

TechBrief

The Concrete Pavement Technology Program (CPTP) is an integrated, national effort to improve the long-term performance and cost-effectiveness of concrete pavements. Managed by the Federal Highway Administration through partnerships with State highway agencies, industry, and academia, CPTP's primary goals are to reduce congestion, improve safety, lower costs, improve performance, and foster innovation. The program was designed to produce user-friendly software, procedures, methods, guidelines, and other tools for use in materials selection, mixture proportioning, and the design, construction, and rehabilitation of concrete pavements.

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U.S. Department of Transportation
Federal Highway Administration

Precast Concrete Panels for Repair and Rehabilitation of Jointed Concrete Pavements

This TechBrief discusses the use of precast concrete panels to repair distressed concrete pavements. It presents a brief summary of the development of precast repair technology, the results of recent field trials of precast concrete pavement repairs, and recommendations for ensuring successful precast repair installation.

BACKGROUND

Precast pavement technology is an innovative process that can be used to meet the need for rapid repair and rehabilitation of asphalt and jointed concrete pavements. Precast pavement systems are fabricated or assembled off-site, transported to the project site, and installed on a prepared foundation (existing or regraded). The system components require little or no field curing time to achieve strength before opening to traffic. These systems are primarily used for rapid repair and rehabilitation of asphalt and portland cement concrete (PCC) pavements in high-volume-traffic roadways. The precast technology can be used for intermittent repairs or full-scale, continuous rehabilitation.

In *intermittent repair* of PCC pavement, isolated full-depth repairs at joints and cracks or full-panel replacements are conducted using precast concrete slab panels. The repairs are typically full-lane width. Key features of this application are precast panel seating and load transfer at joints.

In *continuous applications*, full-scale, project-level rehabilitation of asphalt concrete and PCC pavements is performed using a series of adjoining precast concrete panels.

Precast concrete repairs are an alternative to conventional cast-in-place, full-depth concrete repairs, especially in situations where high traffic volumes and consideration of the delay costs to users due to lane closures favor rehabilitation solutions that may expedite opening to traffic. Precast panels also offer the advantage of being “factory made” in a more controlled environment than cast-in-place repairs, and thus may potentially be more durable and less susceptible to construction and material variability.

FHWA CPTP Initiative

Recognizing the need for effective, rapid rehabilitation methods, the Federal Highway Administration, through its Concrete Pavement Technology Program, sponsored the development of precast concrete panel technology for full-depth repair of concrete pavements in a study, “Field Trials of Concrete Pavement Product and Process Technology—Precast Concrete System for Rapid Repairs,” that resulted in development of design and construction

guidelines for use of precast concrete slabs for joint repair and slab replacement on in-service roads in Michigan. This technique was also used by the Ministry of Transport, Ontario, Canada, as part of a demonstration project on use of precast concrete panels. This TechBrief provides details of the precast concrete panel system for intermittent repairs of jointed concrete pavements that was developed at Michigan State University (Buch 2007).

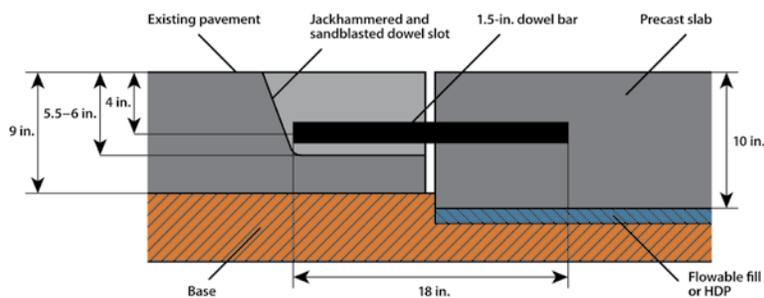
MICHIGAN FIELD STUDY

A precast concrete panel repair field study was conducted on I-675 in Zilwaukee, Michigan, and M-25 in Port Austin, Michigan. I-675 is a principal arterial with average annual daily traffic of 1,400 vehicles (5 percent trucks), and M-25 is a minor arterial with average annual daily traffic of 900 to 4,000 (3 to 11 percent trucks). At both sites the existing pavement is 225 mm (9 in.) of concrete on a dense-graded aggregate base. The existing slabs on I-675 had joints spaced at 21.6 m (71 ft), and the existing slabs on M-25 had joints spaced at 30.2 m (99 ft).

Typical Precast Panel Details

The precast concrete panels were fabricated by the contractor. The typical concrete mixture used to fabricate the panels is summarized below:

- Cement 312 kg/m³ (526 lbs/yd³)
- Water 127 kg/m³ (212 lbs/yd³)
- Fine aggregate 810 kg/m³ (1,366 lbs/yd³)
- Coarse aggregate 10,908 kg/m³ (1,838 lbs/yd³)
- Air-entraining agents 0.59 ml/kg (0.9 fl oz/cwt)



HDP=high-density polyurethane

Figure 1. Schematic cross section of dowel assembly for Michigan field study (Buch 2007). Current practice is to fabricate the precast panels 6 to 13 mm (0.25 to 0.5 in.) thinner than the existing concrete pavement.

The average 28-day compressive strength based on 18 specimens was 30 MPa (4,300 lbf/in²). All panels were 1.8 m (6 ft) long, 3.7 m (12 ft) wide, and 250 mm (10 in.) thick. The precast panels were fitted with three dowel bars 38 mm (1.5 in.) in diameter, 450 mm (18 in.) long, and spaced at 300 mm (12 in.) on center along each wheelpath. Perimeter steel was included to resist handling and transportation stresses. Steel mesh (10 mm [0.375 in.] in diameter placed at 150-mm [6-in.] intervals and held together with 6-mm [0.25-in.] ties) was placed at the panel mid depth to resist the potential of early-age cracking. The panels were wet-cured for 7 days using wet burlap covers. The 20 precast panels were fabricated and stockpiled at the ready-mix concrete supplier's yard. Eight panels were installed at the I-675 site, and 12 were installed at the M-25 site. The typical joint details are illustrated in figure 1.

The precast panel installation was accomplished with the following sequence of on-site activities.

1. Documenting distresses.
2. Identifying and marking repair boundaries.
3. Sawcutting panel boundaries and concrete removal.
4. Initial cleaning of the exposed base.
5. Sawing and jackhammering the dowel slots.
6. Air cleaning and sandblasting the dowel slots.
7. Placing the leveling fill.
8. Installing the precast panel.
9. Adjusting panel elevation to match elevation of adjacent panels.
10. Grouting the dowel slots with a high-early-strength concrete mixture or a proprietary material.
11. Sealing the joints.

Note that placing a leveling fill material (step 7) is not part of the installation process when the precast panel grade adjustment is done using high-density polyurethane (HDP) foam. In that case, after cleaning and grading of the base, the precast panel is placed, and

the HDP foam is injected (through pre-formed holes or drilled holes in the slab) as needed to bring the panel to the correct elevation. This method of leveling was used for 6 of the 8 precast panels at the I-675 site and 10 of the 12 precast panels at the M-25 site. The other 2 precast panels at each site were leveled with flowable fill. The total time required to install the panel was less than 120 minutes. The two most time-consuming activities were the preparation of the dowel slots and adjustment of the panel elevation with respect to the existing concrete pavement. The installation sequence is illustrated in figure 2.

At the I-675 site, all nine panels (eight precast and one conventional full-depth repairs) were installed in 1 day using a single traffic control operation due to the proximity of the areas being repaired. Each precast panel required about 2 hours to install. At the M-25 site, the 12 precast panels were installed over a period of 3 days. The longer total time for the repair operation at the M-25 site was due to the greater distance between the areas being repaired and some delays caused by rain.

Deflection testing after installation of the precast panels at both sites indicated acceptably high load transfer levels (greater than 70 percent in nearly every case). Two years after installation, all but one

of the precast panels at the I-675 site were in good condition; one panel exhibited premature cracking that appeared to be due to dowel misalignment. At the M-25 site, all but two of the precast panels were in acceptable to good condition; two panels exhibited premature cracking that appeared to be due to possible dowel misalignment.

Ontario Study

In November 2004, the Ministry of Transport Ontario carried out a demonstration project to evaluate the use of precast panels for repair of distressed concrete pavements. One of the techniques used was the precast panel system developed in Michigan. The demonstration was carried out during nighttime along a section of heavily travelled Highway 427 in Toronto. Three precast panels were used. The existing pavement was 230 mm (9 in.) thick, jointed plain concrete over a 150-mm (6 in.) cement-treated base. The pavement incorporated randomly spaced, skewed, transverse joints.

Two of the installed slabs sat slightly higher than the adjacent existing concrete surface. This was due to the precast panels being slightly thicker than the actual thickness of the removed pavement. Deflection testing indicated that the precast panels met the minimum load transfer effectiveness of 70 percent.



Figure 2. Precast panel fabrication and installation sequence in the Michigan field study.

EARLIER APPLICATIONS

As noted above, the use of precast, reinforced concrete panels for pavement repairs during the last decade is innovative; however, much earlier applications of precast technology for emergency repair of jointed concrete pavements have been reported.

During the 1960s in Michigan (Simonsen 1972) and Virginia (Tyson 1976), jointed reinforced concrete pavements were constructed with panel lengths of up to 30.48 m (100 ft) and 18.75 m (61.5 ft), respectively. While a number of factors contributed to early deterioration of these pavements, a principal mode of failure was transverse joint “blowups” due to large seasonal and daily joint movements, loss of joint sealing material, intruded incompressible fines, and, typically on very hot summer days following an afternoon rain shower, the sudden compressive rupture and upward thrusting of concrete at the transverse joint. In these cases, the pavement was immediately closed to traffic and required rapid emergency repair to restore it to service. Alternative full-depth repair methods included asphalt patches, very-high-early-strength concrete, and precast reinforced concrete panels.

Some distinguishing characteristics of these earlier precast reinforced concrete panel applications are that they were prefabricated and stockpiled for

use by State department of transportation forces, designed without load transfer, and intended for temporary service of up to 5 years, which they provided. Subsequently, full-scale rehabilitation or reconstruction of these 1960s pavements was accomplished.

The successful use of precast reinforced concrete panels for “temporary” pavement repairs during the 1970s in Michigan and Virginia is a testament to an innovative practice that has found renewed interest during the last decade, primarily due to limited work windows resulting from increased traffic volumes.

IMPLEMENTATION GUIDELINES

The Michigan method discussed in this techbrief is a nonproprietary process and can be used for full-depth repair as well as full-panel replacement. Based on the results of the Michigan and Ontario field trials (Buch 2007, Lane and Kazmierowski 2005) and other recent installations of precast pavement repairs, the following practices are recommended for concrete pavement repair with precast panels:

1. Panel geometry: The panel size is dictated by the area to be repaired.

- a. For full-depth repair, it is recommended that the panels be standardized as full width by 1.8 m (6 ft) long. The panels should be 13 mm (0.5 in.)

PRECAST PAVEMENT INDUSTRY INITIATIVES

Parallel to FHWA’s efforts, several organizations in the United States have initiated independent development activities to refine precast concrete pavement technologies. These technologies have certain proprietary features and require licensing for product use. Privately developed technologies include the following:

1. The Fort Miller Super Slab system. For information, contact Peter J. Smith (psmith@fmgroup.com) or Michael Quaid (mquaid@fmgroup.com).

2. The Uretek Stitch-in-Time Load Transfer System for Precast Concrete Panels. For information, contact Mike Vinton (mike.vinton@uretekusa.com).

3. The Kwik Slab system. For information, contact Malcolm Yee (info@kwikslab.com).

Since about 2001, the Fort Miller system has been used on several production projects (continuous and intermittent) for repair and rehabilitation applications. In continuous application, this system simulates conventional jointed plain concrete pavement sections. The Uretek system has also been widely used, according to the developer, for intermittent repairs. This system requires use of expansion joints if a series of adjoining panels is used. The Kwik Slab system has been used on a limited basis in Hawaii. This system simulates long jointed reinforced concrete pavement sections. In addition to the proprietary precast concrete pavement systems, generic systems have also been used and are under development.

shorter in both dimensions to allow the panel to be positioned in the repair area. When repair areas are longer, two panels may be used side by side.

b. For full-slab replacement, the precast panel should match the slab area to be replaced but be shorter by 13 mm (0.5 in.) in both dimensions. When repair areas include longer lengths, more panels may be used side by side.

2. Panel thickness: Verify the actual thickness of the concrete in the area to be repaired. The precast panels should be 6 to 13 mm (0.25 to 0.5 in.) thinner than the existing concrete pavement to account for variable thickness of the existing pavement. For economical repair, it is advantageous if all panels are of uniform thickness and dimensions.

3. Load transfer at transverse joints: A load transfer mechanism must be provided at transverse joints. Use of four dowel bars per wheelpath is recommended for heavy-truck traffic. Otherwise, three dowels per wheelpath may suffice. The following techniques may be considered:

a. Dowels embedded in the precast panel and slots provided in the existing pavement.

b. Slots provided at the surface in the precast panel, dowels inserted, and epoxy grouted in holes drilled in the existing pavement.

c. Load transfer devices retrofitted after the precast panel is installed. This can be done by coring holes 102 mm (4 in.) in diameter and inserting a load transfer device, such as the Double-Vee, in the holes.

d. Slots provided at the surface in the precast panel and matching slots cut in the existing pavement after the panel is installed. Dowel bars are then installed using the dowel bar retrofit technique.

4. Bedding material:

a. A fast-setting cementitious flowable material placed before installation of the precast panel.

b. A fast-setting polymer-based material injected under the panel after installation of the panel.

c. Grading and compacting the base to the desired grade and placing the precast panel directly over the prepared base, especially for longer length areas. The subsealing technique may be used to ensure proper seating of the panels.

5. Provide an expansion cap at one end of the dowel bar to accommodate slab movement due to environmental loading and to prevent closing of the joint, especially for multilane roadways.

6. Provide expansion material along one of the transverse joints to accommodate joint movement due to thermal expansion and contraction.

7. Keep the dowel slot width as narrow as possible to reduce construction time and reduce the potential for dowel skewing in the horizontal plane.

8. Take care to saw the repair areas perpendicular to the centerline to avoid skewing of the precast repair when it is placed.

9. Multitask during the installation process to reduce construction time, particularly when the areas to be repaired are close together.

10. Post-installation activities:

a. Grinding at the transverse joints to ensure desired ride level and to remove high spots at joints that might chip off later as a result of snow plowing operations.

b. Joint sealing, performed as soon as possible after installation, along transverse joints as well as longitudinal joints.

c. Deflection testing at joints to verify the effectiveness of the load transfer mechanism.

SUMMARY

Precast concrete pavement technology is ready for implementation. With respect to intermittent repairs, generic (Michigan method) as well as proprietary systems are available (see sidebar, page 4). Performance of the installed panels, though short in terms of time, indicates that precast pavement systems have the potential for providing rapid repairs that will be durable. The installation of precast pavements has a higher first cost. However, the rapid application that minimizes lane closures and the long-term durability may easily offset the higher initial costs.

REFERENCES

Buch, N. 2007. *Precast Concrete Panel Systems for Full-Depth Pavement Repairs: Field Trials*. (No. FHWA-HIF-07-019). Federal Highway Administration, Washington, DC.

Lane, R., and T. Kazmierowski. 2005. "Use of Innovative Pre-Cast Concrete Slab Repair Technology in Canada." *Proceedings of the 8th International Conference on Concrete Pavements*, Colorado Springs, CO, August 2005, pp. 771–789.

Simonsen, J. E. 1972. *Concrete Pavement Joint Repair With Pre-cast Slabs, Construction Report*. Research project 668F-102, Research report R-804, Michigan State Highway Commission, Lansing. February 1972.

Tyson, S. S. 1976. *Full-depth Repair of Jointed PCC Pavements Cast-in-place and Precast Procedures*. Virginia Highway and Transportation Research Council, VHTRC 76-R44, Charlottesville.

AASHTO PRECAST PAVEMENT TECHNOLOGY IMPLEMENTATION GROUP ACTIVITIES

Recognizing the increasing interest in precast concrete pavement technologies, AASHTO established a Technology Implementation Group (TIG) in 2006 to support technology transfer activities related to precast concrete pavements. The mission of this AASHTO TIG is to promote the use of precast concrete panels for paving, pavement rehabilitation, and pavement repairs to transportation agencies and owners nationwide. In June 2008, the AASHTO TIG completed work on the following documents: *Generic Specification for Precast Concrete Pavement System Approval*, *Guidance and Considerations for the Design of Precast Concrete Pavement Systems*, and *Generic Specification for Fabricating and Constructing Precast Concrete Pavement Systems*.

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