PCPS – A Part of the Pavement Management Toolkit

Chetana Rao, Ph.D.

HfL PCPS Showcase, NJ
October 14 - 15, 2008
Outline

• Pavement Management
  – PCPS as a key tool

• Concrete Pavement Repair and Rehabilitation
  – Design
  – Selection criteria
    • Life cycle cost analyses

• Concluding Remarks
Pavement Management..

...is a coordinated systematic process for carrying out all activities related to providing pavements.
Applications

- Slab replacement
- Full-depth repair
- Conventional paving

Conventional

PCPS

Rehabilitation

Post-tensioning (optional)
New Construction

2007 © ARA, Inc.
Objectives of Pavement Design

• To provide a surface that is:
  – Strong
    • Structural capacity (materials and thickness)
  – Smooth
  – Safe
    • Friction
    • Drainage
  – Economical
    • Initial construction cost
    • Recurring maintenance cost
PCPS Design Components

- Structural capacity for handling
- PCC thickness, material properties
- Existing structure
- Load transfer mechanism with new or existing pavement
- Grouting materials
- Pretension in transverse direction option (PPCP)
- Post-tensioning option (PPCP)
- Friction reducing interlayer or filler material (N.T.S.)
- Slab length
- Slab length

2007 © ARA, Inc.
PCPS Design Considerations

• Structural capacity
  – Load transfer across joint
  – Thickness to match existing pavement
  – Conventional design for new construction
    • If prestressing used, adjust thickness accordingly
  – Expansion joints (longer segments)

• Performance requirements
  – Cracking
  – Joint faulting*
  – Smoothness
  – Other

Need for PCPS performance data collection
Indicators for Long Life

Full scale testing in California

Falling Weight Deflectometer

Heavy vehicle simulator

Test results show no cracks or distress

- 140-240 million ESALs
- 25-37 years of traffic
- Grout verifications
Mechanistic-Empirical Pavement Design Concepts (MEPDG)
Concrete Pavement Analyses

- PCC Modulus
- Traffic
- Granular Base Modulus
- Subgrade Modulus
- Cement Treated Base Modulus
- Time, years
- Each load application

Each load application is applied at regular intervals, causing changes in the modulus of the materials over time.
Daily Temperature Variation

Each load application

Day 1  Day 2  Day 3  Day 4

Temperature, deg C

0.0  0.5  1.0  1.5  2.0  2.5  3.0  3.5  4.0

Time after concrete placement, days

PCC Top

PCC Bottom

Daytime

Nighttime
Slab Curling and Warping

- Warmer or wetter
  - Positive gradient
- Cooler or dryer
  - Negative gradient

Temperature or moisture vs. Depth

- Positive gradient
- Negative gradient
Precast pavements affect the construction of PCC slabs in different ways. Cast off-site in controlled conditions ensures almost zero gradient built-in, minimizing corner curl. Zero stress temperature is achieved with the flat slab at construction. Zero gradient results in corner curl up, while a negative gradient increases corner curl up. 

- Positive gradient – Flat slab at construction
- Zero gradient – Corner curl up
- Zero stress temperature
- Cast off-site in controlled conditions
- Almost zero gradient built-in
- Negative gradient – minimal corner curl
PCPS Design Considerations, Cont.

- Smoothness
  - Prefabrication process (tolerances)
  - Grinding if necessary
- Safe (Friction and slope requirements)
  - Prefabrication process
- Economical
  - Total life cycle cost (not just initial cost)
Design Summary
Precast vs. Cast-in-Place

• Design of precast and cast-in-place concrete pavement are the same

• Precast pavement design issues:
  – Base material
  – Different consideration of curling and warping*
  – Load transfer mechanism*
  – Expansion joints*
  – Prestress options*
  – Smoothness
Project Level Decision Logic or PCPS Selection Criteria

- Project Scope
- Pavement Treatment Alternatives
- Cost Consideration
- Project Specific Considerations
- Construction Considerations
- Maintenance and protection of traffic
Project Level Decision Logic or PCPS Selection Criteria

- Project Scope
- Pavement Treatment Alternatives
- Cost Consideration
- Project Specific Considerations
- Construction Considerations
- Maintenance and protection of traffic
Project Scope

- Pavement service life and objectives
- Current & projected traffic density
- Slab replacement criteria
- Estimated project duration
- Work window options
Project Level Decision Logic or PCPS Selection Criteria

- Project Scope
- Cost Consideration
- Construction Considerations
- Project Specific Considerations
- Pavement Treatment Alternatives
- Maintenance and protection of traffic

PCPS Project Selection
Pavement Treatment Alternatives

General rules of thumb, based on lane occupancy times

Cast in place

VHES

PCPS

HES

Hours

0  4  8  12  16  20  24
Project Level Decision Logic or PCPS Selection Criteria

- Project Scope
- Pavement Treatment Alternatives
- Cost Consideration
- Construction Considerations
- Project Specific Considerations
- Maintenance and protection of traffic
Project Specific Considerations

- Need for accelerated construction
  - M&PT considerations, seasonal restrictions, stakeholder impact
- Funding guidelines
- Design and engineering data requirements
- Construction risk
- Specifications
- Prequalification

Maintenance and protection of traffic
Project Level Decision Logic or PCPS Selection Criteria

- Project Scope
- Pavement Treatment Alternatives
- Cost Consideration
- Project Specific Considerations
- Construction Considerations

Maintenance and protection of traffic

PCPS Project Selection Logic or criteria
Construction Considerations

- Qualified precaster presence in area
- Contractor’s familiarity with PCPS construction process
- Planning and scheduling
- Quality assurance
- Contract plans
Project Level Decision Logic or PCPS Selection Criteria

- Project Scope
- Pavement Treatment Alternatives
- Project Specific Considerations
- Construction Considerations
- Maintenance and protection of traffic

Cost Consideration

PCPS Project Selection
Cost Considerations

• Should expand beyond initial costs
• LCCA - reduced maintenance costs and user-delay cost
• MTO reports only 10% higher cost than high early strength
• Economies of scale and industry familiarity
Concluding Remarks

• PCPS is a proven technology
• PCPS is part of a pavement management toolkit
  – Design
  – Construction specifications
  – Performance monitoring
• Life cycle cost analyses provides a realistic estimate of economic benefits
Thank You

Chetana Rao
(217) 356-4500
crao@ara.com