Retrofit Dowel Bars In Jointed Concrete Pavement - Long Term Performance and Best Practices

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NATIONAL CONFERENCE ON PRESERVATION, REPAIR, AND REHABILITATION OF CONCRETE PAVEMENTS
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Outline

- Background
- Long Term Performance Case Studies
- Minnesota Best Practices
- Construction Issues and Rehabilitation

Background

- One of the major distresses in jointed concrete pavement is joint and or crack faulting
  - Traffic load/volume change (previously undoweled)
  - Excessive panel length (mid-panel cracks)
  - Dowel deterioration (not common)
- Retrofit dowel bars are a proven technique
  - Most research focused on quantity and spacing of bars
- Need to understand longer term performance with respect to backfill material in extreme climates

Long Term Performance Case Studies
TH 52, Zumbrota, Minnesota

- First retrofit dowel bar project in state - 1994
- Original 9” thick JRCP pavement constructed in 1984
  - 27 foot long panels, mesh reinforcement across mid-panel cracks
  - Virtually no faulting of mid-panel cracks (10 years old)
  - Transverse doweled contraction joints in good condition
  - HCADT = Approx 2100

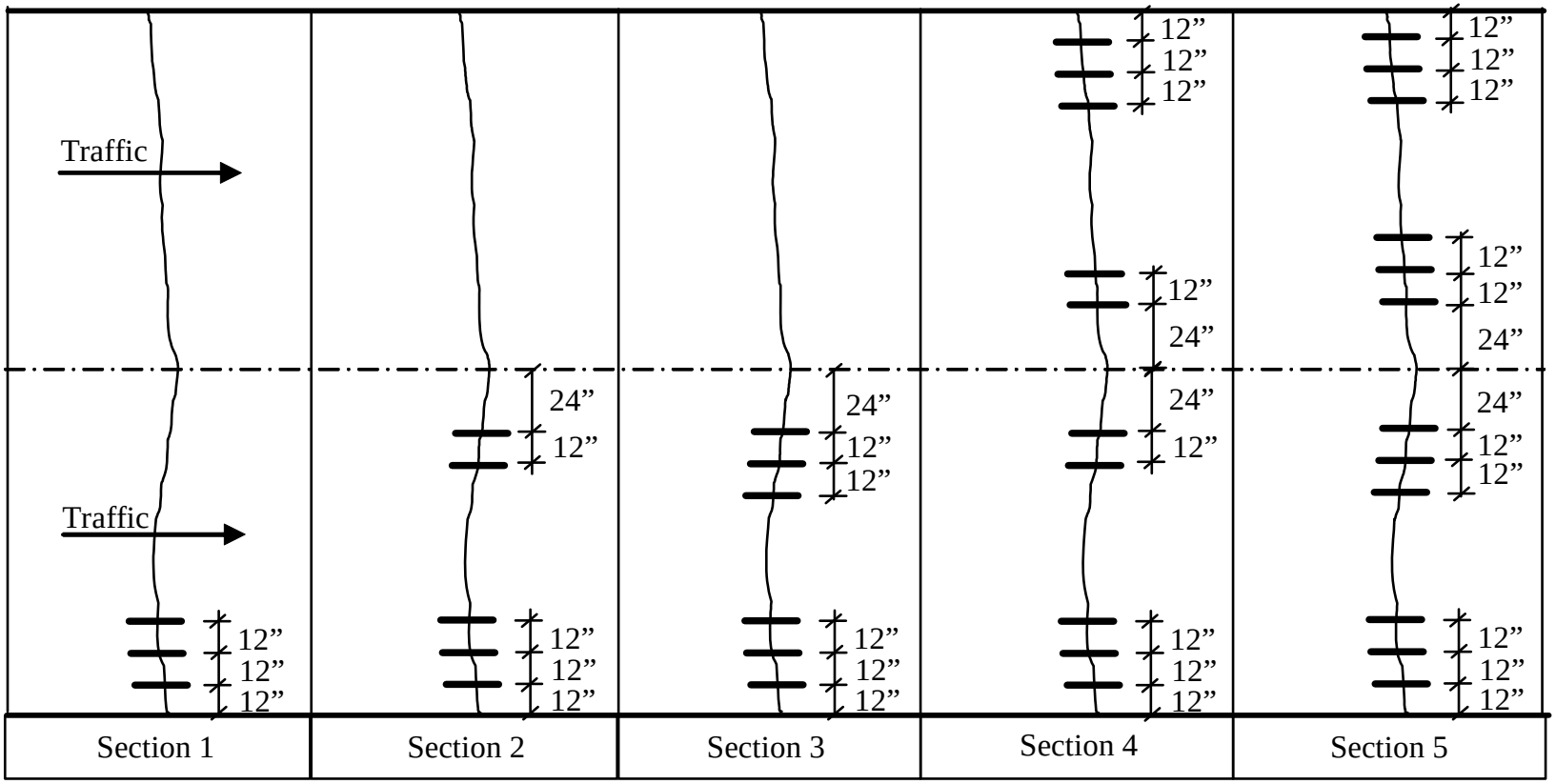
- Project objective: To determine if retrofit dowel bars could prevent or slow down faulting of mid-panel cracks
  - No surface grinding necessary (no faulting yet)

Long Term Performance Case Studies
TH 52, Zumbrota, Minnesota

- Design variables
  - Backfill mortar type
    - Polymer-modified quickset patch (PMQP) material
    - Mn/DOT 3U18 patch mix
  - Saw and chip slotting method
  - Two dowel bar sizes
    - 1.5 inch dia. x 15 inch long
    - 1.5 inch dia. x 18 inch long
  - Various retrofit dowel bar placement patterns

Long Term Performance Case Studies

TH 52, Zumbrota, Minnesota



Long Term Performance Case Studies
TH 52, Zumbrota, Minnesota

- Observed Performance (14 years after retrofit)
  - Faulting of mid-panel cracks minimal (avg = 1.7 mm)
  - Small number of distressed retrofit dowel bar slots caused by longitudinal cracking
  - Backfill material performance very good
    - PMQP had some loss of material near surface
    - Mn/DOT 3U18 patch mix good despite early shrinkage cracking around slots
  - LTE (2006)
    - 60 to 80 percent

Long Term Performance Case Studies

TH 52, Zumbrota, Minnesota

13 years old

Longitudinal panel crack

Long Term Performance Case Studies

TH 52, Zumbrota, Minnesota

13 years old

Mn/DOT 3U18

PMPQ

Long Term Performance Case Studies

TH 52, Zumbrota, Minnesota

13 years old

Faulted mid-panel crack

Long Term Performance Case Studies

TH 12, Willmar, Minnesota

- Retrofit in 1996
- Original 8” thick JPCP pavement constructed in 1981
  - 15 foot long panels, undoweled transverse joints
  - Substantial faulting in outside wheel tracks (15 years old)
  - Wide joint openings (up to 1.25 inch)
  - HCADT = Approx 600

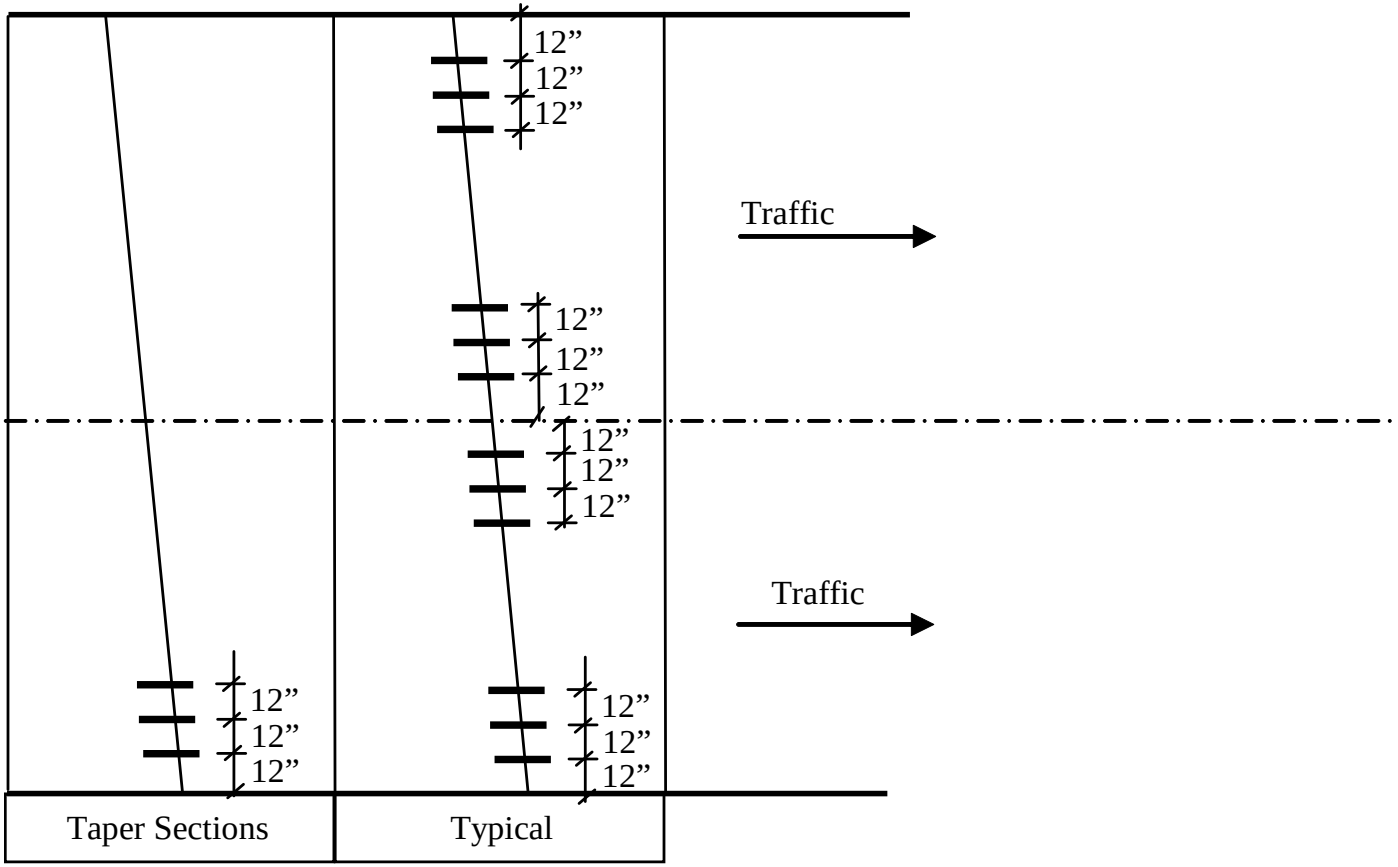
- Project objective: To determine if retrofit dowel bars and surface grinding could extend service life

Long Term Performance Case Studies
TH 12, Willmar, Minnesota

- Design variables
  - Backfill mortar type
    - Mn/DOT 3U18 patch mix
  - Slots established using milling machine
  - Dowel bar size
    - 1.5 inch dia. x 18 inch long
  - Two retrofit dowel bar placement patterns

Long Term Performance Case Studies

TH 12, Willmar, Minnesota



Long Term Performance Case Studies
TH 12, Willmar, Minnesota

- Observed Performance (12 years after retrofit)
  - Faulting of transverse joints minimal (avg = 1.5 mm)
  - Backfill material performance good
    - Minor surface distress in slots near joint
    - May be linked to milling process
  - LTE (2006)
    - 51 to 65 percent

Long Term Performance Case Studies

TH 12, Willmar, Minnesota

12 years old

Backfill mortar distress near joint

Long Term Performance Case Studies

TH 23, Mora, Minnesota

- Retrofit in 1998
- Original 9-7-9” thick JPCP pavement constructed in 1952
  - 16 foot long panels, undoweled transverse joints
  - Substantial faulting in outside wheel tracks (46 years old)
  - Wide joint openings (no aggregate interlock)
  - HCADT = Approx 500

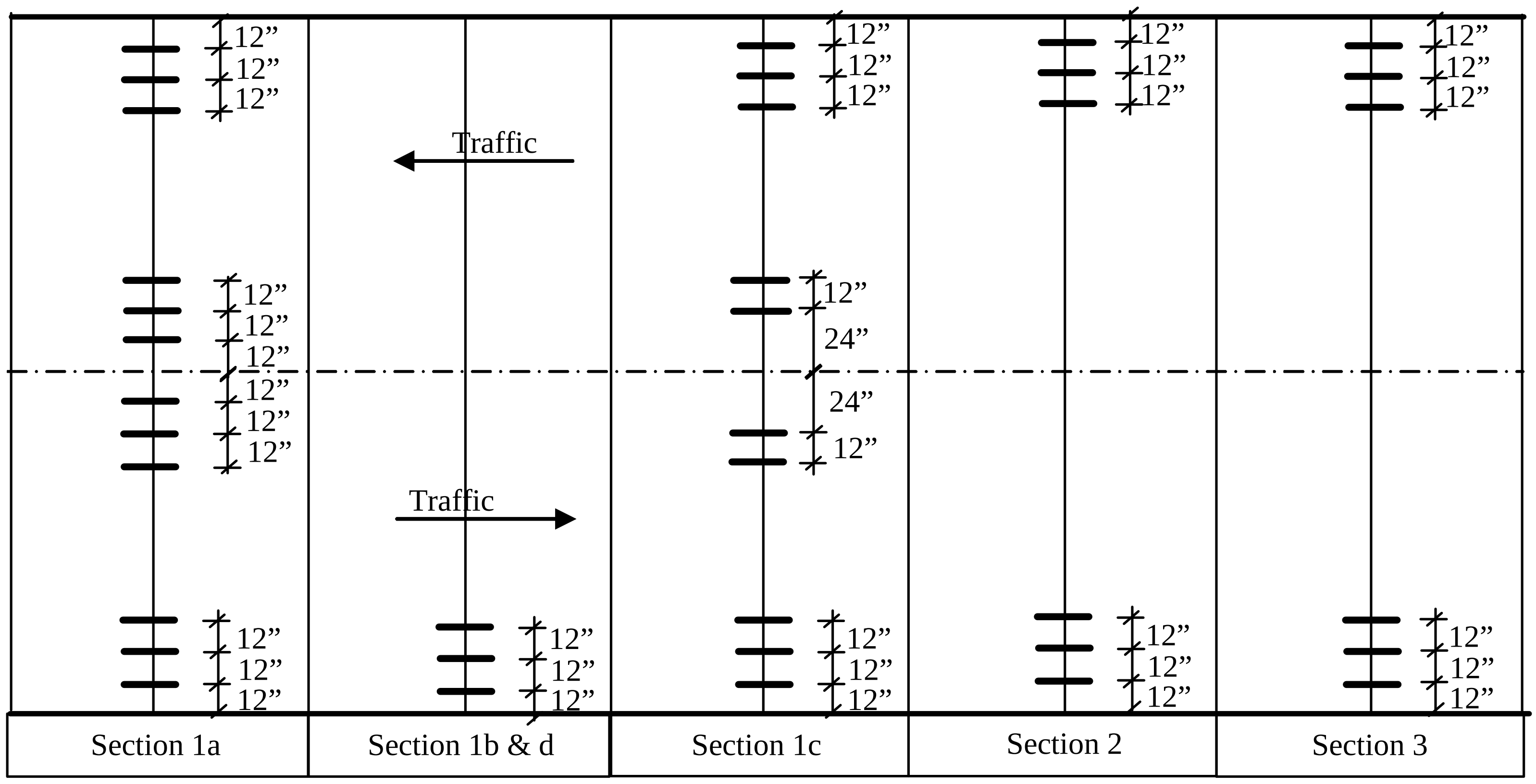
- Project objective: To determine if retrofit dowel bars and surface grinding could extend service life of a very old pavement

Long Term Performance Case Studies
TH 23, Mora, Minnesota

- Design variables
  - Backfill mortar types
    - Rapid Set Mortar (RSM)
    - Mn/DOT 3U18 patch mix
  - Saw and chip slotting method
  - Two dowel bar size
    - 1.5 inch dia. x 15 inch long
    - 1.5 inch dia. x 13 inch long
  - Various retrofit dowel bar placement patterns

Long Term Performance Case Studies

TH 23, Mora, Minnesota



Long Term Performance Case Studies
TH 23, Mora, Minnesota

- Observed Performance (10 years after retrofit)
  - Faulting of transverse joints minimal (avg = 0.5 mm)
  - Backfill material performance very good
  - LTE (2006)
    - 64 to 80 percent

Long Term Performance Case Studies

TH 23, Mora, Minnesota

8 years old

Mn/DOT 3U18 backfill mortar

Long Term Performance Case Studies

I-90, Beaver Creek, Minnesota

- Retrofit in 1999
- Original 9” thick JRCP pavement constructed in 1984
  - 27 foot long panels, mesh reinforcement across mid-panel cracks
  - Significant faulting of mid-panel cracks (15 years old)
  - Transverse doweled contraction joints in good condition
  - HCADT = Approx 1200

- Project objective: To determine if retrofit dowel bars and surface grinding could restore ride quality and slow down redevelopment of mid-panel crack faulting

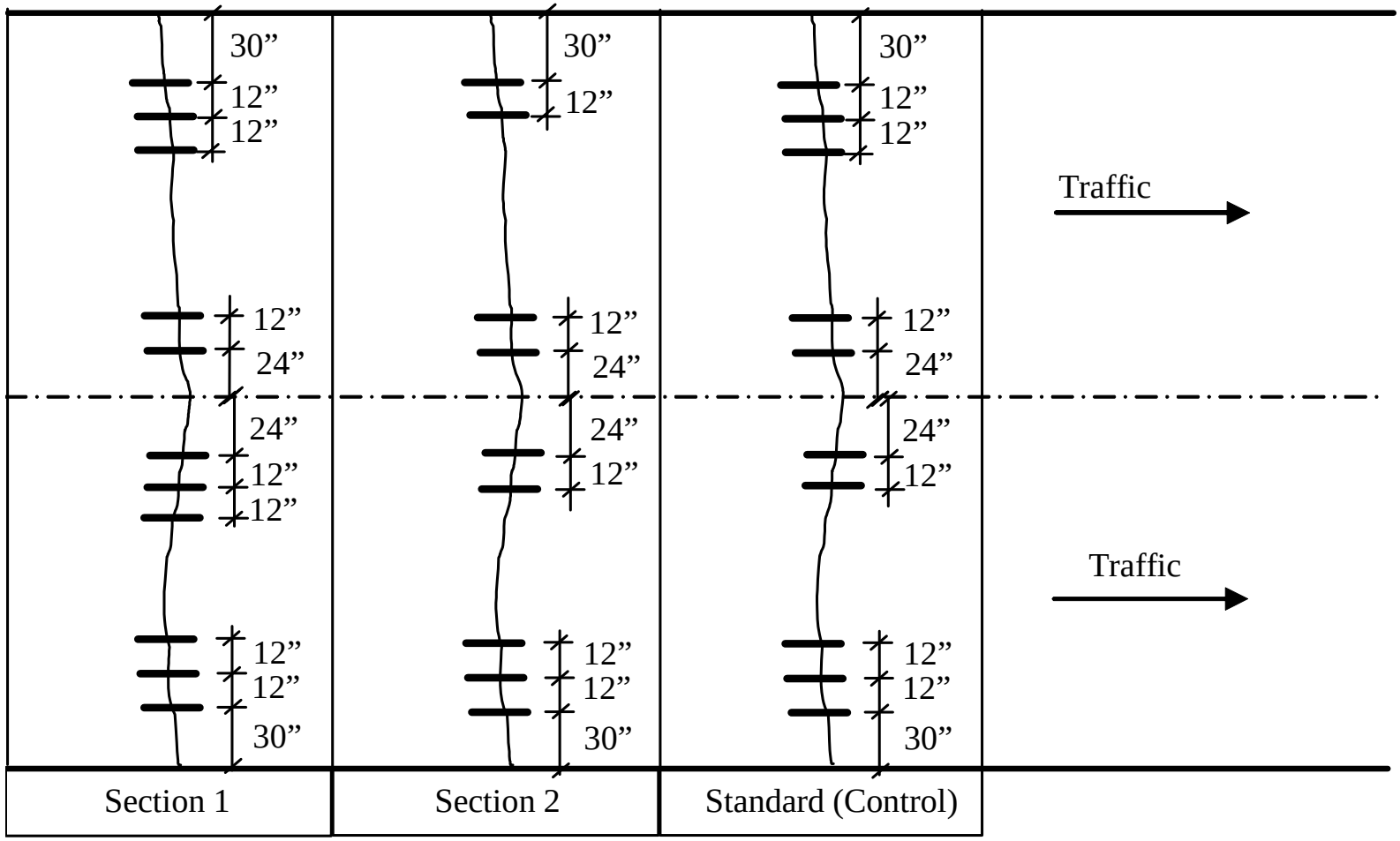
Long Term Performance Case Studies

I-90, Beaver Creek, Minnesota

- Design variables
  - Backfill mortar type
    - PMPQ patch mix
  - Saw and chip slotting method
  - Dowel bar size
    - 1.5 inch dia. x 15 inch long
  - Two retrofit dowel bar placement patterns

Long Term Performance Case Studies

I-90, Beaver Creek, Minnesota



Long Term Performance Case Studies
I-90, Beaver Creek, Minnesota

- Observed Performance (9 years after retrofit)
  - Faulting of mid-panel cracks minimal (avg = 0.3 mm)
  - Backfill material performance very good
  - Some slot distresses caused by transverse and longitudinal panel cracking after retrofit installation
  - LTE (2006)
    - 70 to 89 percent

Long Term Performance Case Studies

- Summary
  - Retrofit dowel bar applications:
    - Prevention of faulted mid-panel cracks
    - Structural capacity improvement
    - Extension of service life (for very old pavement)
    - Restoration of ride quality

Long Term Performance Case Studies

- Conclusions
  - Effective in preventing faulting of mid-panel cracks
  - Effective in extending service life of previously undoweled joints
  - Surface grinding critical to performance of retrofit dowel bars
  - Fairly insensitive to various dowel patterns and bar length
  - Good performance from most backfill materials
  - Milling not recommended for slot formation

Minnesota Best Practices

- Development issues
  - Economical construction
  - Long-term durability in extreme climate
- Slot formation
  - Saw and Chip recommended
  - Milling quicker, but long-term performance not as good
- Dowel bar length
  - 1.25 inch dia x 15 inch long recommended
  - Minne-ALF testing demonstrated that bar lengths down to 13 inches perform satisfactorily (= shorter slots)

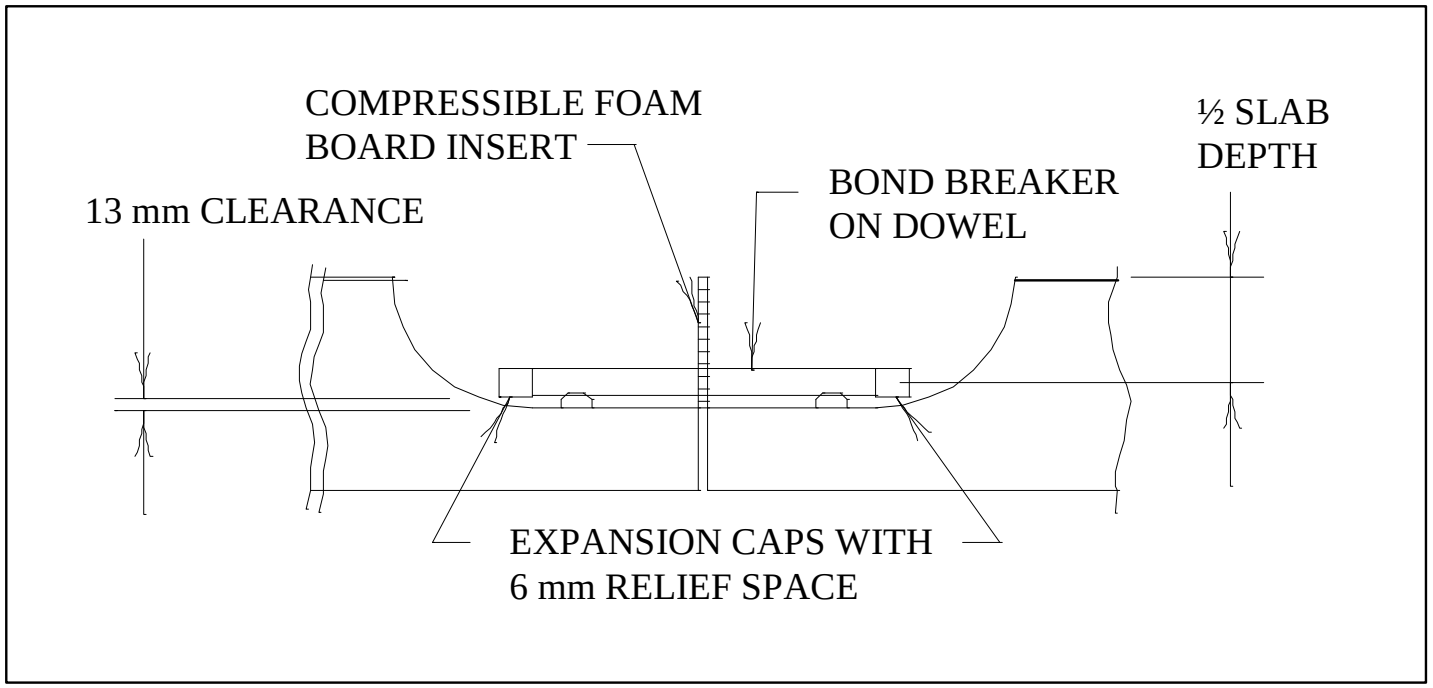
Minnesota Best Practices

- Dowel bar placement
  - Faulting near outer wheelpath
    = 3 dowels outer wheel track
  - Faulting across entire joint/crack
    = 3 dowels outer wheel track, 2 dowels inside wheel track
  - Adjust for traffic volume (example: passing lane)
    = 2 dowels outer wheel track, 2 dowels inside wheel track
  - Center groups of bars within wheel track (12 inches on center)
  - Install so embedment length is equal across joint or mid-panel crack

Note: Two dowels in a wheel track are as efficient as three, however joint deflections increase (Minne-ALF results)

Minnesota Best Practices

- Dowel bar design



Shallower cover has been found to work successfully (Minne-ALF)

Minnesota Best Practices

Minnesota Best Practices

- Construction Method
  - Mn/DOT requires contractor to construct a small test section
    - 24 retrofit dowels in test area
    - 24 hours after retrofit installation, three 6 inch diameter cores taken and inspected
      - Continuity at dowel/concrete interface and consolidation beneath dowel
      - Check that dowel supports do not collapse
      - Check bond between backfill mortar and slab
    - Paid for at unit price

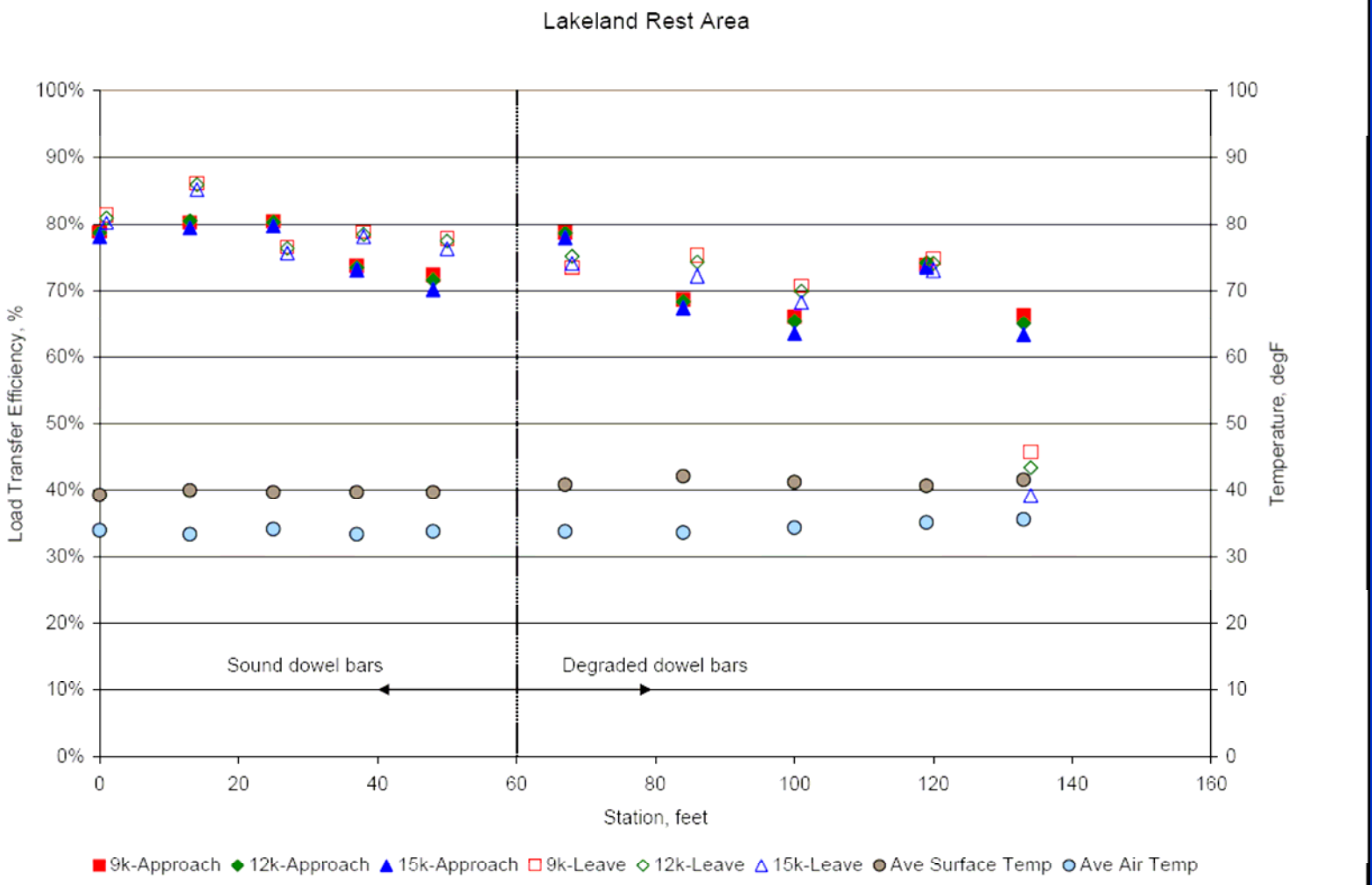
Construction Issues

Honeycombing of backfill mortar ► Switched mortar type

Rehabilitation of Retrofit

Age = Approximately 5years

Rehabilitation of Retrofit



Age = Approximately 5years

Thank you

QUESTIONS?