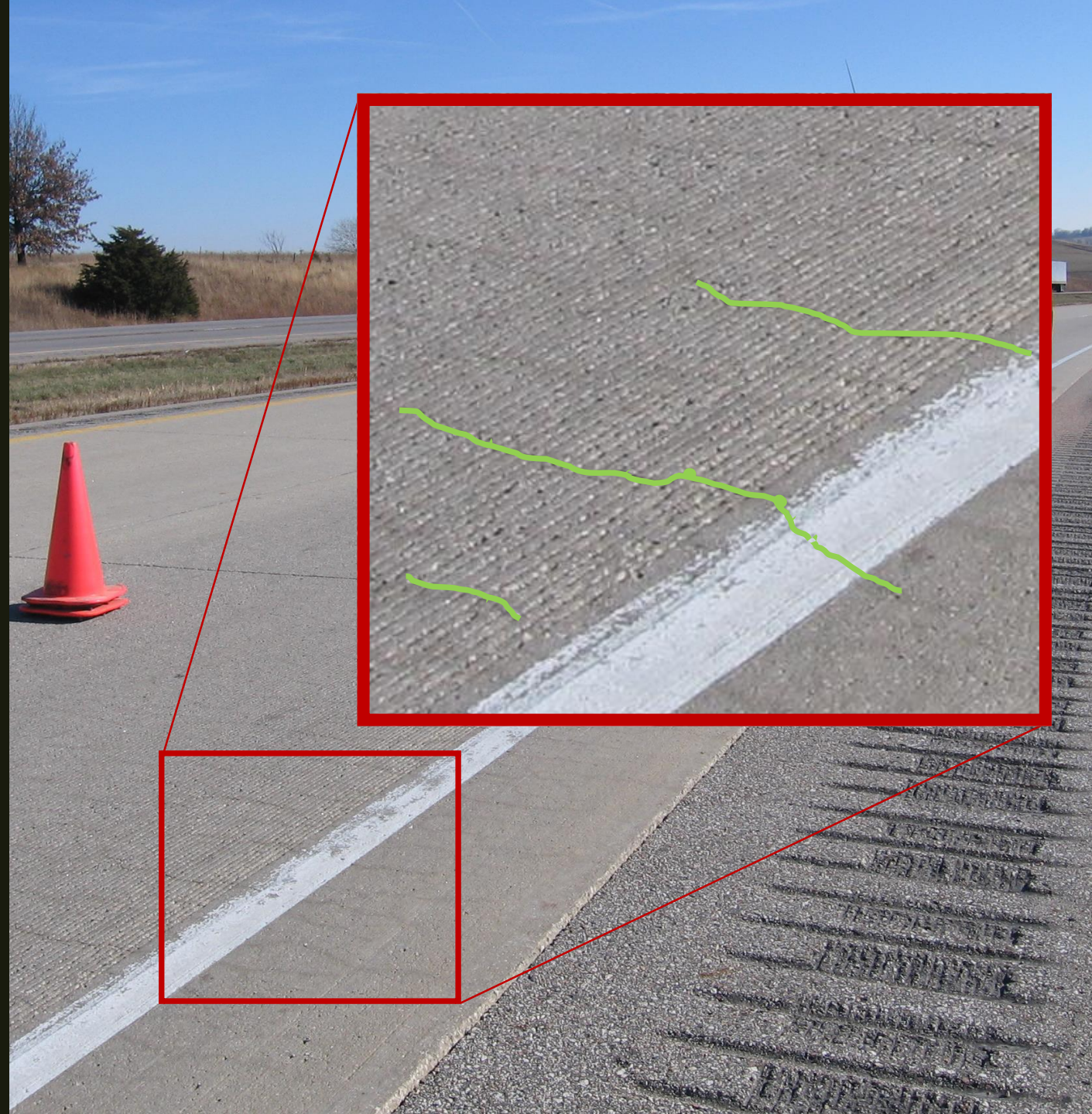
Started at about 10 years old

Standard Design

- 12” JPCP
- 26’ wide pavement (14’ driving lane)
- 20’ transverse joint spacing
- Paved on granular subbase
- 12” RAP subgrade treatment (from existing full depth HMA pavement)

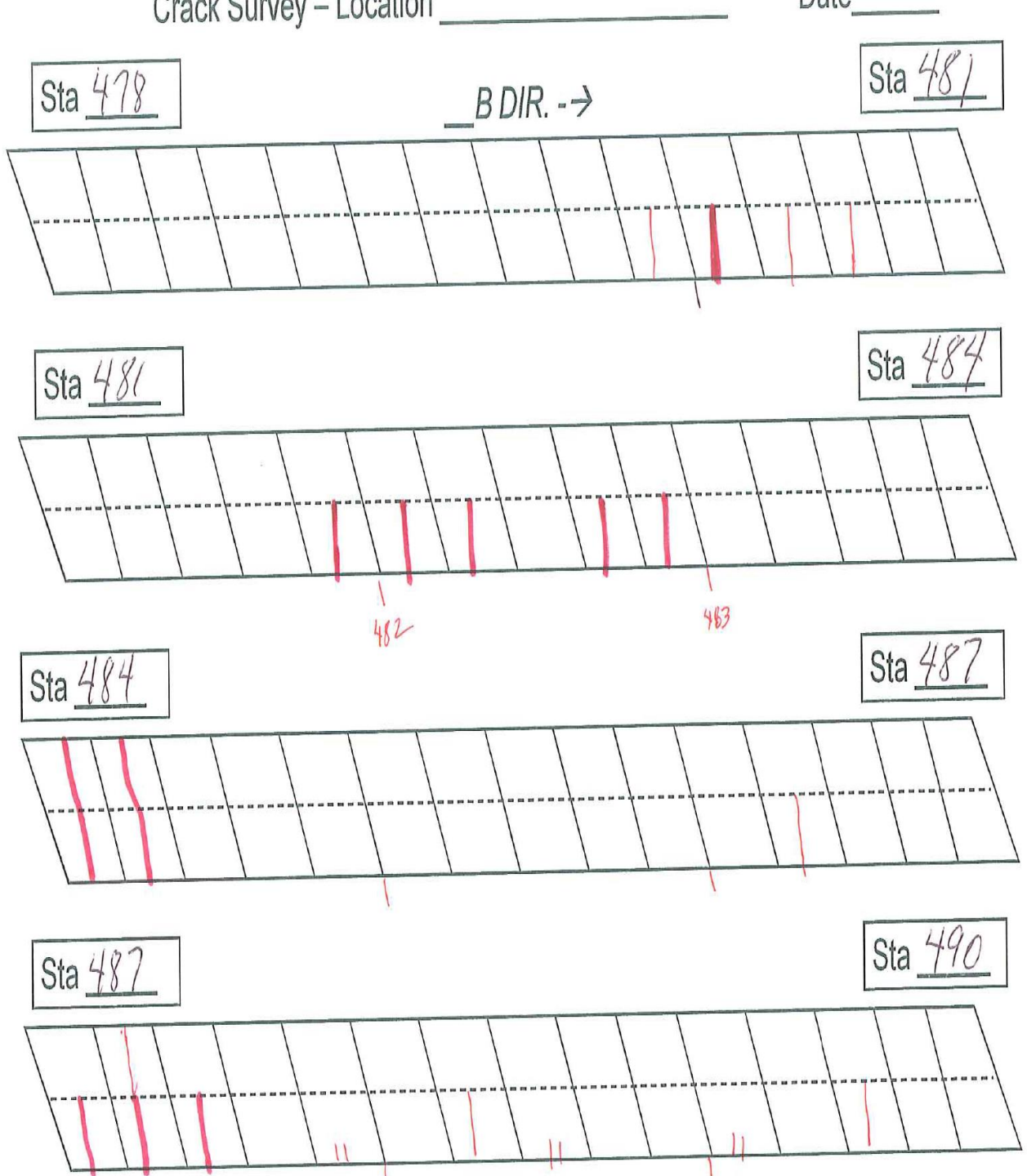
Pavement investigation

- Coring
- FWD
- Crack surveys
- GPR (dowels & tie steel alignment)



Cracking Evaluation

- Detailed crack surveys
- 3 years of surveys
- Very little change in number of cracks over 3 years – 3%
- 96% were just ½ width cracks



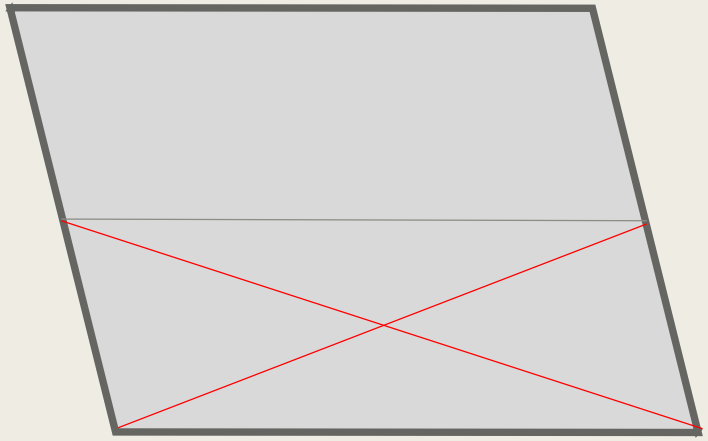
Initial Conclusions

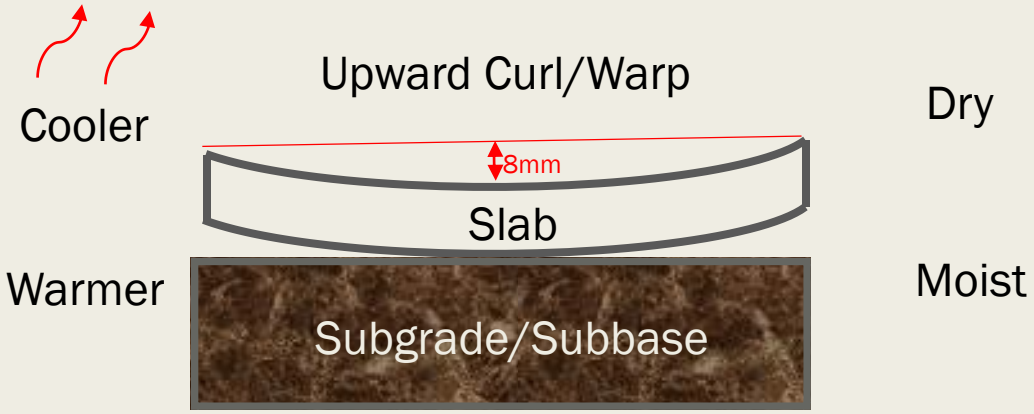
- Not a result of low PCC strength
- Did not appear to be a subgrade issue (12” RAP over old soil/aggregate subbase)
- Believe transverse joints were fully developed joints (working joints)
- Not due to misaligned dowels or tie steel
  - *Rutgers University – GPR study*
- Mike Darter (ERES/ARA consultants) believed that the issue was extensive curling and warping of the PCC pavement.

→ *Curling investigations*

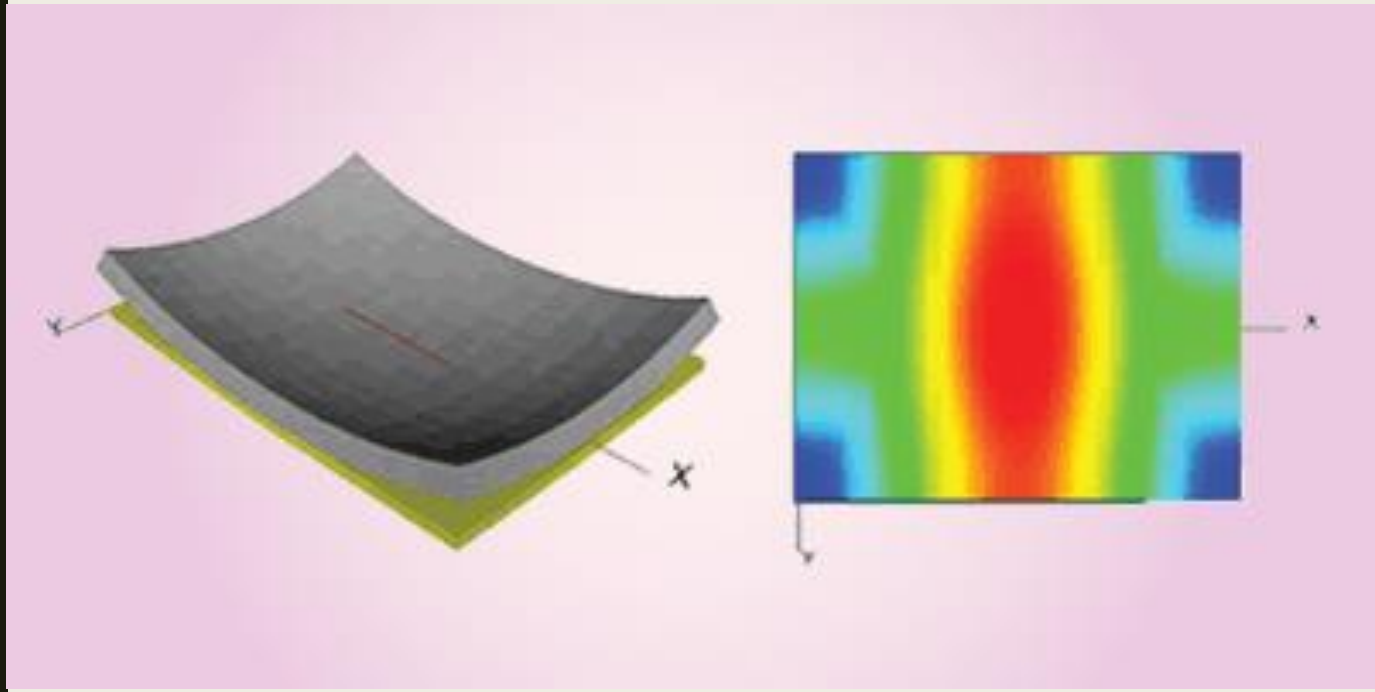
Curling/Warping measurements on Adair I-80

- Found 8mm of curl/warp at center of slab by measuring the diagonals of the slabs
- Most extreme curl/warp occurred in the Fall with cool morning temps
- Curl/warp could be more than 50% less in the afternoon with warmer temps
- Most is typically due to temperature curling



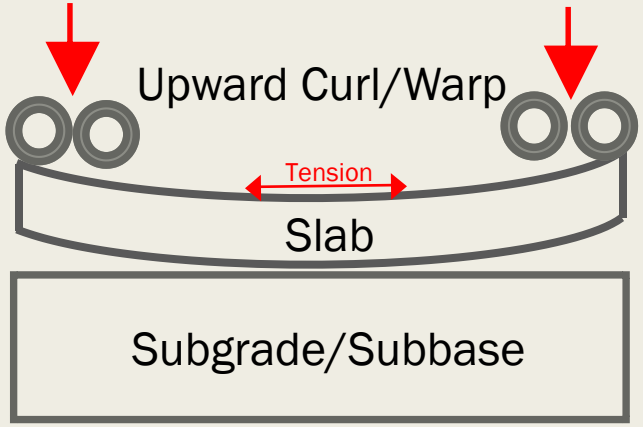


Curl/Warp in PCC pavement



Theory is that as heavy axles load the pavement, the top of the slab is placed in tension.

Transverse cracks develop from edge of pavement.



REHABILITATION

Do not Route and Seal

Maintenance did their job protecting the pavement

Impacts rehabilitation options

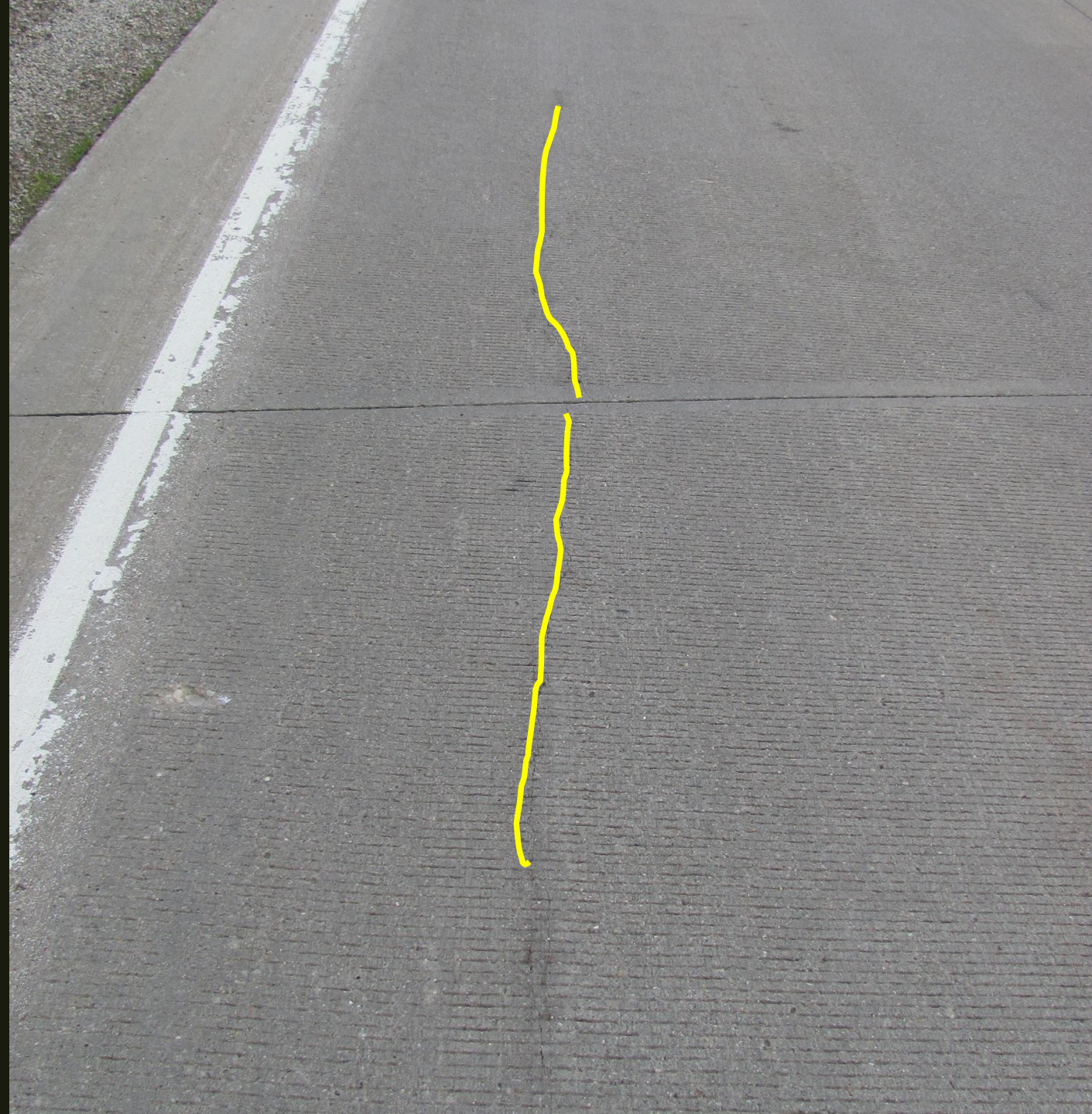
Makes cracks excessively wide

Solution was DBR and diamond grinding

And now…The next problem

Began measuring curl/warp on other pavements.

Longitudinal cracking was discovered on a pavement several years after the Adair I-80 cracking problem



Begin as hairline cracks originating at the transverse joint.

Progress to longer and more pronounced crack

Location varies from 2’-4’ from the edge of pavement

After time spalling begins

Top down cracks that may not extend through the pavement.

Unlike transverse cracks, the mechanism for development is not fully understood.

Curling measurements have reached 19mm

07/22

Continued with manual measurements and ....

Worked with the Office of Design to conduct LiDAR surveys.

Began research projects with ISU

1st study – “Impact of curling and warping on concrete pavements”

2nd study – “Prevention of longitudinal cracking in Iowa widened concrete pavement”

Complicating issues

- Doesn’t seem to develop before 10 years of age
- Not all pavements have measurable curling/warping
- AND not all pavements that are curled have cracking
- Tied PCC shoulders seem to mitigate or delay the cracking of 14’ lanes. (small sample size).

Solutions

- No issues on 12’ wide slabs
- Change to 12’ slabs with tied PCC shoulders (pavement thickness stays the same)
- Change to 12’ slabs with alternate HMA/PCC shoulders (requires thicker pavement to carry loads).
- Both alternatives will also likely require us to change our transverse joint spacing since the length to width ratio of the slab will change.
  - *Negatives*
    - Adds more joints
    - Increases cost
  - *Big Positive is improved performance*

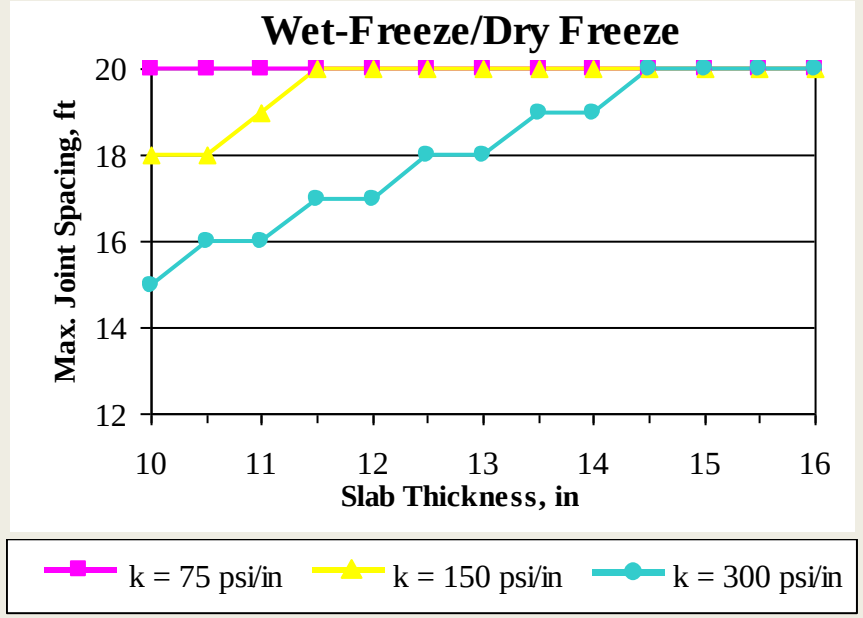
Alternative 4-lane PCC Paving Typicals

Alt. 1 (slightly thicker PCC)

Alt. 2

- Changing to 12’ pavement width also required shortening the transverse joint spacing.
- Existing L/W ratio: 20/14 = 1.43
- Possible ratio 15/12 = 1.25 (33% more joints)
- Proposed ratio: 17/12 = 1.41 (18% more joints)
- Additionally the ratio of slab length to radius of relative stiffness should not exceed 5.0
  - *17’ spacing is acceptable*

- Recent fatigue based design indicates 17’ is acceptable for our pavement thickness, base stiffness, and climate.

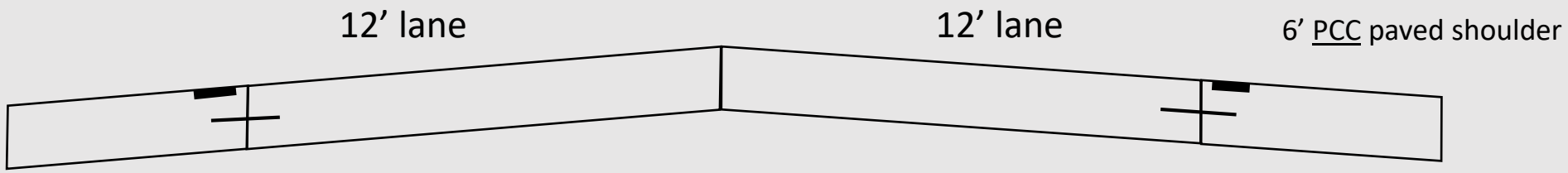


NCHRP 1-32

Consulted with Mike Darter

- Joint spacing scenarios
- Advantages and Disadvantages of paved shoulders and widened lanes
- DOT Management agreed to new design and requiring tied PCC shoulders.

2-lane PCC Paving Typical



4-lane PCC Paving Typical

QUESTIONS?