Caltrans PCP Evaluation

ACPA Annual Meeting
November 29, 2018
Objectives of Caltrans Study

- Identify factors impacting poor behavior of some PCP systems
- Determine elements that are key to successful PCP projects in California
- Determine performance criteria and design details that impact future performance of PCP
- Provide best practice recommendations:
  - Design, construction, and modifications to specifications
  - PCP technology
  - Worker training
Evaluation of Existing Projects

- Site reconnaissance
- Multi-functional vehicle (MFV)
  - Data used to determine IRI and overall condition of precast concrete pavement
- Condition Surveys
  - Detailed distress survey and documentation (photos)
- Falling weight deflectometer (FWD)
  - Determine layer moduli
  - Calculate load transfer efficiency at joints
    - Effectiveness of joint/dowel system
    - Evaluate potential for voids under joints
- Caltrans’ RE interviews
Systems Evaluated

- Precast post-tensioned concrete pavement (PPCP)
- Precast jointed concrete pavement (PJCP)
- Individual precast slab replacement (IPSR)
## Project Locations

<table>
<thead>
<tr>
<th>Expenditure Authorization</th>
<th>Year Built</th>
<th>County</th>
<th>Route</th>
<th>Post Mile</th>
<th>Precast Pavement Type¹</th>
<th>Two-Way AADTT²</th>
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<tbody>
<tr>
<td>04-4A0104</td>
<td>2014</td>
<td>Solano</td>
<td>I-80</td>
<td>30.6/38.7</td>
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<td>04-4470U4</td>
<td>2011</td>
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<td>I-680</td>
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<td>07-252004</td>
<td>2014</td>
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<td>2015</td>
<td>Los Angeles</td>
<td>I-5</td>
<td>R43.9/R45.4, C43.9/C46.4</td>
<td>PPCP/PJCP</td>
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<tr>
<td>07-295504</td>
<td>2016</td>
<td>Los Angeles</td>
<td>US-101</td>
<td>1.8/8.4</td>
<td>PJCP</td>
<td>9,804</td>
</tr>
</tbody>
</table>

¹PPCP = Precast Post-tensioned Concrete Pavement; PJCP = Precast Jointed Concrete Pavement, IPSR = Individual Precast Slab Replacement
²Data obtained from the University of California Pavement Research Center
PPCP Condition (MFV Analysis)

- PPCP base panels were in good condition (84% and greater)
- PPCP end panels exhibited more advanced distress development
PPCP Performance

Gap Panel

Base Panel
PPCP Performance

Live-End Panel

Gap Panel
PPCP Performance

Joint Panel

Central-Stressing Panel
PPCP Performance

Cracking and Spalling

Spalled Longitudinal Joint

Transvers Joint Spalling
PPCP Performance

Severe Grout Loss

Exposed dowel bars
PPCP Performance

Mid-Panel Cracking

Deteriorated Transverse Joint (Gap-Panel)
PCP Condition – Field Survey

- Loss of rigid material in dowel bar/post-tensioning slots was most significant on I-80 and I-5
  - Vertical dowel bar slot edges (rely on grout/concrete bond)
  - Projects with intact grout used slanted or teardrop dowel bar slots or the SuperSlab system
Other Problems Observed on PPCP Sections

Severe Joint Deterioration

Lane 4

Lane 3
**PJCP Condition (MFV Analysis)**

- PJCP panels on US-101 were in good condition (96% and greater)
  - Pavement was just over one year old at the time of survey
- PJCP end panels on I-5 exhibited more deterioration (~2 years old)
  - Older precast panel design
  - I-5 had a combined 44% of connector panels in fair and poor condition
  - Highest truck traffic (23,238 2-way AADTT), ~2.4 times greater than US-101
Typical PJCP Performance

Map cracking

Random Cracking

Grout Deterioration
IPSR Condition (MFV Analysis)

- I-680 was the only project that evaluated IPSR panels
- All panels were in good (89%) and adequate condition (11%)
IPSR Performance

Intact transverse joint

Panel Cracking
IPS R Performance

Transverse joint deterioration

Precast slab

JPCP

Longitudinal Joint (at shoulder)

JPCP

Precast-slab

JPCP

Wide transverse joint

Engineering & Environmental Services
PCP Condition – Field Survey

- Significant map cracking was noted on several projects
  - Presence and magnitude of this distress was unexpected since panels were constructed and cured at precast yards
- I-80, I-680 & I-5 exhibited the highest levels of map cracking
International Roughness Index

- IRI values represent precast along the entire project
  - Intermittent IPSR or PCP made it difficult to determine IRI
- I-405 PPCP had the highest IRI among the five projects
  - IRI values significantly higher than expected for a 3-year old pavement
  - Greater than Caltrans’ 170 in/mile critical threshold
  - Did not appear to have received complete profile grind like other projects
FWD Results – LTE

- PPCP base panels had very good load transfer
- PPCP end panels exhibited wide variability in LTE and low average values
FWD Results – Void Detection

- Offset (x-intercept) greater than 2 mils indicates a potential for voids under the joint
- I-80 end panels & all I-680 panels have greatest void potential
  - Further investigation is needed to confirm
Interviews with Caltrans REs

• Learning curve for Caltrans and contractors
• Poor workmanship resulted in wide joints and gaps between panels.
  – Poor measurement (layout) and sawcutting
• Under-slab grouting was rushed and variable
  – Likely the “weak link” in PCP success
  – No way to confirm grouting was done properly
  – Poor workmanship
  – Applies to polyester concrete as well
  – Panels remained un-grouted until the next shift
    • Sometimes weeks later and some cracked
Interviews with Caltrans REs

• Grout spilled on the slab and filled in tining
  – Safety hazard (reduced friction?) prior to grinding

• Alternate designs (permissible by specification)
  – Additional resource demand on Caltrans’ personnel
  – Lack of guidance/specifications for alternates
  – Variations from the shop drawings made “on the fly”

• Allowable work windows were too short
  – Rushed construction and poor product

• 4-foot long gap panels were problematic
  – Rapid distress development observed
## Location of Projects Under Construction

<table>
<thead>
<tr>
<th>Expenditure Authorization</th>
<th>County</th>
<th>Route</th>
<th>Post Mile</th>
<th>Precast Pavement Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>07-2881U4</td>
<td>Los Angeles</td>
<td>I-210</td>
<td>16.1/25.8</td>
<td>PJCP</td>
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<td>07-295704</td>
<td>Los Angeles</td>
<td>I-605</td>
<td>0/20.2</td>
<td>PJCP</td>
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<tr>
<td>07-300704</td>
<td>Los Angeles</td>
<td>I-5</td>
<td>13.8/19.2</td>
<td>IPSR</td>
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<tr>
<td>07-306204</td>
<td>Los Angeles</td>
<td>Route 91</td>
<td>R11.3/R20.7</td>
<td>IPSR</td>
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<tr>
<td>05-1J2404</td>
<td>Santa Barbara</td>
<td>US 101</td>
<td>45.6/46.6</td>
<td>IPSR</td>
</tr>
</tbody>
</table>
PJCP Construction Observations

• Rapid demolition process
  – Some damage occurred to existing concrete
  – Grade was rolled but very uneven in some cases
  – Minimal density testing observed (sometimes none) with no attempt to achieve optimal moisture content
PJCP Construction Observations

- Installation of lean concrete base (LCB) was problematic
- Material consistency was difficult to control and the first portion of each load tended to be “wet”
PJCP Construction Observations

• Panel installation process was very efficient

• Different technologies for installation
  – Leveling shims
  – Proprietary screw lifting system
PJCP Construction Observations

- Slab grouting was a very “sloppy” process
- No way to verify effectiveness, completeness, and uniformity of under slab grouting
- Filled-in tining
IPSR Construction Observation

- Adjacent panels in similar condition to panels being replaced
IPSР Construction Observation

• Slab removal process appeared to be efficient
  – Minor damage to concrete observed
  – More spalling observed on previously installed panels

• Scraped or milled the CTB as existing PCC was thinner than expected or thinner than new replacement panels.
IPSR Construction Observation

- Existing dowel bars interfered with new dowel locations
- On occasion, the drill hit a dowel bar assembly
- Some panels were left un-doweled or with only a few dowels
IPSР Construction Observation

• Panel installation was efficient and went well
• Some panels barely fit (drove crane on to “set”)
• Screw-type leveling system is very useful (“brilliant”)

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![Panel installation process]

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![Screw-type leveling system demonstration]
IPSR Construction Observation

- Dowel bar installation was inadequate at times
  - Insufficient epoxy material coating the dowel
  - Epoxy flowed out of the holes (no retention disks used)
  - Dowel bars likely not secure in the sockets
IPSR Construction Observation

- Grouting process was very inconsistent and sloppy
  - No material control in the field
- Grout over-pour covered portion of the panel surfaces
  - Filled in panel tining
On occasion, poor sawcutting yielded a very wide longitudinal joint.

Filled the joint with LCB-RS
- Poor mix consistency (too much water)
- RSC filled in the tine marks on the new panels
Interviews With Caltrans REs

• Layout of curved panels was challenging
  – Removed from some jobs
• Difficult to identify panels to replace (IPSR)
  – Adjacent panels were in similar condition
• Cranes drove on un-grouted panels during installation
  – Some cracked
• How effective is under-slab grouting?
  – Poor workmanship, not able confirm grouting was correct
  – Likely the “weak link” in the PCP success
• Panels left un-grouted until the next shift (or next weekend)
Interview Themes

• Existing PCC was thinner than IPSR panels
  – Little to no room for under-slab grout
• One RE was proactive prior to panel construction
  – Caltrans cored to verify thickness
  – Focused on panel layout and measurement
    • Resulted in fewer wide joints
    • No thickness issues
    • More efficient panel installation

• Inexperienced contractor resulted in poor quality
• Experienced Caltrans personnel are essential to improve PCP success
Conclusions

- All four PPCP projects exhibited advanced distress development, especially end panels.
- PJCP projects exhibited good (US 101) to adequate (I-5) performance.
- IPSR had mixed performance with high potential for structural distress.
- Reoccurring factors related to poor PCP end panel performance:
  - Wide joints with deteriorated rigid filler material.
  - Dowel bar slot/post-tensioning block-out filler material loss.
Conclusions

• Map cracking observed on all projects except I-405
• Grouting process was inconsistent within and across projects
• Grouting process was not verifiable and a “weak link” in PCP success
• Difficulty using PCP in curves and superelevation
  – Too many panel variations
  – Field layout problematic
Conclusions

• Poor PCP performance heavily influenced by the following:
  – Rushed construction and lane closure time restrictions
  – Lack of contractor experience
  – Lack of Caltrans project personnel experience
  – End panel design and configuration
Questions?

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