PCC Pavements in Illinois

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Overview

- Illinois PCC Pavement Design and History
- Material Quality and Construction Issues
- Experience with Open-Graded Bases
- 2001 Performance Study
  - Bare Pavement
  - Overlaid Pavement
- Research on Design and Repairs

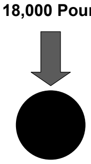
Pavement Design

- Pavement selection determined by life-cycle cost analysis (40-year service life)
- Compare Jointed PCC vs. Full-Depth HMA with a 20-year design life
- Lowest annualized cost based on initial construction and maintenance costs
- If costs within 10%, then Pavement Review Team makes recommendation.

What is an ESAL?

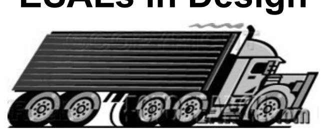
ESAL =
18,000 pound Equivalent Single Axle Load

18,000 Pounds



Mixed loading equated to standard loading

ESALs in Design



Fully Loaded ≈ 4.0 ESAL
Average ≈ 2.0 ESAL

Design lane:

1,375 Trucks/Day @ 2.0 ESAL/Truck = 2,750 ESAL per day

X 365 Days X 20 years

Design Traffic = **20.0** Million ESAL

$$TF = DP\left[\frac{(0.15 \bullet P \bullet PV) + (143.81 \bullet S \bullet SU) + (696.42 \bullet M \bullet MU)}{1x10^6}\right]$$

Jointed PCC History in Illinois

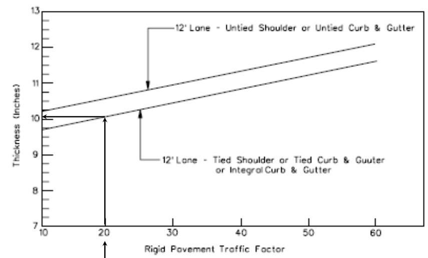
- Originally constructed 100-ft joint spacing with reinforcing bars in panels.
- In 1989 went to short joint spacing, no steel in panels, and hinged joints.
  - 15-ft spacing
  - Dowel bar every third joint
  - Sealed joints
- Current practice is 15-ft joint spacing,12 smooth dowel bars per lane, no joint seal.

Jointed PCC Design

- Currently using Illinois Mechanistic Pavement Design based on mechanistic-empirical principles
- In use since 1989
- Based on performance, not a lot of failures, but data is limited.
- Research underway to update

Jointed PCC Thickness

Round up to next ¼ inch.



Enter with ESALs

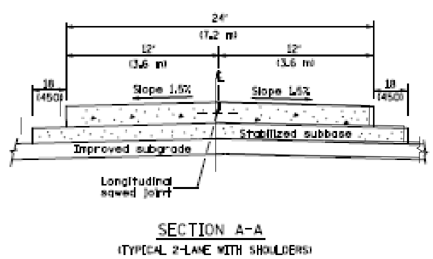
* Assume SSR = Poor

Typical Jointed PCC Designs

Thickness (in.)	ESAL, Millions
9.25	5
9.75	10
10.25	20
10.50	30

Jointed PCC Standard

Standard 420101



History of CRCP in Illinois

- US-40 near Vandalia 1947
  - 7" & 8" CRCP with 0.3, 0.5, 0.7 and 1.0% steel
  - Parts replaced as part of I-70
  - Remainder performed for 50+ years
- 1960's experimented with 6", 7", and 8" CRC, base type, steel depth and percentage

History of CRCP in Illinois

- Originally adopted 7" and 0.6% steel as Interstate standard
  - Broken steel
  - Shallow steel = increased cracking
  - D-cracking problems
- Quickly adopted 8" CRC @ 0.7% steel as replacement for 10-inch 100-foot jointed design
- Mid -1970's traffic required 9" and 10" CRC
- Adopted CRCP as pavement of choice for high volume facilities in 1970's

CRCP Design

- Currently using IL-Modified AASHTO with CRCP = 0.8 JRCP thickness.
- CRCP used if design traffic is 35 million ESALs or higher (3,300 trucks 2-way with growth in 20 yrs)
- Since 2001, only HMA Stabilized Subbase
- Performance indicates design is conservative
- Research underway to update

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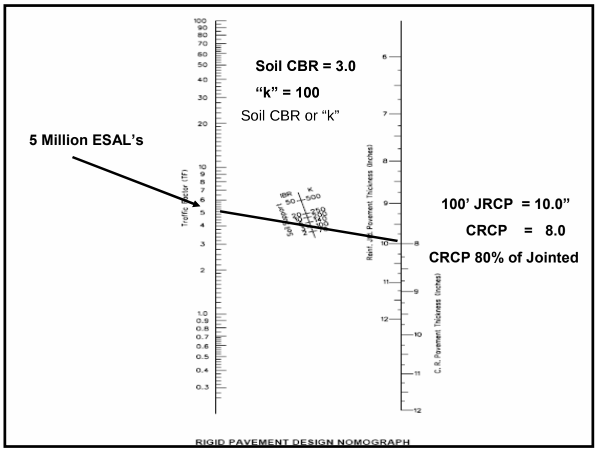

Typical Designs

Thickness	ESAL, Millions
8	5
10	20
12	100
14 (max)	300+

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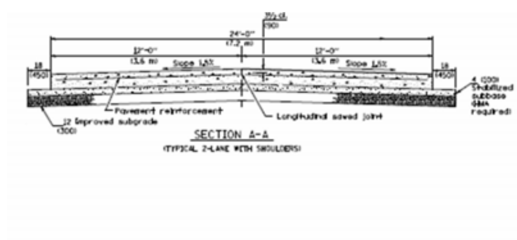
CRCP Standard Drawing



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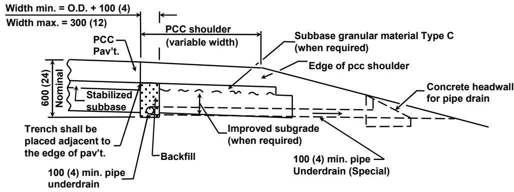
Subsurface Drainage Standard

Standard 601001



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Why Use CRCP?

- No Joints = No Faults
- If built smooth – stays smooth
- Higher level of service during life of pavement
- Ideal for “extremely loaded” facilities
- No reflective joints or cracks in overlay

CRC Pavement 101

Concept: A pavement that relies on tightly closed cracks to transfer load from slab to slab by use of aggregate interlock thus eliminating the need for dowels

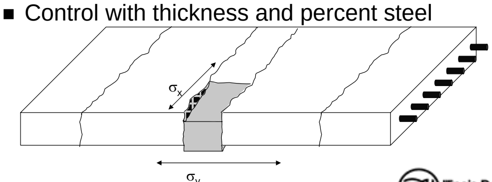
CRC Pavement 101

- No Joints except at free ends/bridges
- Historically thinner pavement than Jointed
- Reinforced with #5, #6, #7-bars or bar mats
  - Uncoated or coated
  - Placed mid-point to 1/3 point from surface
- Uniformity of base important for performance

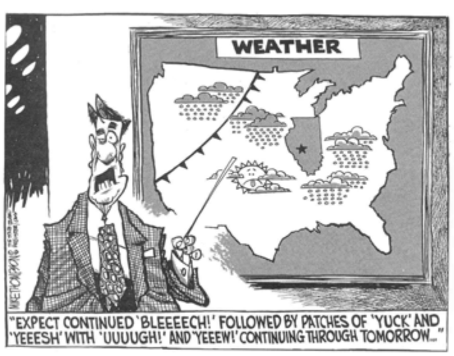
CRCP Failure Modes

Punchout

- Structural failure – load related
- Segment breaks and displace downwards
- Transverse and longitudinal cracks
- Control with thickness and percent steel



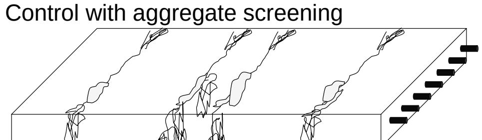
Illinois Weather



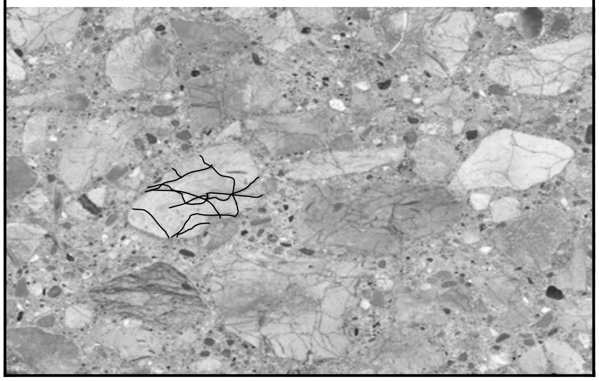
CRCP Failure Modes

Material Durability – “D-Cracking”

- Environmental and Structural failure
- Freeze thaw damage at transverse and longitudinal cracks
- Loading causes potholes
- Control with aggregate screening



D-Cracked Concrete

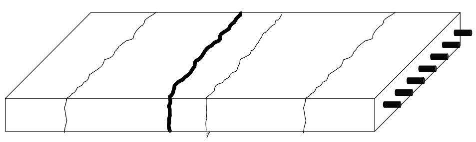


D-Cracked Pavement

CRCP Failure Modes

<u>Steel Rupture</u>

- Environmental
- Need sufficient steel percentage to prevent
- 0.7%-0.8% in Illinois – less if in warmer area



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Crack Spacing Keys

Feature change		Result	
Steel %	↑	Crack Spacing	↓
Steel Depth	↑	Crack Spacing	↑

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CRCP Performance Keys

- Uniform base support
- Percentage of steel matched with climate to prevent steel rupture
- Place steel at level and percentage to obtain the desired crack spacing
- Durable concrete

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3 Keys to Performance

1. Durability!
2. Durability!!
3. Durability!!!

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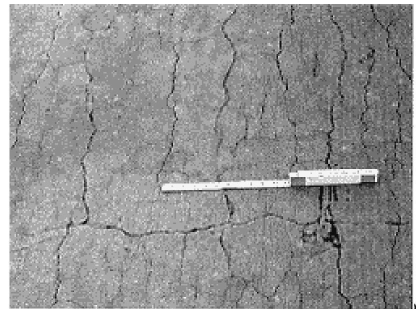
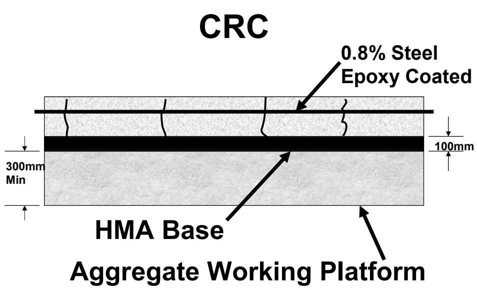
Concrete Materials Durability

- Aggregate
  - Freeze-thaw durability
  - Freeze-thaw cycles --- North - 55, South - 25
  - Reactivity with cement and fly ash (Alkali Silica Reactivity or ASR)
- Concrete permeability
  - Consolidation
  - Curing
- Cement/fly ash reactivity with aggregate (ASR)

ASR in Illinois Sands



Long Life CRCP



Aggregate Screening

- ASTM 666 used since 1982.
  - Freeze in air - thaw in water.
  - Test run to 350 cycles.
  - Average expansion of 3 test beams.
- Decided to use standard test method.
  - 20 year aggregate - Limit to 0.060% expansion.
    - Field performance correlated to test.
    - No overlay during 20 years of pavement life.
  - 30 year aggregate - Limit to 0.040% expansion.
  - 40 year aggregate - Limit to 0.025% expansion.

Construction: Ground Up

- Subbase:
  - Bituminous - Superpave mix
    - 19.0 mm Binder Mix.
    - N 30.
    - Anti-strip added if needed.
- If paving between May 15 and Oct. 15 –
  - Water cool pavement – maintain below 115F.
  - Used to reduce temperature and chance of flash setting from bottom up.

Construction: Subbase Up

Steel:

- All epoxy coated ASTM A706.
- Ties:
  - No 20 (#6) x 600 mm (24”)
    - 600 mm (24”) centers if butt joint
    - 760 mm (30”) centers if sawed joint
- CRC Steel
  - 0.80% Steel
  - Max No. 22 (#7)

Construction: The Pavement

- Paving Equipment:
  - Max speed 0.9 m (3') per minute unless plan in place
  - Vibrator frequency monitoring required.
- Tining – variably spaced (to reduce noise)
- Curing:
  - Spray on curing compound
  - Period - 7 day minimum
  - No traffic of any kind allowed during curing
- Smoothness Requirement:
  - Zero blanking band
  - Incentive/disincentive

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Smoothness Blanking Band

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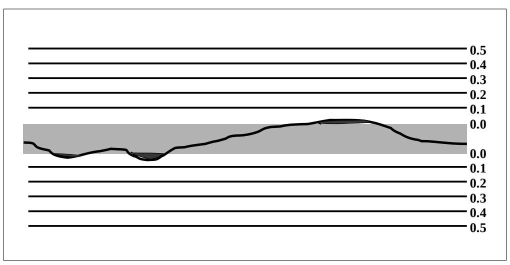
5.0-mm (0.20-in.) Blanking Band



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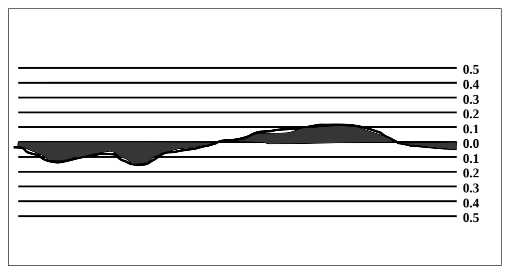
0.0-mm (0.00-in.) Blanking Band



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Lightweight Profiler

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Open-Graded Drainage Layer Research

Physical Research Report #147

http://www.dot.il.gov/materials/research/reports.html

Experimental Sections

- Six experimental sections constructed and monitored.
- Both cement treated (CT) and asphalt treated (AT) layers were used.
  - Three projects used CTOGDL
  - Two projects used ATOGDL
  - One projects used both
- Lime modified subgrade with (3 projects) and without (3 projects) an aggregate separation layer.

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Problems Encountered

- CRCP bonded to OGDL reducing effective steel percentage.
- Subgrade fines infiltrated OGDL base.
- Heavy loads caused vertical movement in pavement:
  - Short sections rebounded
  - Long stretches had permanent full lane-width settlement.

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Emergency Maintenance

- To address deflection of pavement; undersealed OGDL to fill voids.
- To address permanent settlement; used grout to slabjack and restore mainline to the level of the shoulder.
- No patching was needed prior to these activities.

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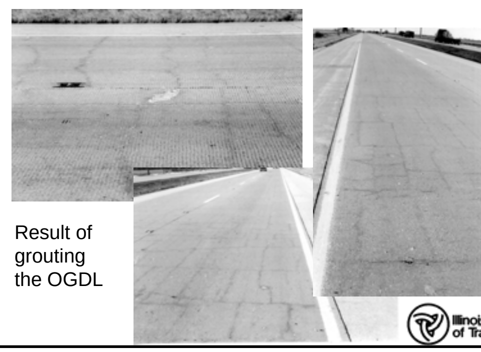
I-80 Section (MP 105 to 111)



Result of grouting the OGDL

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Conclusions/Recommendations

- Significant outflow at underdrain outlet.
- OGDL more expensive than dense graded base; limited benefits do not outweigh cost.
- Must consider subgrade soils, topography, and surface drainage.
- Use bond breaker between CTOGDL and PCC pavements
- Not recommended under CRCP.

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Longevity of Highway Pavements in illinois – 2000 Update

Published in December 2002

http://www.ict.uiuc.edu/Publications.asp

Performance Study Objectives

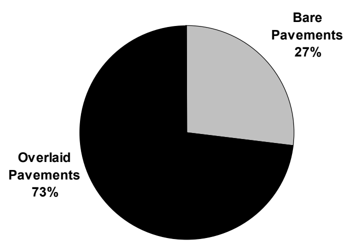
Determine the probability of survival (or failure) and mean life for various designs and families of original and overlaid pavements, in terms of:

- Age (in years)
- Load carrying capacity (equivalent single axle loads (ESALs))

Survival of Original Pavements

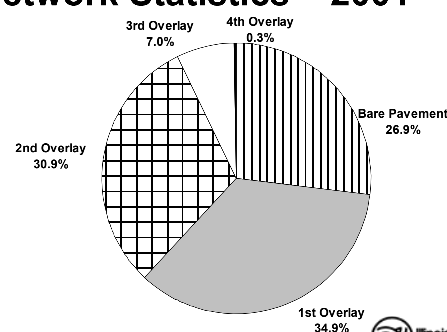
- Region: north and south
- D-cracking status: Yes or No
- Pavement design: JRCP, CRCP (various thicknesses), and HMAC
- End of life is defined as placement of first AC overlay

Network Statistics - 2001

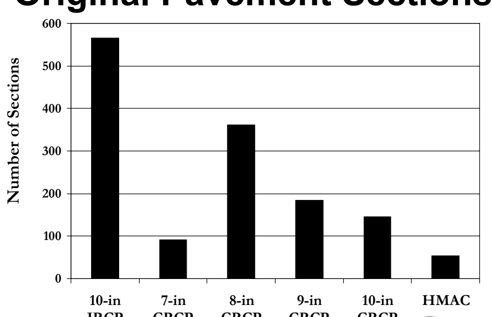


Note: 4% of the bare pavements are reconstructed

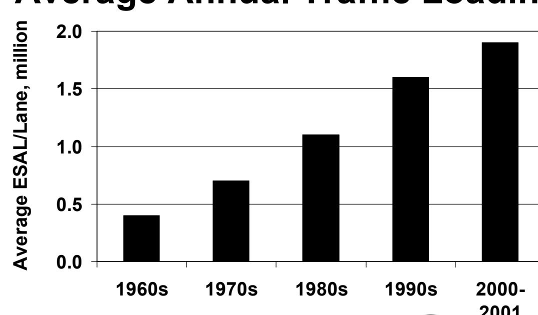
Network Statistics – 2001



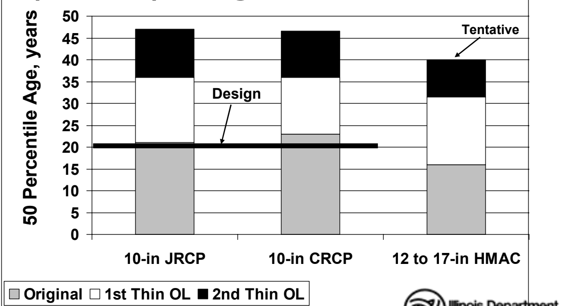
Original Pavement Sections



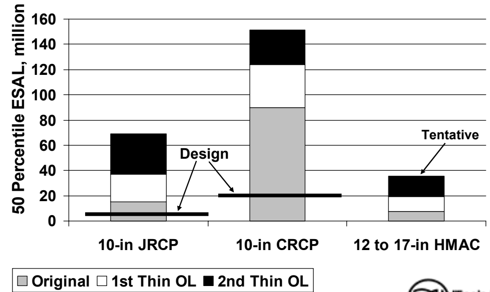
Average Annual Traffic Loading



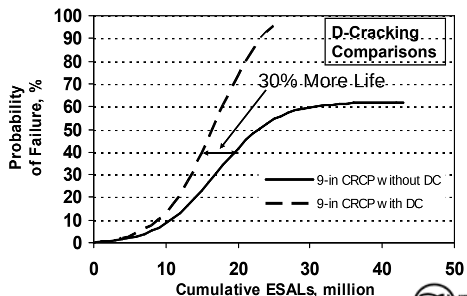
Summary of Pavement Life (No DC) – Age



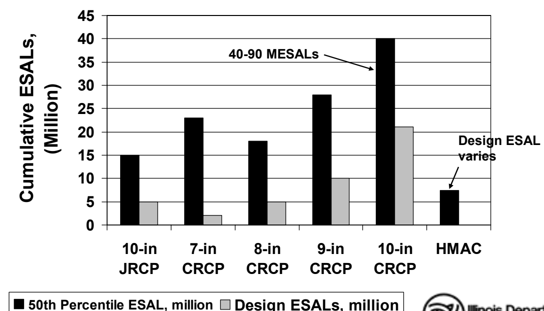
Summary of Pavement Life (No DC) – Cumulative ESALs



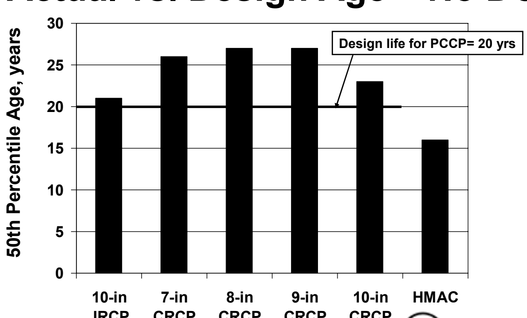
ESAL Survival of Original Pavements – Southern IL



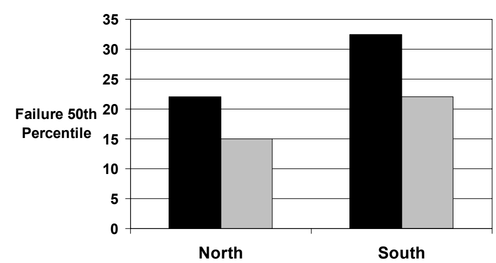
Actual vs. Design ESAL – No DC



Actual vs. Design Age – No DC



North vs. South 8-in CRCP



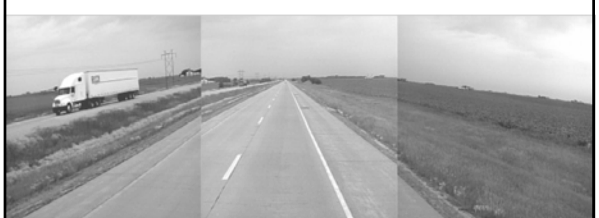
* Without D-Cracking

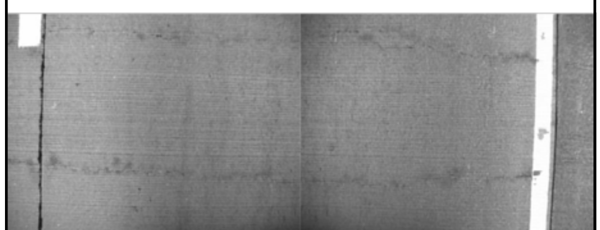
What can we do to improve longevity?

- Thicker CRCP carries heavy traffic and exhibits long life performance.
- CRCP also carries large amounts of traffic after AC overlays are placed (if not allowed to deteriorate too far – less than 2% patching).

I-39 Photo Review

Bare CRCP 16 years old
Typical Performance





I-39 Photo Review

Bare CRCP 16 years old
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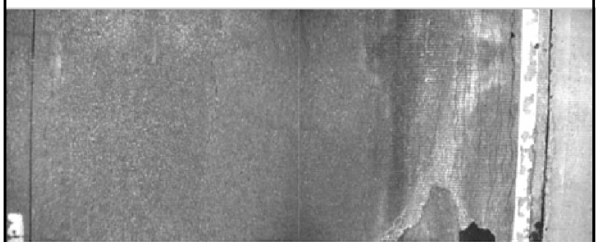
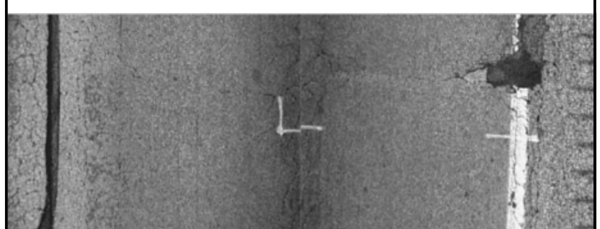


I-70 Photo Review

Overlaid CRCP 14 years old
Typical Performance



Research on CRCP Repairs

Repairs of CRCP

- Not pleased with patch performance
- 1990’s research improved patching
  - 60% problem in the patch causing repatching
  - 40% next to patch
- Study found steel fibers provided best performance, but expensive
- Next best cross-tied steel

Design, Construction, and Analysis of CRCP Patching Techniques

Physical Research Report No. 124

March 1998

http://www.dot.il.gov/materials/research/reports.html

Research to Update Design

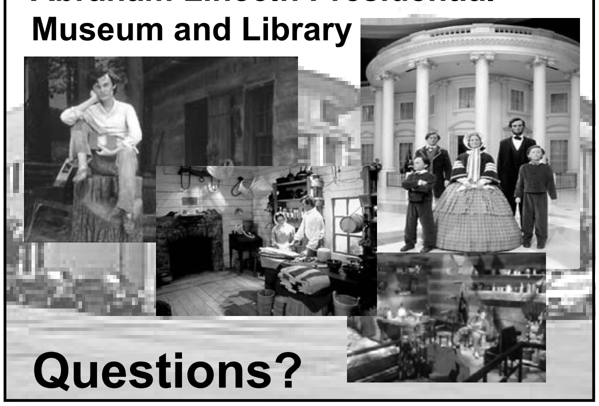
PCC Research Details

- Develop and implement M-E design process for CRCP.
- Refine JPCP design using performance data since short joint spacing implemented.

Summary

- Illinois has not experienced failures using current design procedures.
- Evaluating long life pavements.
- Intend to improve design and performance
  - Design updates
  - Tighter materials control

Abraham Lincoln Presidential Museum and Library



Questions?

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