# 2010 TRB Webinar

## Precast Pavement Technology: Current and Future Directions

**July 28, 2010**

**Time:** 2:00 PM – 3:30 PM EDT

<table>
<thead>
<tr>
<th>TIME</th>
<th>TOPIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:00 PM</td>
<td>Webinar Instructions – Lisa Marflak, Transportation Research Board (TRB)</td>
</tr>
<tr>
<td>2:05 PM</td>
<td>Webinar Overview – Neeraj Buch, Michigan State University and Dulce Rufino Feldman, California Department of Transportation (Caltrans)</td>
</tr>
<tr>
<td>2:10 PM</td>
<td>FHWA Perspective and Activities to Advance Precast Pavement Technology – Sam Tyson, Federal Highway Administration (FHWA)</td>
</tr>
<tr>
<td>2:25 PM</td>
<td>Considerations and Guidelines for Designing and Specifying Jointed Precast Concrete Pavement – Mark Snyder, Engineering Consultant</td>
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<tr>
<td>2:40 PM</td>
<td>Considerations and Guidelines for Constructing Jointed Precast Concrete Pavement – Peter Smith, The Fort Miller Company, Inc.</td>
</tr>
<tr>
<td>2:55 PM</td>
<td>Industry Initiatives and Advances in Precast Prestressed Concrete Pavement – David Merritt, The Transtec Group, Inc.</td>
</tr>
<tr>
<td>3:10 PM</td>
<td>Webinar Summary – Neeraj Buch, Michigan State University</td>
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<tr>
<td>3:15 PM</td>
<td>Questions and Answers</td>
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<tr>
<td>3:45 PM</td>
<td>Adjourn</td>
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</tbody>
</table>
Precast Pavement Technology: Current and Future Directions

Moderated by:

Neeraj Buch, Professor, Michigan State University
Dulce Rufino Feldman, Chairperson AFD50, Caltrans
Why Precast Concrete Pavement?

✓ Traffic control issues and limited construction windows along heavily traveled roadways present challenges for repairing and constructing concrete pavements using traditional strategies.

✓ So in light of these challenges precast concrete pavement systems provide an effective time- and cost solution because:
  ▪ The slabs are fully cured
  ▪ Highly durable
  ▪ Can be put in service almost immediately after installation
Webinar Presentation Outline

• FHWA Perspective on Precast Pavement Technology
  – Mr. Sam Tyson, Federal Highway Administration

• Jointed Precast Concrete Pavements
  – Design Considerations-Dr. Mark Snyder, Engineering Consultant
  – Construction Considerations-Mr. Peter Smith, The Fort Miller Company

• Precast Prestressed Concrete Pavement (PPCP)
  – Industry Initiatives and Advances in PPCP-Mr. David Merritt, The Transtec Group, Inc.

• Question and Answers
Federal Highway Administration – Perspective & Activities to Advance Precast Pavement Technology

Sam Tyson, Office of Pavement Technology
Webinar – TRB Committee AFD50 on Rigid Pavement Design
July 28, 2010
FHWA Office of Infrastructure

- Pavement Technology
- Bridge Technology
- Asset Management
- Program Administration
- Highways for LIFE
Why Precast Concrete?

- Proven construction technique for bridges, commercial buildings and parking structures
- High-performance concrete from controlled manufacturing facilities
Why Precast Pavement?

- Maintenance of Traffic – Nighttime and Off-Peak Work Zones
- Long-Life Pavement Performance
FHWA’s Precast Concrete Pavement Program

Supports the advancement of precast concrete pavement applications through technology transfer, innovation, demonstration, and increased product knowledge.
Vision for Implementation of Precast Concrete for Pavement Applications

Rapid repair, rehabilitation, and reconstruction of asphalt and portland cement concrete pavements on high-volume roadways for long-life performance.
Pavement Condition

- Excellent
- Increased Capacity
- Repair / Restoration
- Rehabilitation
- Critical Condition
- Reconstruction
- Failed

TIME and TRAFFIC
Precast Prestressed Concrete Pavement; VDOT – 1200 ft of I-66 3 west-bound lanes and shoulder

Precast Doweled Concrete Pavement; VDOT – 3900-ft ramp in outside lane only
Demonstration projects by State DOTs support FHWA’s precast pavement program
Progression of Precast Prestressed Pavement Projects

2000 – Feasibility Study, Univ. of TX / Austin
2002 – Frontage Road, I-35, Georgetown, TX
2004 – Lane Addition, I-10, El Monte, CA
2006 – Reconstruction, I-57, Sikeston, MO
2006 – Bridge-Approach, Rte 60, Sheldon, IA
2009 – Turning Lanes, Rte 896, Newark, DE
2009 – Reconstruction, I-66, Fairfax, VA
2010 – Project Support (Caltrans; FDOT)
Progression of Precast Jointed Pavement Projects
Progression of Precast Jointed Pavement Projects

Square Yards of Jointed Precast Slab Installations

- New York
- New Jersey
- Canada
- Illinois
- Misc
- California

Jointed Precast Slab Installation Timeline
- Total Slabs Installed
- Production Slabs Installed
- Intermittent Repair Slabs Installed
- Firm Orders
- Firm Orders + Projects Expected to Bid

Nassau Queens
Future Activities

- Further development and refinement of precast concrete pavement systems.
- International Scan / AASHTO & NCHRP: France; Indonesia; Japan; The Netherlands; and Russia.
- Showcase & document planning, design, construction & performance of projects.
- Advance the development of specifications & guidance documents for routine use with industry organizations: ACPA; NPCA & PCI.
Thank you.

Additional information –

Sam Tyson sam.tyson@dot.gov
Phone: 202-366-1326
Considerations and Guidelines for Designing and Specifying Jointed Precast Concrete Pavement

prepared by
Mark B. Snyder, Ph.D., P.E. – Engineering Consultant
Suitable (and already proven) Locations for Precast Concrete Pavement

Intermittent repair of mainline pavement
Continuous mainline pavement (very heavily traveled areas)
   Interstate access ramps
Heavily traveled intersections (with multiple utilities)
   Beneath overpasses
   Bridge approach slabs
Airport taxiways, runways and aprons
Project Feasibility

- Qualified precasters near project?
  - Should be NPCA- or PCI-certified
- Determine whether slabs can be delivered to the site when needed
  - Check local freight regulations
- Verify enough room for installation (MPT plan)
  - Two lanes preferable
  - One lane possible but difficult
Design Parameters of Current Jointed Precast Pavement Systems

- Concrete strength, volumetric (thermal, shrinkage) characteristics.
- Panel thickness (including planar vs. nonplanar surfaces)
- Panel reinforcement (including structural fibers)
  - Temperature and shrinkage
  - Transport and handling
  - Design for service loads
Design Parameters of Current Jointed Precast Pavement Systems

• Load transfer system design
  ▪ Various dowel/tie embedment systems
    • Slot orientation (top-down, bottom-up)
    • Hardware anchor materials and injection systems
    • Dowel/tie materials (e.g., epoxy-coated steel, solid or clad stainless steel, zinc-clad products, others)
  • Dowel/tie designs (e.g., cylindrical vs. elliptical vs. plates)
Effectiveness of Proposed Load Transfer Devices

- Standard load transfer dowels typically used
  - Dowel design as required for CIP pavement
  - Long-life dowels may be appropriate in some installations

- Top-of-slab slot systems
  - Slots must be prepared (sand blasted) properly
  - Slots must be filled and grout cured before opening to traffic

- Bottom-of-slab slot systems
  - May be opened to traffic prior to grouting
Design Parameters of Current Jointed Precast Pavement Systems

- Surface texture and materials
  - Monolithic vs. multi-lift construction
  - Various textures for noise, friction, drainage
- Panel support system
  - Grade-supported, grout-supported, pile-and-beam supported
How Effective is Slab Bedding System?

• Slabs must be fully supported by subgrade surface
• Bedding technique must support “rapid” agenda
• Commonly used and proven techniques
  ▪ Injected urethane
  ▪ Precisely graded aggregate bedding material
    • Augmented with bedding grout to fill voids
• Flowable cementitious fill and bedding grout also used
Consideration

Will Proposed System or Concept Work?

- Evaluate each concept as a “System”
  - Consider feasibility of bedding and load transfer methods

- Review test results and performance records (if available)

- Determine if design, fabrication and construction support are provided

- Make sure the system can be installed rapidly

- Consider simplicity of the system – big potential impact on cost and quality of the finished installation
Design Guidance: New Construction

• Thickness and other design features selected to meet project needs
  ▪ Replicate existing pavement structure
  ▪ Provide additional design life
  ▪ New pavement design
Design Guidance: Slab Dimensions

- Slab Dimensions: Jointed Systems:
  - Thickness and other design features selected to meet project needs
  - Replicate existing pavement structure
  - Provide additional design life
  - New pavement design
Design Guidance:
Slab Dimensions

• Conventional Jointed Systems
  ▪ Develop using standard cast-in-place design procedures (e.g., AASHTO)

• Precast/Prestressed Systems
  ▪ Induced compressive stresses reduce required thickness (or increase load capacity) - use mechanistic design

Balance design features and concrete strength
Design Guidance: Adding Lanes

• Finished surface to match adjacent surface(s), which may require
  ▪ Addition/removal of subbase material
  ▪ Precasting nonplanar (warped) panels or post-installation diamond grinding

• Design using materials/geometrics that avoid potential drainage problems

• Match existing (adjacent) transverse jointing types and pattern
Design Guidance: Pavement Repair Projects

• Facilitate estimates and production by using “standard” size panels (e.g., 6-ft, 8-ft and 10-ft long, full lane width).
  ▪ Use combinations or full panels for larger areas.
• Match existing pavement thickness (or surface level, as appropriate)
Design Guidance: Pavement Repair Projects

- High-early strength grout or urethane for support/stabilization
- High-early strength dowel encasement material
- Need for ties to adjacent pavement
  - Consider precast panel length
  - Other factors
Designing (and Building) Slabs to Fit

- Single-plane slabs will usually work for intermittent repair
- Slabs must be sized and shaped to fit:
  - Between longitudinal joints (field data required)
  - Horizontal curves and 3-dimensional surfaces
  - Trucking requirements (in cities)
- Continuous installations typically require longer slabs (16’ max.)
- Slabs must be shaped to fit around utilities
Field Size and Shape Constraints

- Fitting Between Longitudinal Joints
- 75 m Radius
- Horizontal and Vertical Curves
- Contour Plan of Rockaway Blvd., Queens, NY
Smoothness Requirements

• Use same criteria as standard specs for conventional concrete pavements
• Diamond grinding may be required to achieve acceptable smoothness
• May be OK to allow opening to traffic before smoothness measurement for short window construction operations.
Surface Texture and Friction Req’ments

- Same criteria (and pay items) as standard specs for conventional concrete pavements
Current Methods for Specifying Jointed PCPS

• Three common specification approaches:
  ▪ product-specific specifications
  ▪ “allowable system” specifications
  ▪ generic (specifications

• Each is a good fit for specific situations
Product-Specific Specifications

Essentially a “sole source” specification

- Calls for the use of the product(s) of a particular manufacturer
- Based upon experience gained from previous successfully completed projects.
- Straightforward adoption
- Often used by agencies who believe that it offers less chance of design or construction problems than less specific specifications
- May present problems for agencies with concerns about the specification of proprietary products.
Allowable System Specifications

- Allows use of one of a number of pre-approved systems.
- May be used by agencies that are sensitive to sole source specifications.
- Drawback: often difficult to completely capture in a single spec all of the system-specific details necessary for successful installation of each approved system.
“Generic” Specifications

- Essentially performance-based specifications
- Example: guide specifications developed by the AASHTO Technology Implementation Group (TIG) on Precast Concrete Paving Slabs
  - Establishes sensible performance criteria that all systems (proprietary or nonproprietary) must meet
  - Describes a supplemental pre-approval process for competing systems
Online Resources:
www.aashtotig.org

- Basic PCPS info and commentary
- Detailed info about leading PCPS
- Design guidelines and guide specifications
  - Design of PCPS
  - Fabricating and construction PCPS
  - System approval
- Research reports
- Proven agency specs
Requirements of Precast Pavements  
(Same as for Cast In Place Pavements)

- Concrete must be of high quality
- Precast pavement must be fully bedded (supported)
- There must be effective load transfer across joints
- Surface must be accurate and smooth
  - Three dimensional surfaces are required in many cases
- Must be able to accommodate utilities
- Must be capable of being installed rapidly
  - As in “overnight”
What We Are Emulating

Concrete Pavement Fully Bedded With Accurate Surface
Effective Load Transfer Dowels at Joints (to be sawed)

(If you can possibly cast good concrete in place and get a good cure, don’t use precast!)
Achieving Cast-In-Place Equivalency

Guidelines

• Manufacture geometrically accurate slabs
  ▪ Tight tolerance required to stay within allowable joint widths
  ▪ Three-dimensional shapes may be required
• Achieve full and complete bedding of slabs
• Develop effective load transfer at joints
• Seal joints as required
• Exercise accurate grade control and/or grind, as necessary to achieve IRI requirements
Precast Panel Fabrication

Guidelines

- Qualify (specify) precaster’s capability
  - Reference DOT Precaster requirements
  - Specify NPCA or PCI certification
- Insure precasters are fully trained
- Specify accurate forms
  - Should be accurate to 1/16” +
  - Forms must be capable of making 3-dimensional slabs
- Reference QA & QC requirements
- Require pre-pour & post-pour measurement checks
Controlled Fabrication Conditions

Forms Accurate to 1/16” ±

Roller Screed Insures Accurate Top Surface

Accurate Piece Drawings (every dimension critical)

Ideal Finishing (and curing) Conditions
Shipping

Guidelines

- **Size slabs for shipping**
  - Keep under 12’ wide (if possible)
  - Permits for city and night delivery required

- **Ship slabs in order**
  - Use mark numbers to organize orderly storage and shipping

- **Provide unloading lane**
  - Out of traffic if possible
  - Two lanes required for installation
Achieving Full and Complete Bedding

Guidelines

The Roman Road System
- Use HD Polyurethane on Fully Compacted Base
- Inject to Raise Slab to Grade

The Super-Slab® System
- Precisely-Grade Bedding Material to $\pm \frac{1}{8}$
- Install Bedding Grout to Fill Any Voids

Consideration

Proof
Achieving Good Load Transfer With Top-Slot Systems

Guidelines

• Saw and chip carefully
  ▪ Don’t damage existing pavement
  ▪ Keep slots parallel to traffic

• Clean slots for good bond
  ▪ Sand blasting required in most states

• Use joint former in slot

• Before Opening to traffic
  ▪ Slots must be filled
  ▪ Grout must reach 2500 psi
Achieving Good Load Transfer With Bottom-Slot Super-Slab® System

Guidelines

- Use properly-designed grout
  - Must be pumpable
  - 2500 psi in 2 hours (before traffic)
  - Grout must be freeze-thaw durable
- Use proper pumping technique
  - To insure slots are completely filled
- Fill joints along with slots
Accommodating Utilities

Guidelines

- Gather accurate “x”, “y”, “z” data of utility
  - Prior to shop drawing preparation
- Arrange joints around utilities
  - Maintain load transfer between slabs
- Keep utilities isolated
- Fill holes with temporary material to maintain traffic
- Use good fast track concrete around utility
Installation Rates (Intermittent Installations)

Guidelines

- Installation rates drive project duration
  - Maximize work window when possible
- Rates depend upon work window and how close holes are together
  - Check installation rates on similar projects
- 8 hour work windows (Super-Slab®)
  - 12 – 15 slabs (12’ x 10’) per (night) shift
- 5 hour work windows
  - 7 – 9 slabs (12’ x 10’) per (night) shift
Installation Rates (Continuous Installations)

Guidelines

• Grading, placement and grouting rate of Super-Slab® installation
  ▪ 8 – 10 Slabs (1500 – 2000 SF) per Hour
  ▪ 12’ x 14’ slabs
  ▪ Average rate of over 6000 SF (667 SY) per 8 hour – I-15, Ontario, CA
    • Equates to nearly one mile in two weeks
• Rates should improve over time
  ▪ As contractors become more familiar
  ▪ As specialized equipment improves
Guidelines

- Small differences between slabs are to be expected
  - There are tolerances allowed (by necessity) in slab fabrication
  - There are tolerances allowed in the grading
- **Super-Slab®** specifies finished surfaces ± 1/8”
  - May be acceptable for slow speed traffic
- For best International Roughness Index - grind
  - Grinding is a known, accepted and cost-effective practice
Expertise Requirements

Guidelines

- Successful project requires coherent plans and specifications
- Precasters must be trained and equipped to make accurate panels
- Contractor’s personnel must be trained in proper installation techniques
- Owner’s representatives (inspectors) must be trained in proper precast pavement installation details
Total Jointed Installations (all Systems) Since 2001

• Over 17 lane miles on nearly 50 projects
  ▪ Installations in 11 states
  ▪ Plus two Canadian Provinces

• Jointed slabs used successfully in a multiple of applications

• Contractors are becoming more proficient at installation
  ▪ One NY contractor completed 3 precast pavement projects

• Fabricators prove capable of making accurate slabs
  ▪ In three dimensions

• Significant uptick in installations since 2007
Keys to Success
(Still More to Learn)

Good engineering
Open minds
Real partnering
Industry Initiatives and Advances in Precast Prestressed Concrete Pavement (PPCP)

2010 TRB Webinar

Precast Pavement Technology: Current and Future Directions

28 July 2010

David K. Merritt, P.E.
Overview

- Background
- PPCP Concept
- Benefits
- Completed PPCP Projects
- Industry Initiatives
Background

- 1998-2000: FHWA PPCP Concept Developed
- 2002-2009: Demonstration projects completed in TX, CA, MO, IA, DE, and VA through FHWA support.
- 2009: 22-mile project completed in Indonesia
- 2010-?: Additional projects in CA, FL, and Indonesia
Overview

- Background
- PPCP Concept
- Benefits
- Completed PPCP Projects
- Industry Initiatives
What is PPCP?

- **Precast** Prestressed Concrete Pavement
  - “Standardized” full-depth precast panels
  - Keyed panel joints for vertical alignment during assembly
  - Constructed over a prepared base (HMA, LCB, Aggregate Base, Pervious PCC, etc.)
What is PPCP?

- Precast *Prestressed* Concrete Pavement
  - 2-way prestressing
  - Combination of pretensioning/post-tensioning
  - 2-way post-tensioning
  - Bonded/grouted P-T system
Typical PPCP Panel

- Ducts for Post-tensioning
- Continuous Shear Key
- Pretensioning Strands
PPCP Panel Installation

- P-T Strand Ducts
- Polyethylene Sheeting
- Traffic Flow

Joint Panel

Subbase/Subgrade
PPCP Panel Installation

Post-tensioning
PPCP Panel Installation
Overview

- Background
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Benefits of *Prestressed* Precast Concrete Pavement

- Reduces/eliminates slab cracking (maintenance)
- Reduced number of working joints (maintenance/smoothness)
- Ability to span voids/non-ideal support layers
- Reduced Slab Thickness (8” vs. 12”)
  - Material savings
  - Allows for replacement of pavement in-kind
- Proven Long-Term Performance
Overview

- Background
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- Industry Initiatives
Interstate 35 (FR) - Georgetown, TX
Route 896 - Newark, DE
Interstate 66 – Fairfax, VA
Overview

- Background
- PPCP Concept
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Industry Initiatives

- Precast/Prestressed Concrete Institute (PCI)
  - 2006: Pavement Committee established
  - 2009: FHWA and PCI establish a Cooperative Agreement to help promote precast prestressed concrete pavement technology within the precast industry
  - 2010: Pavement Committee is currently developing four Guidance Documents for PPCP
    1) Project Selection
    2) Project Layout and Design
    3) Precast Panel Fabrication
    4) Construction Recommendations
Industry Initiatives

◆ ACI
  • 2007: Precast Pavement Subcommittee established under ACI-325, Concrete Pavement Committee

◆ AASHTO Technology Implementation Group
  • 2006: Lead States Team established for Precast Concrete Pavement Systems
  • 2008: AASHTO TIG developed and adopted three Guide Specifications for precast concrete pavement systems (prestressed and jointed-reinforced)
  • http://tig.transportation.org/Pages/PrecastConcretePavingSlabs.aspx
Thank You!

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