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*Tech Brief*

# PRECAST CONCRETE PAVEMENT IMPLEMENTATION BY U.S. HIGHWAY AGENCIES

## INTRODUCTION

Precast concrete pavement (PCP) technology is gaining wider acceptance in the U.S. for rapid repair and rehabilitation of concrete pavements as well as for reconstruction of heavily trafficked asphalt concrete intersections. Widespread use in the U.S. is fairly recent, with most projects in service less than about 14 years. Nonetheless, dozens of projects have been constructed, and advances continue to be made in all aspects of the technology, including panel design, fabrication, and installation. PCP technology is being used for intermittent repairs (both full-depth repairs and full panel replacement) and for continuous applications (longer-length/wider-area rehabilitation) with service life expectations of at least 20 years for repairs and at least 40 years for continuous applications, without significant future corrective treatment.

Available PCP systems include jointed PCP with reinforced or pretensioned panels installed singly or in a continuous series, as well as posttensioned PCP that typically incorporates thinner panels installed and posttensioned in a continuous series, resulting in fewer joints. The use of PCP technology can significantly reduce traffic impacts of roadway repair and reconstruction projects, particularly on heavily traveled routes. The technology is applicable to small segments, enabling flexibility in construction phasing, as well as for use in corridor-wide pavement rehabilitation/reconstruction. A review of projects constructed in the U.S. and field testing of selected projects indicate that sufficient advances have been made to reliably design and construct PCP systems to achieve five key attributes of successful pavements, as follows:

- Constructability – Techniques and equipment are available to ensure acceptable production rates for the installation of PCP systems.
- Concrete durability – Plant fabrication of precast panels results in excellent concrete strength and durability.
- Load transfer at joints – Reliable and economical techniques are available to provide effective load transfer at transverse joints in both jointed and pretensioned PCP systems.
- Panel support – Techniques to provide adequate and uniform base support conditions are available and continue to be improved.
- Performance/efficiency – Panels can be thinner than standard cast-in-place concrete and last longer because of prestressing and/or reinforcing elements in the PCP systems.

U.S. Department of Transportation
Federal Highway Administration

The use of both jointed and posttensioned PCP systems has advanced during the last decade due to a combination of work sponsored by the Federal Highway Administration (FHWA), projects constructed by highway agencies, and innovations by the construction industry. PCP has been adopted for routine use by several highway agencies, as detailed in this Tech Brief. Twelve agencies have received funding awards under Round 3 and Round 6 of the Strategic Highway Research Program 2 (SHRP2) Implementation Assistance Program (IAP) (http://www.fhwa.dot.gov/goshrp2/ImplementationAssistance). The Lead Adopter awards supplement the cost of a PCP project constructed by each recipient, and the User Incentive awards help recipients to make PCP technology available for use on an agency-wide basis.

This Tech Brief summarizes PCP technology implementation related activities for pavement repair and rehabilitation by 29 U.S. highway agencies.

## PCP BACKGROUND

The application of PCP technology can be classified as follows:

- Intermittent repair applications – Under this approach, isolated pavement repairs are made using precast concrete panels. Two types of repairs are possible:
  - Full-depth repairs, to repair deteriorated joints, corner cracking, or cracking adjacent to the joint.
  - Full-panel replacement, to replace cracked or shattered slabs.

  The process is similar for full-depth repairs and full-panel replacement, and both repairs are typically a full lane wide.
- Continuous applications – Under this approach, full-scale project-level rehabilitation (resurfacing) or reconstruction is performed using precast concrete panels.

For both repair and continuous applications, generic and proprietary panel designs are available. An important characteristic of the panel design relates to the provision of load transfer at transverse joints using slots or other features. In this Tech Brief, reference is made to the following panel types for jointed PCP:

- Bottom slot panels. Certain aspects of this panel design may be proprietary.
- Top slot panels as used by the Illinois Tollway. This is a non-proprietary panel design.
- Hybrid top slot and duct panels. Certain aspects of this panel design may be proprietary.
- Top slot panels as used by Caltrans using teardrop-shaped top slots. This is a non-proprietary panel design.

In addition to the panel design, the bedding layer type needs to be considered. The use of a bedding layer (or interlayer) is important to ensure uniform contact between the flat bottom of a panel and the graded/finished base. The choice of this interlayer material is affected by the way the panels are installed. Panels may be placed directly on grade (grade-placed option) or panels may be set over a thin layer of bedding grout (grout-supported option) using leveling lifts. For the grade-placed option, the panels are placed over a thin layer of cemented granular material or cemented sand for grade-placed systems. For the grout-supported option, the panels are set about ¼ to ½ in. (6 to 13 mm) over the completed base using a leveling lift system. Then, a fast-setting flowable cementitious grout is used to fill the gap under the panels.

### Traffic Considerations

The decision to use PCP for any repair or rehabilitation project is greatly influenced by the traffic volume along the project and availability of alternate routes to detour traffic without impacting traffic flow along the project and adjacent roadways. The questions to consider include:

- Is traffic heavy enough to preclude other pavement repair/rehabilitation alternatives? If fast-track fixed-form or slipform paving techniques are possible, use of precast pavement may not be the best option.
- Can traffic be staged or detoured? If yes, then the use of precast pavement may not be the best option.

But, if work zones are limited to only 8 hours or less to perform the repair/rehabilitation work during nighttime lane closures, then the use of precast pavement should be strongly considered.

### PCP Application Types

To date, the widest application types for PCP have been as follows:

- Heavily-traveled mainline interstate/primary system and urban roadways – a critical need on the aging highway system in the U.S.
- Interstate/primary system and urban ramps – where often no alternative routes are available and the ramps carry heavy traffic.

Other important applications of PCP include:

- Intersections – Especially where rutting and shoving of asphalt is a recurring problem and traffic needs to be maintained.
- Bridge approach slabs – A large number of approach slabs across country need to be rehabilitated with minimum interruption to traffic.
- Underpasses – Where overhead clearance restrictions may limit rehabilitation options.
- Bus pads – Where alternative bus stop locations are not an option, and rutted bus pads can be replaced overnight.
- Utility "bridges" – Over failed drainage pipes and culverts.

## PCP IMPLEMENTATION

This section describes the actions taken by 29 highway agencies in the US to implement the use of PCP for repair and rehabilitation of asphalt and concrete pavements. Individual agencies are at various stages of PCP implementation, with some just beginning to develop specifications and to identify projects where PCP can most effectively be used, and others monitoring the performance of one or more in-service PCP projects and planning for additional applications of PCP.

### Alabama

During September 2017, the Alabama Department of Transportation (DOT) used PCP to rehabilitate a rutted AC pavement section of the Exit 2 ramp from southbound I-165 in Mobile. The project construction was supported by a Lead Adopter Award, under the SHRP2 IAP. A total of 67 two-lane (25-ft (7.62 m) wide bottom slot panels were used over a length of 531 ft (161 m). The panels were grout supported.

### California

The use of PCP is gaining wide acceptance in California. Caltrans constructed the first demonstration project using the generic posttensioned PCP system along a section of I-10, near El Monte, during April 2004. During 2005, Caltrans tested A PCP with bottom slots using an accelerated load testing facility. Since then, several PCP projects using both jointed and posttensioned PCP systems have been constructed in various Caltrans districts. These projects include both intermittent repair and continuous applications.

Caltrans has developed standard plans and specifications for intermittent repairs, jointed PCP, and posttensioned PCP. For jointed PCP, Caltrans allows use of panels with top slots as well as panels with bottom slots. Some of the recent PCP projects have included several hundred to several thousand precast panels. Caltrans allows only use of grout supported panels.

For major PCP projects, Caltrans requires just-in-time training before the start of a project to review project-specific plans and specifications and to review the contractor's approach to precast panel installation.

### Colorado

Colorado DOT constructed a PCP project during 2002 along a section of I-25, north of Denver. This was an unbonded overlay application and used the proprietary URETEK Stitch-in-Time repair system. This system is no longer marketed. Colorado DOT has not constructed additional PCP projects.

### Connecticut

During October 2016, Connecticut DOT used PCP to rehabilitate two AC bus pads along CTfastrak, a regional busway. The bus pads were located in New Britain and exhibited significant rutting that prevented opening of the bus doors at the platforms. The project construction was supported by a Lead Adopter Award, under the SHRP2 IAP. A total of 24 bottom slot panels were used for the two bus pads. The panels were grout supported.

### Delaware

Delaware DOT used FHWA's generic posttensioned PCP system during 2009 to rehabilitate a section of Route 896 northbound at Route 40 (left-turn lane and outside lane and shoulder). During 2018, Delaware DOT rehabilitated an intersection in Dover using bottom slot panels that were placed on grade using a thin granular bedding later.

### District of Columbia

During 2015, the District of Columbia DOT was awarded a User Incentive Award, under Round 6 of

the SHRP2 IAP, to support activities leading to implementation of PCP technology.

## Florida

The Florida DOT constructed an unbonded overlay using FHWA's generic posttensioned PCP system during 2009 along a section of US 92 westbound. This project was funded by FHWA's Highways for LIFE program. During 2018, Florida DOT rehabilitated the east-side bridge approach slab along westbound I-10 near Quincy, Florida, using structurally reinforced precast panels. The project construction was supported by a Lead Adopter Award, under the SHRP2 IAP.

## Georgia

Georgia DOT used PCP to rehabilitate a 0.72-mile (1,200-m) section on SR11/SR53/SR211/Broad Street in downtown Winder during 2013. The roadway carries a large volume of heavy truck traffic. This project was funded by FHWA's Highways for LIFE program. This project used 348 bottom slot panels that were placed on grade using a thin granular bedding later.

## Hawaii

During mid-2015, Hawaii DOT used panels with hybrid top slot and ducts to rehabilitate a section of interstate H-1. The concrete pavement at this section of H-1 had exhibited settlement and had been overlaid with progressively thicker layers of asphalt. The panels were grout supported. The PCP implementation was supported by a Lead Adopter Award, under the SHRP2 IAP.

Also, during 2016, Hawaii DOT used grout supported panels with hybrid top slot and ducts and a posttensioned PCP system to rehabilitate a section of Middle Street near Honolulu International Airport. This project was funded by FHWA's Highways for LIFE program.

As a result of the success of the early PCP projects, Hawaii DOT installed over 1,200 grout supported bottom slot panels along sections of Hawaii H1 during 2018.

## Illinois

The Illinois Tollway operates and manages several hundred lane-miles of toll highways in the Chicago area. The Tollway first used the bottom slot panels for repairs along a section of I-294 in December 2007 to perform emergency repairs. The Tollway subsequently developed generic plans and specifications during 2009 for its own system for repair applications. Since then, the Tollway has used bottom slot panels typically for ramp rehabilitation and its own generic top slot panels typically for repair applications.

During 2015, the Tollway developed a precast panel system for rehabilitation of bridge approach slabs using 30-ft long by 12-ft wide (9.1-m long by 3.7-m wide) (nominally) structurally reinforced panels. This system was used for the rehabilitation of the approach slabs to the Midlothian Turnpike Bridge along I-294 in June 2015. The Tollway plans to use the precast panel approach-slab system together with PCP transition panels for rehabilitation of existing bridge approaches as well as for new bridge approaches.

Illinois DOT also has used PCP to rehabilitate concrete pavements. Illinois DOT's first PCP project in the Chicago area was a repair application constructed along a section of Route 62.

## Indiana

During 2003-2004, Indiana DOT sponsored a study at Purdue University to assess the feasibility of PCP implementation. During 2015, Indiana DOT initiated the planning for a field testing program to evaluate several PCP systems used for repair and continuous applications. Indiana DOT was awarded a User Incentive Award, under the SHRP2 IAP, to advance PCP implementation activities.

During 2018, over 1,100 bottom slot panels, placed directly over the base using a thin granular bedding layer, were used to rehabilitate two roadways in Richmond, Indiana.

## Iowa

Iowa DOT has adopted the use of PCP technology for bridge approaches. During August-September 2006, Iowa DOT installed FHWA's generic posttensioned PCP system at the approaches of a newly constructed bridge along SR-60 near Sheldon. Subsequently, Iowa DOT developed a jointed PCP system that was used in 2008 to rehabilitate the approaches at a bridge along US-63 at the interchange with Bremer County Road C-50, near the city of Denver.

## Kansas

In the fall of 2015, Kansas DOT used bottom slot panels, placed over a thin cemented-sand bedding layer, to rehabilitate two intersections and a bridge approach slab along a section of US 73 that serve through-traffic as well as traffic entering and leaving Fort Leavenworth. This project included subgrade

remediation work and new base placement. The PCP implementation was supported by a Lead Adopter Award, under the SHRP2 IAP.

### Louisiana

During 2018, the Louisiana Department of Transportation and Development (DOTD) used PCP to rehabilitate a ramp from northbound LA 169 to eastbound I-20. The PCP implementation was supported by a Lead Adopter Award, under the SHRP2 IAP. A total of 260 bottom slot panels were used. The panels were grout supported.

### Michigan

During 2003, Michigan DOT evaluated the feasibility of using PCP as a full-depth repair alternative by installing a PCP system developed by researchers at Michigan State University at several locations along I-675 and M-21. During the fall of 2013, Michigan DOT used the bottom slot panels, placed over a thin granular bedding layer, to rehabilitate several bridge underpasses along I-94.

### Minnesota

The Minnesota DOT evaluated the feasibility of precast concrete panels as a rapid renewal pavement alternative during 2006 along a section of TH-62 between I-35W and TH-55 in the southeast metropolitan Minneapolis area. Bottom slot panels, placed over a thin granular bedding layer, were used for this project.

### Missouri

The Missouri DOT evaluated the feasibility of using PCP by using FHWA's generic posttensioned PCP system to reconstruct a section of northbound I-57 near Sikeston during 2006. The width of the panels for this project included two traffic lanes as well as the inside and outside shoulders. The panels were crowned at the pavement centerline.

### Nevada

The Nevada DOT installed bottom slot panels, placed over a thin granular bedding layer, along a section of US 395 in Washoe County during 2010.

### New Jersey

During 2007-2008, the New Jersey DOT used bottom slot panels, placed over a thin granular bedding layer, for concrete pavement repairs along a section of I-295 in Burlington County. This project was originally bid as a cast-in-place full-depth patching project. It was converted to a precast panel replacement project because of concerns with construction traffic management. Since then, New Jersey DOT has used the bottom slot panels, placed over a thin granular bedding layer, for several repair projects and as a pre-overlay treatment to correct severely distressed joints and cracks in existing concrete pavements.

### New York

The production use of PCP was started in the State of New York by the New York State Thruway Authority (NYSTA). The first project was installed in 2001 at the Tappan Zee Toll Plaza along I-95 using the newly developed bottom slot panels, placed over a thin granular bedding layer. Since then, the NYSTA, New York State DOT, and New York City DOT have constructed several projects using the bottom slot panels, placed over a thin granular bedding layer, and panels with top slots, placed over a thin high-density polyurethane foam bedding layer, for repair and rehabilitation of both jointed concrete pavements and asphalt pavements.

The New York State DOT, New York City DOT and NYSTA continue to actively use PCP throughout the state. During 2015-2016, a New York City metro area project used newly developed hollow dowel bars that make it easy to attach new precast panels to previously placed panels.

### Oregon

The Oregon DOT used 10 bottom slot panels, placed over a thin granular bedding layer, to rehabilitate a section of I-5 in Multnomah County during 2011 during a weekend closure.

### Pennsylvania

The Pennsylvania DOT used the bottom slot panels, placed over a thin granular bedding layer, to rehabilitate a section of I-676 in downtown Philadelphia during 2009. In recent years, Pennsylvania DOT and the Pennsylvania Turnpike have used bottom slot panels, placed over thin granular or cemented-sand bedding layer, to repair and rehabilitate several roadways in the state.

### Rhode Island

The Rhode Island Turnpike and Bridge Authority installed bottom slot, planar and non-planar, panels, placed over a thin granular bedding layer, to rehabilitate the north and south two-lane approach pavements at Mount Hope Bridge. The panels were installed one lane at a time. A total of

fourteen panels were used at each approach. The south approach panels were placed during October 2016. The north approach panels were placed during October 2017.

### Texas

The Texas DOT's first project using FHWA's generic posttensioned PCP system was constructed along a section of I-35 frontage road near Georgetown in 2001. In 2015, the DOT developed its own jointed PCP system to rehabilitate an intersection at SH 97 and SH 72, which carries a high volume of heavily loaded trucks in Texas's "energy district," 90 miles (150 km) south of San Antonio. The PCP implementation at this project was supported by a Lead Adopter Award, under Round the SHRP2 IAP. Also, in 2015, the Texas DOT started the planning process for use of FHWA's generic posttensioned PCP system to rehabilitate a section of I-35 southbound through Austin.

During 2018, Texas DOT awarded a contract to rehabilitate an intersection in El Paso using jointed PCP. At this project, bottom slot panels will be used.

### Utah

During 2009, the Utah DOT commissioned a scan tour of several PCP projects in conjunction with attending a meeting and project showcase jointly sponsored by FHWA's Precast Pavement Task Force and FHWA's Highways for LIFE. The scan tour included 28 Utah DOT representatives, consultants, and contractors who traveled to New Jersey and Delaware during May 19-22, 2009. The PCP projects that were visited included New Jersey DOT's PCP project on Route I-280 and the Delaware DOT's posttensioned PCP project on Route 896 at Route 40.

During June 2011, Utah installed a PCP system developed by the Utah DOT on a ramp along a section of southbound I-215. Utah no longer uses this system.

Since 2009, Utah DOT has constructed several repair and rehabilitation projects using the bottom slot panels, placed over a thin granular bedding layer.

### Vermont

During 2011, the Vermont Agency of Transportation installed a bridge approach slab using PCP panels at a bridge in Chester.

### Virginia

The Virginia DOT is one of the few agencies that had investigated, prior to 2000, the use of precast panels for repair of jointed concrete pavements. During the mid-1970s, PCP was investigated as an emergency treatment for full-depth repair of concrete pavements due to blowups. During 2004, Virginia DOT evaluated the use of PCP for repairing jointed concrete pavement along a section of US 60. During 2009, Virginia DOT used the bottom slot panels, placed over a thin granular bedding layer, to rehabilitate an exit ramp from I-66 westbound to US 50WB and used a modified version of FHWA's posttensioned PCP system to rehabilitate a 4-lane section of I-66 westbound.

### West Virginia

During 2014, the West Virginia Department of Highways (DOH) used the bottom slot panels, placed over a thin granular bedding layer, for a demonstration project constructed on the I-64/I-77, Exit 97 ramp. Since then, the DOH has constructed several PCP projects using the bottom slot panels, placed over a thin granular bedding layer.

### Wisconsin

The Wisconsin DOT constructed a test section using the bottom slot panels, placed over a thin granular bedding layer, along a section of I-94 in St. Croix County during mid-2013. During mid-2014, Wisconsin DOT used 623 bottom slot panels, placed over a thin granular bedding layer, to rehabilitate a section of Beltline Highway (US 12), a primary east-west route carrying a high volume of traffic around Madison. The PCP project on the Beltline Highway was supported by a Lead Adopter Award, under the SHRP2 IAP. During 2015, the Wisconsin DOT installed approximately 200 full-depth bottom slot panels at the I-90/I-94 interchange in Madison.

## SUMMARY

PCP technology is gaining wider acceptance in the U.S., and advances have been made to reliably design and construct PCP systems to achieve acceptable levels of constructability, concrete durability, load transfer at joints, panel support, and performance.

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