Precast Concrete Pavement for Intermittent Concrete Pavement Repair Applications

Shiraz Tayabji,¹ Neeraj Buch,² and Erwin Kohler³

ABSTRACT

Precast pavement technology is a recently improved construction method that can be used to meet the need for rapid pavement repair and construction. Precast pavement systems are fabricated or assembled off-site, transported to the project site, and installed on a prepared foundation (existing pavement or re-graded foundation). The system components require minimal field curing time to achieve strength before opening to traffic. These systems are primarily used for rapid repair, rehabilitation, and reconstruction 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 panels. The repairs are typically full-lane width. The process is similar for full-depth repairs and full-panel replacement. In continuous applications, full-scale, project-level rehabilitation (resurfacing) or reconstruction of asphalt and PCC pavements is performed using precast concrete panels.

Recognizing the need for effective, rapid rehabilitation methods, the Federal Highway Administration, through its Concrete Pavement Technology Program, and several U.S. and Canadian highway agencies have initiated programs to investigate the feasibility of using precast concrete for pavement repair and rehabilitation. Parallel to agencies’ efforts, several organizations in the United States also initiated independent development activities to refine precast concrete pavement technologies. These technologies have certain proprietary features and require licensing for product use. The Strategic Highway Research Program 2, as part of its rapid highway renewal focus area, has sponsored a study (begun in early 2008) to advance modular/precast pavement technologies to enable cost-effective rapid repair and rehabilitation of pavements in high-volume traffic areas.

This paper provides a summary of current initiatives related to precast pavement technology for intermittent repair of concrete pavements and provides a framework for advancing the technology in future years.

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INTRODUCTION

Pavement rehabilitation and reconstruction are major activities for all U.S. highway agencies, and have significant impact on agency resources and traffic disruptions because of extensive and extended lane closures. The traffic volumes on the primary highway system, especially in urban areas, have seen tremendous increases over the last 20 years, leading in many instances to an earlier-than-expected need to rehabilitate and reconstruct highway pavements. Pavement rehabilitation in urban areas is resulting in serious challenges for highway agencies because of construction-related traffic congestion and safety issues. Many agencies also continue to wrestle with the age-old problem: longer delays now and longer service life versus shorter delays now and shorter service life. In recent years, many agencies have started investigating alternative strategies for pavement rehabilitation and reconstruction that allow for faster and durable rehabilitation and reconstruction of pavements.

A promising alternative strategy is the effective use of precast concrete pavement technologies that provide for accelerated repair and rehabilitation of pavements and also result in durable, longer lasting pavements. Accelerated construction techniques can significantly minimize the impact on the driving public, as lane closures and traffic congestion are kept to a minimum. The safety of both highway users and construction workers is improved by reducing the frequency and duration of work zones.

Precast concrete pavement technologies have been looked into sporadically over the last 20 plus years. In the early years, the technology was utilized as a matter of technical curiosity, that is, to investigate whether precast concrete pavement technology was technically feasible. No serious attempts were made then to fully develop the technology as a cost-effective strategy and to implement the technology on a production basis. Now, as more mileage on the primary highway system and urban roadways are reaching maturity and the need for timely pavement repair and rehabilitation becomes acute and urgent, highway agencies are looking at innovative technologies, including precast concrete pavement technologies, that will result in shorter lane closures and long-life pavements that are economical over the life cycle and do not require major interventions for repair or rehabilitation during their service life. Over the last 10 years, significant developments have resulted in precast concrete pavement technologies, and the use of these technologies is becoming technically feasible and economically justifiable.

BACKGROUND

Developments related to prefabricated pavement technology have focused primarily on the use of precast concrete panels. This section presents a brief overview of the historical development of precast concrete pavement technologies for intermittent repair of jointed concrete pavements. In intermittent repair of PCC pavement, isolated full-depth repairs at joints and cracks or full-panel replacements are accomplished using precast concrete panels. The repairs are typically full-lane width. Key features of this application are precast panel seating and load transfer at joints. 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.
Pre-1995 State of Practice

One of the earliest reported uses of precast concrete pavement technology in the United States was during 1960 in South Dakota where a precast pavement was constructed over a granular bedding layer. Since then, several minor efforts were made to investigate the use of precast pavements, primarily as rapid repair alternatives. 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. A principal mode of failure for these pavements was transverse joint “blowups” due to large seasonal and daily joint movements, loss of joint sealing material, and intruded incompressible fines. 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 (DOT) forces, designed without load transfer, and intended for temporary service of up to 5 years, which they provided. 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.

No further efforts were made in the United States before about 1995 to seriously investigate use of precast concrete panels for repair of concrete pavements or for rehabilitation of concrete as well as asphalt pavements. Since about 1995, there has been significant interest in the United States to investigate the effective application of precast concrete pavements as a strategy for accelerated repair, rehabilitation, and reconstruction of pavements.

FHWA/CPTP Initiative

Recognizing the need to develop effective solutions for rapid rehabilitation of the Nation’s highway system, the Federal Highway Administration (FHWA) and the Michigan Department of Transportation (MDOT), as part of the FHWA’s Concrete Pavement Technology Program (CPTP), sponsored a study during the late 1990s that investigated the feasibility of using precast concrete panels for full-depth repair of concrete pavements. This work was conducted at the Michigan State University and has resulted in several field trials of this technology (Buch et al. 2006).

Industry Initiatives

Parallel to the FHWA-sponsored efforts, several organizations in the United States also initiated development activities to refine precast concrete pavement technologies, primarily for repair applications. These technologies have certain proprietary features to the products and as such require licensing for use of the technologies. One of them, the Fort Miller Super-Slab® 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.
Highway Agency Initiatives

In the last few years, several agencies have developed specifications that allow use of precast concrete pavement systems for repair applications. Also, several agencies have installed test sections to demonstrate the feasibility of using the precast concrete pavement systems. In addition, the Illinois Tollway has established a task force to develop a generic precast concrete pavement system for intermittent repair applications.

AASHTO Technology Implementation Group Activities

Recognizing the increasing interest in precast concrete pavement technologies by US highway agencies, and to provide an effective platform for technology transfer activities, the American Association of State Highway and Transportation Officials (AASHTO) established a Technology Implementation Group (TIG) during 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 and to present an unbiased representation to the transportation community on the technical and economic aspects of the current precast paving systems utilized in the marketplace. In June 2008, the AASHTO TIG completed work on the following documents:


Strategic Highway Research Program 2 Project R05: Modular Pavement Technology

The objective of Strategic Highway Research Program (SHRP) 2 activities is to achieve highway renewal that is performed rapidly, causes minimum traffic disruption, and produces long-lived facilities. A related objective is to achieve such renewal not just on isolated, high-profile projects, but consistently throughout the Nation’s highway system.

The focus of Project R05 is to develop tools that public agencies can use for the design, construction, installation, maintenance, and evaluation of modular pavement systems. By necessity, the primary focus of this study will be precast concrete pavements. Project funding was established at $1 million. Phase I of the study includes a review of modular pavement systems, review of highway agency and industry experience, and identification of successful strategies, promising technologies, and future needs related to modular pavement systems.

WHY PRECAST CONCRETE PAVEMENT TECHNOLOGIES?

The primary use of precast concrete pavement technologies is to achieve construction time savings in high-traffic-volume highway applications and for rapid repair/rehabilitation applications at airfield pavements. Without the benefit of time saving, use of precast concrete pavement technologies cannot be justified economically, at least at current pricing for these systems. Use of precast concrete pavement technologies must result in reduced lane closures or better managed lane closures that in turn result in less traffic disruptions and improved safety at
construction zones. In addition, precast concrete pavement systems must be capable of providing low-maintenance service life of the desired duration.

The following factors need to be considered when assessing the use of precast concrete pavement as a viable candidate for rapid repair of concrete pavements:

1. Fabricating the precast concrete panels at a nearby plant. Plant location is critical for economical production repairs, to reduce cost and to reduce traffic disruptions.

2. Transporting precast concrete panels to the site (traffic issues, especially for night-time operations).

3. Site access for heavy cranes.


5. Rapid preparation of the base/subbase.

6. Installing precast concrete panel on finished base/foundation

7. Matching adjacent pavement surface grade as closely as possible.

8. Interconnecting precast concrete panels and existing pavement using a mechanical load-transfer system, typically a version of the dowel bar retrofit technique.

9. Grouting the dowel/tie-bar slots, as applicable.

10. Injecting bedding grout to firmly seat panels, as applicable.

Intermittent repairs, such as full-depth repairs and slab panel replacement, are typically performed at night with a work window from about 8:00 p.m. until about 5:00 a.m. the next morning. Typically, 10 to 15 panel placements are targeted during each work window. The tight work windows and the need to open the facility to traffic by about 6:00 a.m. in the morning make it necessary that the contractor have sufficient equipment and manpower to complete the planned work each night.

**PRECAST SYSTEMS FOR INTERMITTENT REPAIR OF CONCRETE PAVEMENTS**

Two types of intermittent repairs are possible using precast pavement systems:

1. Full-depth repairs—to repair deteriorated joints, corner cracking or cracking adjacent to the joint.

2. Full-panel replacement—to replace cracked or shattered slab panels.

The repairs are typically full-lane width. The process is similar for full-depth repairs and full-panel replacement, except for the length of the repair area. Key features of this application are:

1. Slab panel seating.

2. Load transfer at joints.
Fort Miller Super-Slab System

The Super-Slab system is a proprietary precast concrete pavement technology suitable for both intermittent and continuous paving operations. This paving system is an assemblage of precast slabs placed on a precision-graded fine bedding material (maximum aggregate size of 12 mm [0.5 in.]). The transverse joints in the assembly of precast panels are fitted with standard dowel bars to provide load transfer. The basic features of the Super-Slab system are as follows:

1. Produce base within 1.2 mm (0.06 in.), using laser controlled grading equipment.
2. Place slab panels. Subseal with grout to eliminate voids.
3. Provide slab-to-slab interlock at joints through dowel/slot system.
4. Provide surface with 6 mm (0.25 in.) diamond grinding if better tolerance desired.
5. Thickness as specified (similar to jointed concrete pavement).
6. High-performance concrete, 27.6 MPa (4,000 lbf/in^2) (or as required).

Figure 1 illustrates the typical slab panels used and the joint load-transfer system. This particular precast concrete pavement technology lends itself to the construction and rehabilitation of freeway entry and exit ramps because the manufacturer can produce panels with varying cross-slopes (warped slabs). This system has the most production paving experience to date. The system has been field-tested by New York State DOT, the Minnesota DOT, the Ministry of Transportation in Ontario, Canada, and others. Caltrans conducted accelerated load testing of the system in 2006.

Figure 1. The Super-Slab System.

Uretek-Based System

In 1997, Uretek USA, Inc., introduced a new process for fixing faulted joints and restoring load transfer to concrete pavements. Uretek has developed two patented technologies. The first is the Uretek® Method, which is the process that employs high-density polyurethane foam to lift, realign, underseal, and void-fill concrete slabs that are resting directly on base soils. The
second is the Stitch-In-Time® Process, which is a repair system for restoring load transfer to jointed concrete pavements that are cracked, spalled, or otherwise damaged. Pavements undergoing repair are first undersealed using the Uretek Method, and then the Stitch-In-Time Process is applied to restore load transfer.

The Uretek-based system has been applied to installation of precast panels. The basic features of the Uretek-based precast concrete pavement system are as follows:

1. The panels are brought to the site on a flatbed truck and lowered into the excavated repair site.
2. The panels are elevated to the proper grade by injecting polyurethane foam under the panels.
3. The panels are stitched to the existing slab or to another panel using fiberglass boards, as illustrated in Figure 2.

![Figure 2. Uretek fiberglass stitches.](image)

For the longer length application of the Uretek system, expansion joints need to be placed at intervals of 14 to 18 m (45 to 60 ft); otherwise, premature slab cracking can develop.

**FHWA CPTP System**

The FHWA CPTP technology is a doweled, full-depth system suitable for isolated or intermittent repair of highway pavements (Buch 2007). This is a nonproprietary precast concrete pavement technology. The repair panels are typically 1.8 m (6 ft) long and 3.7 m (12 ft) wide and fitted with three or four dowel bars in each wheelpath. The dowels are placed at 305 mm (12 in.) on center, and their diameter depends on the slab thickness. Typical design and installation details are illustrated in Figure 3. The dowel slots are cut in the adjoining existing pavement. This precast concrete pavement technology was developed in a partnership between Michigan State University and the Michigan DOT. This technology can be utilized to repair both jointed and continuously reinforced concrete pavements.

In the several demonstration/test projects constructed in Michigan (I-94 BL, I-196, M-25 and I-675), Virginia, and the Province of Ontario, the typical distresses exhibited by the candidate panels scheduled for repair included medium- to high-severity transverse cracking with associated spalling and faulted joints and cracks. The advantages of this technology include the
following: (i) the transportation to and storage of multiple panels at a jobsite or at the agency’s maintenance yard does not present a problem; (ii) the panels can be mass produced at the precast plant or at the ready mix supplier’s yard (the latter was demonstrated in Michigan); (iii) based on the geometry and proximity of repair sites, 8 to 10 panels can be installed in a day and be ready for traffic shortly thereafter; (iv) a typical agency paving mixture design can be used for the construction of the panels if appropriate moist curing is applied; and (v) the presence of dowel bars across the transverse joints ensures adequate load-transfer efficiency.

Figure 3. The full-depth precast repair system (Michigan installation).

FIELD APPLICATIONS

Since about 2000, many highway agencies in North America have expressed interest in the use of precast concrete for intermittent repair or continuous applications in heavily trafficked urban areas where extended lanes closures are difficult. The U.S. and Canadian highway agencies that have accepted the use of precast pavement for production work include the following:

1. Caltrans
2. Illinois Tollway Authority
3. Iowa DOT
4. Ministry of Transportation, Ontario
5. Ministry of Transportation, Quebec
6. New Jersey DOT
7. New Jersey Turnpike
8. New York State DOT
9. New York State Thruway Authority

U.S. agencies that have investigated or are investigating the use of precast pavement include the following:

1. Colorado DOT
2. Delaware DOT
3. Florida DOT
4. Hawaiian Agencies
5. Indiana DOT
6. Michigan DOT
7. Minnesota DOT
8. Missouri DOT
9. Texas DOT
10. Virginia DOT
11. Airport Authorities
   a. Port Authority of New York and New Jersey
   b. Metropolitan Washington Airport Authority
12. U.S. Air Force

In addition to the North American initiatives, The Netherlands, France, Russia (previously Soviet Union), and Japan are actively investigating or using modular pavement technologies.

**Illinois Tollway Experience**

The Illinois State Tollway Authority has used the Super-Slab system of precast panels for repair and rehabilitation of jointed concrete pavements.

**Emergency Repairs on I-294**

During December 2007, 17 Super-Slab precast panels were installed in an interior lane of the southbound direction of a section of I-294. All panels but one were 3.8 m (12 ft 5.5 in.) long by 3.6 m (11 ft 10.5 in.) wide. The panel thickness was 305 mm (12 in.). The work window was 8-hour, weekday nights. A practical problem encountered was the need for a low-rise crane due to the adjacent overpass. A heavier crane was needed to place the slabs, which required a weight permit. The emergency repairs were caused by problems with rapidly deteriorating pavement under winter conditions between lanes that had been rehabilitated.

**I-88 Ramps**

Approximately 37 Super-Slab panels were installed during June 2008 along an exit ramp and an acceleration ramp on I-88 in the Chicago area. The exit ramp, shown in Figure 4, made use of warped plane slabs that were placed during a weekend traffic closure. The panel thickness was 330 mm (13 in.). The acceleration ramp used nonwarped slabs (single plane), 305 mm (12 in.) thick. These panels, shown in Figure 5, were placed during several 8-hour, weekday, night closures.

![Figure 4. View of the exit ramp with the precast panels.](image-url)
Future Projects

The Illinois Tollway Authority plans to use precast panels for repair and rehabilitation of deteriorated pavement areas. During 2008, the Tollway Authority began working with the local paving and precast industries to develop competitive options for use of precast panels. As of March 2009, a technical task force had developed a generic precast panel repair system that can be used on the Illinois Tollway for concrete pavement repair and rehabilitation.

New Jersey Experience

During 2007–2008, New Jersey DOT (NJDOT) used precast pavement for repairs along a section of I-295 in Burlington County. This first 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. A total of 5,760 m² (62,000 ft²) of precast panels were installed using the Fort Miller Super-Slab system. The project details are summarized below:

1. Three lanes in each direction.
2. Annual average daily traffic (AADT)—100,000.
3. Existing pavement:
   a. 50+ years long jointed reinforced concrete pavement with panels 258 m (82 ft 2 in.) long and 19 mm (0.75 in.) expansion joints (by design) and multiple cracks per slab panel.
   b. Slab thickness—229 mm (9 in.) over a 305-mm (12-in.) granular base.
   c. Many expansion joints and cracks severely deteriorated, requiring repair or replacement of a large number of panels.
   d. Repair areas located in all three lanes in each direction.
4. Repair panels—2.4, 3.1, 3.6, or 4.2 m (8, 10, 12, or 14 ft) long, full-lane width, 229 mm (9 in.) thick.
5. Load transfer at joints—Four dowels per wheelpath.
6. Nighttime placement—8:00 p.m. to 6:00 a.m.; work window about 8 hours.
7. Placement rate—8 to 16 panels replaced per night on average.
8. Process:
   a. In advance—sawcut repair boundaries.
   b. Night of repair—remove damaged panel; prepare base; drill dowel bar holes in existing adjacent panels; insert dowel bars; install precast panel.
   c. Next night—patch dowel slots; underseal panel.

The precast panel installation steps are shown in Figure 6. During June 2008, a blowup occurred at one of the installed panel locations. The blowup was attributed to the elimination of the expansion joints in the repaired areas.

Figure 6. I-295 precast panel installation.
NJDOT has awarded two additional rehabilitation projects requiring use of precast panels:

1. Route 21, Essex and Passaic counties (under construction during 2008):
   a. AADT—70,000.
   b. Precast panel quantity—4,088 m$^2$ (44,000 ft$^2$).

2. Route I-280, Essex County:
   b. AADT—120,000.
   c. Precast panel quantity—3,252 m$^2$ (35,000 ft$^2$).

New York State Experience

The New York State DOT (NYSDOT) and the New York State Thruway Authority (NYSTA) were two of the first agencies to implement the precast pavement technology for repair and rehabilitation of jointed concrete pavements. The first major project was installed by NYSTA during 2001 at the Tappan Zee Toll Plaza along I-95 using the Super-Slab system. Since then, several projects have been constructed using the Super-Slab System for repair and rehabilitation of jointed concrete pavements throughout the State of New York:

1. Belt Parkway, Queens
2. Rt 112, Long Island
3. Fordham Road, Bronx
4. X-Town, Schenectady
5. I-90, Albany
6. Korean Veteran Parkway, Staten Island
7. Route 9A, Manhattan
8. I-95, New Rochelle

All of the New York State projects have had the following in common:

1. High traffic counts:
   a. Tappan Zee Toll plaza—135,000 vehicles per day (vpd).
   b. I-90, Albany—105,000 vpd.

2. Short work windows (less than 8 hours).


4. Night work (typically from 10:00 p.m. to 6:00 a.m.).

5. Use of the Fort Miller Super-Slab system.

The Tappan Zee Tollway Plaza project details are summarized below:

1. Produce base within 1.6 mm (0.06 in.) using laser-controlled grading equipment.

2. Place slab panels directly on grade and subseal with grout.

3. Provide slab-to-slab interlock at joints using a dowel/slot system.

4. Top surface within 6 mm (0.25 in.) tolerance; to be diamond-ground if not in compliance.
5. Load-transfer devices—31.75-mm (1.25-in.) transverse dowels; 19-mm (0.75-in.) longitudinal tie bars.

6. Astro-turf drag finish.

7. High-performance concrete—27.6 MPa (4,000 lbf/in²).

8. Production rate—average 20 panels installed per 8-hour shift (279 m² [3,000 ft²] with panels 2.1 m and 3 m [7 ft and 10 ft] wide and 5.5 m [18 ft] long).

9. Work area used two to three lanes at a time, with traffic using all other plaza lanes.

10. Open by 6:00 a.m. every day.

The precast panel installation under traffic is shown in Figure 7.

Figure 7. Precast panel installation at the Tappan Zee Toll Plaza.

The NYSDOT expects the precast pavement to perform equivalent to a cast-in-place concrete pavement. After some early failures along the Route 9A project in Manhattan, NYSDOT, during 2005, developed the following documents to ensure a quality product and minimize field installation problems:

1. Precast Pavement Design Guidelines:
   a. Candidate project selection criteria.

2. Precast Pavement Material specifications:
   a. Fabrication Standard Drawings.
   b. Fabrication Working Drawings for projects.
   c. Manufacturer’s Installation Instructions:
      i. Subbase preparation.
      ii. Slab panel installation.
      iii. Leveling of slab panels.
      iv. Backfilling grout—use and strength gain.
   d. Trial installation (test section).
3. Precast Pavement Construction Specifications:
   a. Joint layout plan by contractor.
   b. Slab panel installation process.
   c. Surface tolerances.
   d. Opening to traffic requirements.

NYSDOT and NYSTA continue to consider use of precast pavement on production projects and have ongoing projects (during 2008 and 2009). In addition, the Port Authority of New York and New Jersey (PANY/NJ) has also investigated the use of precast concrete pavement for roadway applications. During July 2003, the Super-Slab system was used by PANY/NJ to replace the approach slabs to the Lincoln Tunnel.

SUMMARY OF GAPS IN TECHNOLOGY AND PRACTICE

While much progress has been made in the last few decades to improve precast concrete pavement technologies, many challenges remain. Some of the technical and institutional challenges are listed in Table 1.

The U.S. Congress established the second Strategic Highway Research Program (SHRP 2) in 2006 to investigate the underlying causes of highway crashes and congestion in a short-term program of focused research. As part of this program, a highway renewal research plan has been developed. The Renewal focus area emphasizes the need to complete highway pavement projects quickly, with minimal disruption to the users and local communities, and to produce pavements that are long-lasting. The goals of this focus area include applying new methods and materials for preserving, rehabilitating, and reconstructing roadways. The effective use of precast concrete pavement technologies for rapid repair, rehabilitation, and reconstruction of pavements addresses this goal.

The objective of the ongoing SHRP2 R05 project is to develop tools for use by highway agencies to design, construct, install, maintain, and evaluate precast concrete and modular pavement systems. These tools are to include the following:

1. Guidance on the potential uses of precast concrete pavement systems for specific rapid renewal applications.
2. Generic design criteria for precast concrete pavement systems.
3. Project selection criteria for precast concrete pavement systems.
5. A long-term evaluation plan to assess the performance of precast concrete pavement systems and to refine these systems.
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The primary warrants for use or promotion of precast concrete pavement technologies are rapid application and long-term durability. If the application is not rapid, it will not be relevant if it is not cost-competitive. If the application is rapid, but not durable, it will not have any future. As such, it is important that structural design features and precast concrete pavement material properties are optimized and integrated to assure rapid applications as well as long-life. For repair applications, the service life may be a few years to 20-plus years, depending on the projected rehabilitations needs of the pavement undergoing repair; but the other requirements are still applicable.

Although several types of precast concrete pavement systems have been successfully demonstrated and are considered proven systems, further research is needed in several key areas to ensure good long-term pavement performance, to improve constructability, and to make the systems cost-competitive.

IMPLEMENTATION GUIDELINES

Based on the results of the Michigan and Ontario field trials (Buch et al. 2006; 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.) 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 precasting and management of panel inventory, 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 and 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. A 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 snowplowing 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 has seen significant improvements in the last decade. Several precast concrete pavement systems have been developed and are being implemented on production projects. While current precast pavement projects have been in service for only a few years, the field 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. In addition, limited accelerated load testing to date indicates that precast systems are viable alternatives for rapid repair and rehabilitation of existing pavements.

The installation of precast pavements may have a higher first cost compared to traditional cast-in-place full-depth/full slab repair methods. However, the rapid application that minimizes lane closures and the long-term durability may easily offset the higher initial costs. The next few
years should see further improvements in the precast pavement technologies as the products from the SHRP 2 research program become available.

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