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“Moving Advancements into Practice”

MAP Brief November–December 2011

Describing promising technologies that can be used now to enhance concrete paving practices

Precast Concrete Pavements

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ROAD MAP TRACK 8
Concrete Pavement Construction, Reconstruction, and Overlays

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Moving Advancements into Practice (MAP) Briefs describe innovative research and promising technologies that can be used now to enhance concrete paving practices. This MAP brief provides information relevant to Track 8 of the CP Road Map, Concrete Pavement Construction, Reconstruction, and Overlays.

The Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map) is a national research plan developed and jointly implemented by the concrete pavement stakeholder community. Publications and other support services are provided by the Operations Support Group and funded by TPF-5(185).

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Introduction

Since 2001, nearly 30 lane-miles of precast pavement have been constructed in 12 States and two Canadian provinces. Nearly triple this amount is now in service in other countries (based largely on U.S. practice). While many projects have been constructed as demonstrations of the technology, several highway agencies recognize the advantages of precast pavement and are beginning to adopt it as standard practice for certain types of projects.

Precast pavement is a long-life solution primarily used for rapid reconstruction and rehabilitation of existing pavements with short construction windows. However, it has also been used for construction of new pavements where cast-in-place concrete is not a viable option due to lack of availability of ready-mixed concrete batch plants and slipform paving equipment. Precast panels are fabricated and cured in a controlled environment (figure 1), ensuring a durable, long-lasting product. On-site cure time is not required. The top face of the panels serves as the riding surface for the finished pavement, which allows opening to traffic immediately after the panels are installed.

Primary Systems

Two precast concrete pavement systems (PCPSs) are predominantly used in the United States: precast prestressed concrete pavement (PPCP) and jointed precast pavement (JPP).

Precast Prestressed Concrete Pavement

PPCP utilizes prestressing to put the pavement slab in compression in order to reduce tensile stresses and the potential for cracking. Prestressing can be incorporated through pretensioning at the fabrication plant and through post-tensioning on site.

Prestress results in thinner precast panels when compared to a conventional cast-in-place pavement design, and longer spacing (100–250 ft +) between working joints in the pavement slab. Keyways are formed into the transverse faces of the panels to help align the panels as they are installed (figure 2).

Load transfer between individual precast panels is provided through compression of the joints between panels from post-tensioning. Post-tensioning strands are inserted into ducts

Figure 1. Precast concrete pavement panels are produced and cured in a controlled environment (steam curing [bottom] is not required but is an option for some precasters).

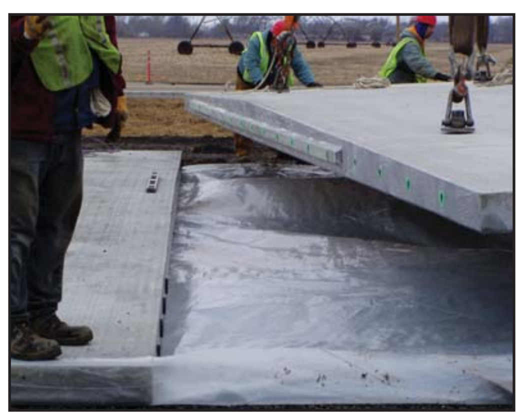

Figure 2. PPCP panels utilize keyways for alignment during installation.

cast into the precast panels and tensioned to put the entire section of precast panels (between expansion joints) in compression (figure 3).

Jointed Precast Pavement

JPP systems replicate conventional cast-in-place concrete pavement, using precast panels of similar dimensions to jointed plain concrete pavement slabs, and dowels for load transfer between panels (figure 4). However, the precast panels are heavily reinforced for handling purposes and to keep any cracks that may form during construction or over time held tightly closed. Several proprietary JPP systems are currently available and have been used extensively in the United States.

The Best of Both

A recently completed project on Interstate 680 in California (District 4, Contra Costa County) utilized both PPCP and a JPP system (figure 5).[1] In lieu of reinforcing steel, the JPP panels were prestressed using a two-way pretensioning technique developed by the precast fabricator, while still using dowels for load transfer between panels. This permitted the use of longer (36-ft) precast panels for sections of the project where JPP was specified, while also allowing the use of a thinner, more durable design. The 36-ft length was also used for panels on the PPCP portions of the I-680 project, result-

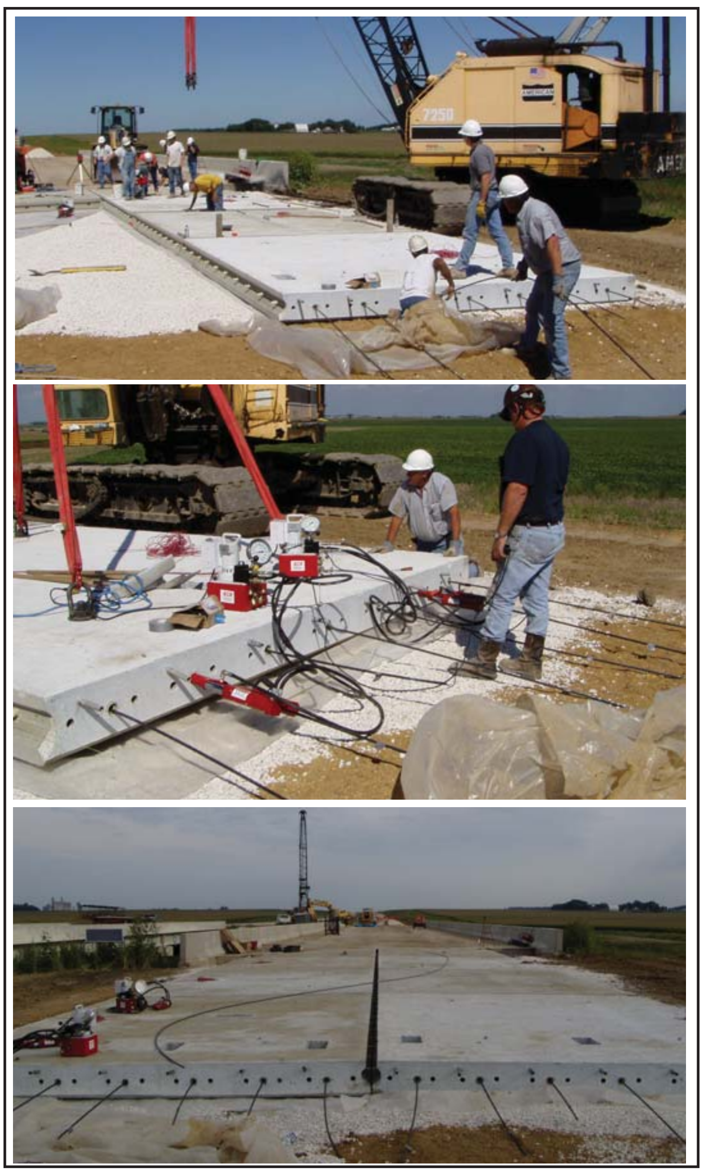

Figure 3. Post-tensioning strands are fed into ducts and though a series of precast panels (top) and are tensioned (center) to put the pavement in compression (bottom).

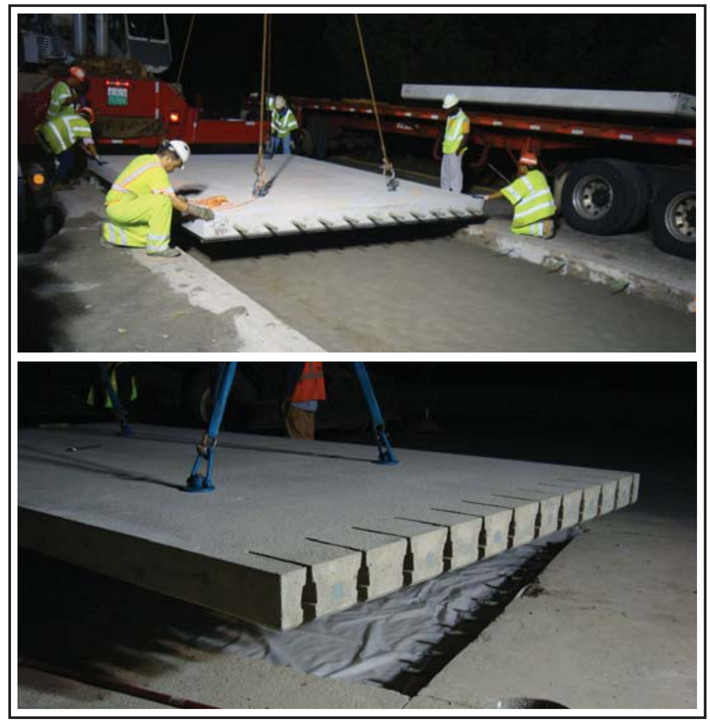

Figure 4. JPP systems use dowels (top) and slots to receive the dowels (bottom) to provide load transfer between panels.

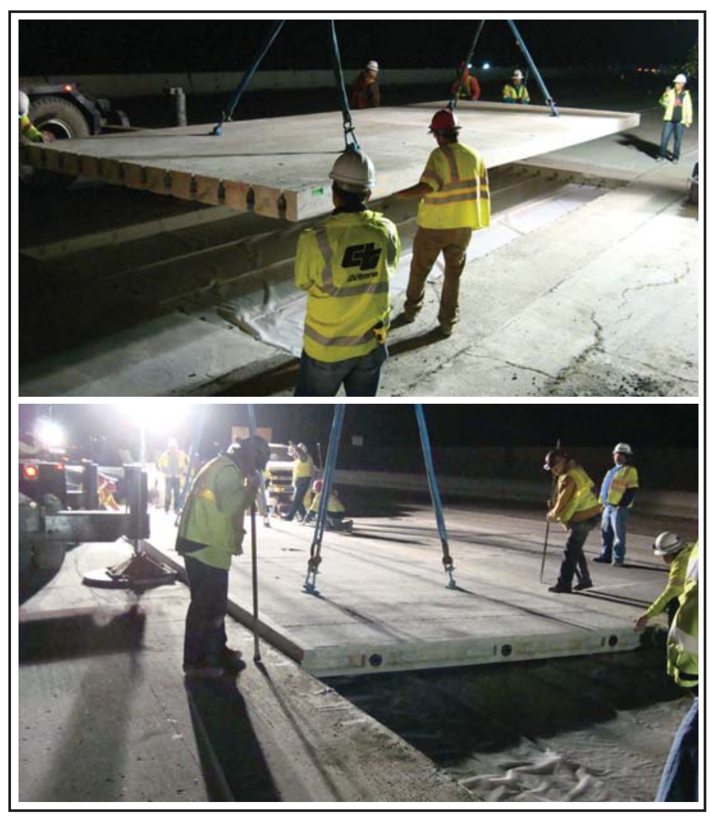

Figure 5. The Interstate 680 project utilized both JPP (top) and PPCP panels (bottom).

ing in significantly increased rates of placement compared to earlier projects using 10-ft panel lengths.

This project was an example of a State highway agency embracing precast pavement technology and the precast industry advancing the technology by working closely with the agency and contractor to develop an efficient and effective solution.

Applications

The primary application for PCPS in the United States to date has been reconstruction of existing mainline concrete pavements in urban areas. Precast pavement allows reconstruction to be completed during lane closures as short as 5-7 hours, minimizing disruption to the traveling public by limiting construction to off-peak travel times. While similar lane closures can be utilized with rapid-strength concretes, the relatively short service life of such concretes makes precast concrete a more attractive option.

Precast pavement applications are generally classified as either intermittent or continuous. Intermittent applications typically involve "spot reconstruction" of single slabs, joints, or other isolated areas. Continuous applications typically involve reconstruction of longer, continuous sections of pavement in one or more lanes. JPP systems are most commonly used for intermittent applications, while both PPCP and JPP systems can be used for continuous applications.

Other applications for PCPS include bridge approach slabs, intersections, ramps, and unbonded overlays (figure 6).

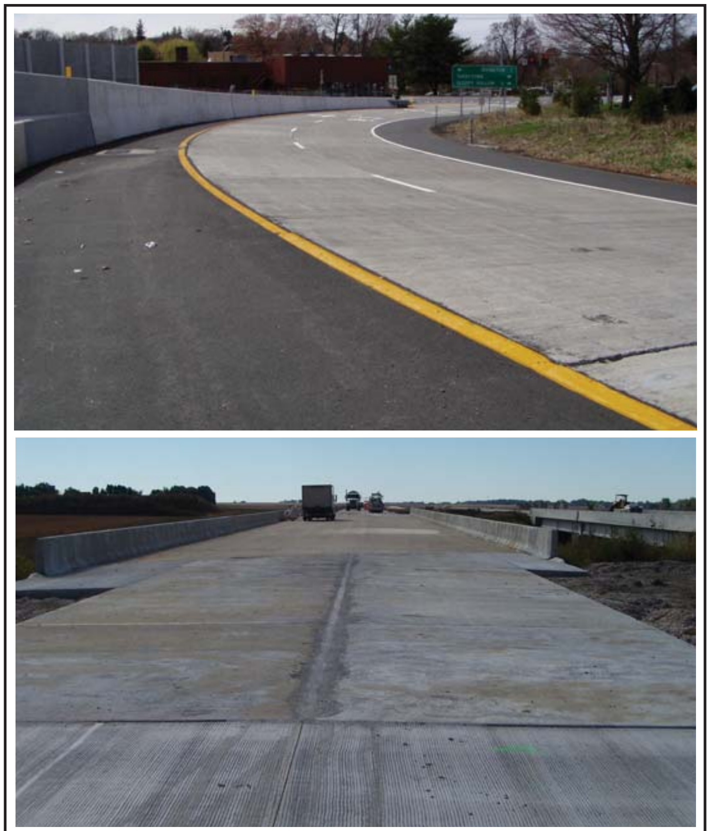

Figure 6. Precast concrete pavement applications include ramps (top) and bridge approach slabs (bottom).

Sustainability Benefits

Precast concrete is a sustainable solution for pavement reconstruction and rehabilitation. From a design standpoint, precast pavement offers an efficient solution that uses full-depth precast panels constructed over the existing subbase and subgrade whenever possible, minimizing the need for excavation and virgin materials. By incorporating prestress, the thickness of the precast pavement can be reduced, thereby saving concrete materials, and producing a longer life pavement.

With regard to fabrication, the precasting operation is very efficient, minimizing concrete waste and beneficially re-using any waste material elsewhere in the plant. Precast concrete mixture designs also commonly use supplementary cementitious materials, such as fly ash recycled from coal combustion.

Sustainability benefits as they pertain to construction are realized through the reduction in construction-related traffic congestion by limiting lane closures to off-peak travel times. And finally, because precast pavement is a long-life, low-maintenance product, the reconstruction cycle time is maximized and the environmental and user impacts of maintenance activities over the life of the pavement are minimized.[2]

Moving Advancements into Practice

At least two State highway agencies are using precast pavement technology in standard practice. The California Department of Transportation (Caltrans) is currently developing statewide standard plans and non-standard special provisions for precast concrete pavement. Following completion of two successful PPCP demonstration projects, heavy-vehicle simulator testing and a Highways-for-LIFE sponsored project utilizing a proprietary JPP system, Caltrans is currently incorporating precast pavement into numerous projects. A recent project on Interstate 680, mentioned previously, was the first example PCPS being incorporated into a large-scale pavement rehabilitation project, using nearly 5.5 lane-miles of PCPS.[1]

The New York State Department of Transportation (NYSDOT), likewise, has standardized the use of precast pavement in the state. NYSDOT has developed a standardized specification for precast pavement systems[3] and a "Materials Approved List" for PCPS that meet the criteria outlined in the specification.

Precast pavement technology has also been used extensively in other countries. In 2009, the largest PPCP project ever constructed was completed on a toll road near Cirebon, West Java, Indonesia. Based largely on the PPCP concept developed in the U.S., the project consists of 22 miles (88 lane-miles) of PPCP (figure 7).

The rationale for using PPCP stemmed from the need to improve mobility and expand the network of roads in a remote area of the country. Mobilization of large paving equipment was not practical or economically feasible. However, producing precast panels at a fabrication plant near this project

Figure 7. The precast pavement project in Indonesia utilized precast prestressed concrete pavement for 22 miles of new pavement (photos courtesy of Tommy Nantung).

helped to employ hundreds of local workers and provided a boost to the local economy. The need for a long-lasting, low-maintenance pavement was also satisfied.[4]

Ongoing Efforts

Several concurrent efforts have contributed to the advancement of precast pavement technology over the past decade.

FHWA

The Federal Highway Administration (FHWA) supports the deployment of PCPS technology through demonstration projects and cooperative efforts with the precast industry. PPCP demonstration projects have been completed in Texas, California, Missouri, Iowa, Delaware, and Virginia.[2][5] Additional projects in California and Virginia have been completed under the FHWA Highways for LIFE program, and at least two more projects are underway or planned in Florida and South Carolina.

FHWA is also working with the precast industry to produce guidance documents and to establish an online precast pavement information repository for agencies, designers, precasters, and contractors.

SHRP 2

Under the Strategic Highway Research Program 2 (SHRP 2), a Renewal focus area project on Modular Pavement Technology (Project R05) was recently completed. This project synthesized the current state-of-the practice for precast concrete pavements throughout the world, evaluated the performance of several precast pavement projects in the United States, and provided recommendations for the design and construction of precast concrete pavement based on the information gathered during the course of the project. Generic specifications were also developed and will be included with the project final report due to be released in December 2011.[6]

AASHTO

In 2005 PCPS was selected as a focus technology under the American Association of State Highway and Transportation Officials (AASHTO) Technology Implementation Group (TIG) program. The Lead States Team for this TIG was comprised of numerous U.S. and Canadian highway agency representatives with firsthand experience with PCPS, key FHWA staff members, industry partners, and representatives from academia. The TIG developed guidance and generic specifications for design, construction, and approval of PCPS.

Industry Initiatives

In an effort to promote the use of precast pavement within the precast concrete industry, the Precast/Prestressed Concrete Institute (PCI) has established a technical committee within their organization. The PCI Pavement Committee is currently developing guidance documents and technical material to further expand the body of knowledge within the plant-produced concrete industry.

For More Information

For more information, please visit:

- http://www.fhwa.dot.gov/pavement/
- http://tig.transportation.org/Pages/PrecastConcretePaving-Slabs.aspx
- http://www.precastpavement.com
- http://precastconcretepavement.com/

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2. Merritt, D.K. and S.S. Tyson. "Sustainable Pavements with Precast Prestressed Concrete." Proceedings of the 90th Transportation Research Board Annual Meeting. Washington, D.C., January 22-27, 2011.

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5. Merritt, D.K. and S.S. Tyson. "Precast Prestressed Concrete Pavement Applications in the USA." Proceedings, International Workshop on Best Practices for Concrete Pavements. Recife, Brazil. October 21-23, 2007.

6. Tayabji, S., D. Ye, and N. Buch. Modular Pavement Technology, Final Report, SHRP 2 Project R05, Transportation Research Board, Washington, DC, 2011.