# Evaluation of Concrete Pavement Repair Using Precast Technology in Virginia

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## ABSTRACT

The Virginia Transportation Research Council has recently evaluated the use of precast concrete patches for repairing jointed concrete pavement in Virginia. Six patches were placed: three had dowels cast into them during fabrication, and three had dowels inserted in place (dowel bar retrofit). Fabrication and placement were documented. The load transfer efficiency at the joints and the ride quality were determined approximately 2 weeks after construction.

After 1.5 years, the general condition of the patches was determined by a visual survey for cracks and spalls. In general, there were no distresses on the replaced slabs except for a few hairline cracks; however, there were failures in the joint area, mainly because of dowels, that were attributed to poor construction practices.

The Virginia Department of Transportation has planned another demonstration project in cooperation with the Federal Highway Administration's Highways for LIFE program for precast prestressed concrete pavement rehabilitation. This new project will include precast, precast prestressed, and cast-in-place slabs.

This paper summarizes the past work, the difficulties experienced, and the improvements that will be incorporated in the new project.


## INTRODUCTION

Concrete is a durable paving material that resists heavy and repeated loads, effectively providing long-lasting performance. However, deterioration occurs toward the end of the service life or prematurely because of base failure or variability in material and construction quality. When an area of concrete pavement is in need of repair because of extensive cracking, faulting, or spalling, the deteriorated concrete section is replaced with a concrete patch. If cast-in-place patches are used, the distressed concrete must be removed and the patch placed and cured before the repaired section can be opened to traffic.

In order to construct patches during the limited lane closures allowed, high early strength concretes are used. The durability of the patches can be compromised to meet high early strength requirements (*1*). The high cement content in high early strength concrete patches increases the chance of cracking because of thermal effects and shrinkage. The use of precast slabs as patches is an alternative to the use of cast-in-place patches. They can provide a higher quality

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product when strict time constraints are required. In some applications, they may also be more economical through the use of less cementitious products and possibly be placed faster than cast-in-place patches.

Because precast slabs are cast off-site, lane closure times could be reduced and a quality product achieved because of the controlled production environment. The reduced lane closure time was demonstrated in Michigan (*1*). The study showed that one slab could be placed in approximately 3 hours, from the time the deteriorated concrete is removed to the time the joints are sealed and the lane is opened to traffic. However, cast-in-place patches require additional time for setting and strength development before the lane can be opened to traffic. Thus, precast concrete patches may save time and money through a more durable patch material and accelerated construction. However, in full-depth precast patching, the selection of the bedding material is important because the material should enable proper leveling of the precast patch and provide sufficient support and drainage. In addition, the transfer of wheel loads between the slabs and the existing concrete must be done through properly used dowel bars or shear keys. The use of a durable grout for dowel bar and proper construction techniques are essential to ensure adequate performance of these joints.

Concrete slabs crack under tensile stresses. If the concrete is subjected to compressive loads through prestressing, higher tensile stresses would be needed to cause cracking. This would provide improved performance of the slabs under vehicle loads or environmental stresses. Therefore, prestressing should be considered when longevity is desired. Prestressed concrete slabs have been successfully used in several demonstration projects in the United State. The slabs can be pretensioned in the transverse direction and post-tensioned in the longitudinal direction to extend the service life. Prestressing the slabs enables increased durability, reduced slab thickness, and efficient load transfer. It also reduces the chances of cracking in the transverse and longitudinal directions.

Construction congestion and work zone safety have become national concerns. Work zones create unsafe conditions and are inconvenient to the traveling public. Therefore, reduction in needed maintenance through long-lasting pavements and rapid rehabilitation techniques are highly desired by highway agencies. The use of precast slabs in paving applications provides a rapid solution to rehabilitation with a quality product, and prestressing has the potential to extend the service life further. Both prestressed and regular precast slabs can also be used in large-scale pavement rehabilitation or in new construction.

## BACKGROUND

Cast-in-place patches are widely used by the Virginia Department of Transportation (VDOT) to improve rideability and protect the integrity of the distressed concrete pavement section. Precast slabs can provide a similar solution. In 2004, precast slabs were tried in an experimental project to repair distressed sections of a pavement (*2*). The precast slabs (patches) were 12 ft (3.7 m) wide (lane width) and 6 ft (1.8 m) long. A flowable fill material was use as the bedding material to ensure proper support. Six patches were placed; three had dowels cast into them during fabrication, and the other three had dowels inserted in place (as dowel bar retrofit) after placement of the patch. Several proprietary precast pavement systems are used by the industry with reportedly good success.

Three methods of installing precast concrete slabs were tried to repair damaged concrete pavements in Canada: (i) the Michigan, (ii) the Fort Miller Intermittent, and (iii) the Fort Miller Continuous methods (*3*). Fort Miller methods are proprietary system where as the Michigan method has originated from Michigan State University and Michigan Department of Transportation. In the Michigan method, three dowels are cast into the precast slab at each wheelpath. Dowel slots are cut into the existing pavement to accommodate the dowels. A cementitious flowable fill material is placed on the existing base prior to setting the precast slab. The slab is set on flowable fill material, and the exposed dowels are grouted in their slots to connect the precast slab to the adjacent pavement. In the Fort Miller Intermittent method, blockouts are cast into the precast slab to accommodate the dowels. Crusher screenings are placed on the existing base, precision-graded, and compacted. The dowel bars are grouted through ports in the precast slab to connect the precast slabs to the adjacent pavement. Bedding grout is then pumped, also through ports in the precast slab, to ensure that there are no voids beneath the slab. In the Fort Miller Continuous method, dowels and blockouts are cast alternately into a set of precast slabs that fit together and provide continuity. Crusher screenings are placed on the existing base, precision-graded, and compacted prior to setting the precast slabs. The first and last slabs are dowelled into the existing pavement at each end of the excavation, and intermediate slabs are connected to each other. All slabs in the continuous repair are tied into the adjacent lane with drilled and epoxied tie bars. Once the slabs have been set, the dowels and tie bars are grouted through ports in the precast slabs. Bedding grout is also pumped to ensure there are no voids beneath the slabs. The Ministry of Transportation Ontario (MTO) assessed all three methods as reasonable and met the load transfer efficiency (LTE) requirements of 70 percent as measured by falling-weight deflectometer (FWD). MTO recommended the use of dowel all the way across the joint rather than just in the wheelpaths.

Since about 2001, the Fort Miller system (Super-Slab®) has been used on several production projects (continuous and intermittent) for repair and rehabilitation applications. In continuous applications, the system simulates conventional jointed plain concrete pavement sections. Other proprietary systems are also used in such repairs (*4*).The Uretek® system has also been widely used, according to the developer, for intermittent repairs. This system requires the 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.

VDOT has recently planned another demonstration project in cooperation with the Federal Highway Administration's (FHWA's) Highways for LIFE program for precast prestressed concrete pavement rehabilitation. This new project will include precast, precast prestressed, and cast-in-place slabs for a relative comparison. The investigation is consistent with the national interest in rapid construction with minimal disruption and longevity as echoed in the phrase "Get in, get out, and stay out!"

A study for determining the feasibility of using precast prestressed concrete pavement to provide improved durability and rapid construction was completed in 2000 by the Center for Transportation Research (CTR) at the University of Texas at Austin (*5*). This study was followed by an FHWA-funded implementation study conducted by CTR, which resulted in the construction of a 2,300-ft (701.0 m) precast prestressed concrete pavement pilot project near Georgetown, Texas, in spring 2002 (*6*). A total of 339 panels were used. Each panel was 10 ft (3.0 m) long, but some were full width (36 ft [11.0 m]) and others were partial width. Panels were post-tensioned in 250-ft (76.2-m) sections. Each 250-ft (76.2-m) section took about 6 hours to place on a 2-in. (51-mm) hot-mix asphalt (HMA) leveling course covered with polyethylene sheeting for friction reduction. These slabs achieved acceptable ride quality, and diamond grinding was not needed. The second FHWA-funded demonstration project was conducted in California (*7*). A total of 31 panels were placed for a roadway 248 ft- (75.6 m) long. The length of the slabs was 8 ft (2.4 m) to facilitate transportation. Slabs were set on a lean concrete base and then covered with polyethylene sheeting to reduce friction. Placement of the 124-ft (37.8-m) posttensioned section took about 3 hours. The surface was then diamond ground for smoothness.

## PURPOSE AND SCOPE

This paper summarizes the repair of distressed concrete pavement using precast slabs without prestressing on Route 60 in Virginia. It presents the difficulties encountered and lessons learned by VDOT. It also describes a new demonstration project where precast patches will be placed with the focus on improving the weaknesses noticed in the previous study. It includes precast patches with and without prestressing and cast-in-place patches. This project will enable a comparison of different rehabilitation systems and will provide options for the contractor and owner.

## PRECAST PATCH PROJECT ON ROUTE 60

### Description of Activities

The project was located on US-60 eastbound about 0.5 mi (0.8 km) east of the New Kent and James City county line in Virginia. A total of six precast slabs were installed to evaluate the feasibility of such technology in concrete pavement rehabilitation. Fabrication and placement of precast patching slabs were documented. The patches were initially evaluated approximately after 2 weeks of construction for ride quality and load transfer efficiency (LTE) using nondestructive testing (NDT) methods: high speed profiler and FWD. After 1.5 years, the general condition of the patches was determined by a visual survey for cracks, spalls and joint condition.

The study included precast concrete patch installations with two types of jointing, three slabs each. In one type of jointing, patches were fabricated with dowel bars in-place at transverse joints, the existing pavement was sawcut (slotted) to receive the dowels, and the dowels were grouted into the existing pavement after installation of the patch. In the other type, dowels were retrofit after patch installation by cutting slots in the patch and existing pavement together. Three dowels were placed in each of the right and left wheelpaths on both transverse joints of the patch.

The existing pavement consisted of jointed reinforced concrete pavement, 9 in. (229 mm) thick, with a joint spacing of 30 ft. The concrete pavement reportedly was supported by 6 in. (152 mm) of soil cement. The pavement was initially constructed in 1948 using a six-bag concrete mix (564 lb of cement per $yd^3$ [334 kg per $m^3$] of concrete).

### Fabrication and Installation

The patches were fabricated off-site at the contractor's shop. Dowels were cast in three of the patch slabs. During removal of the distressed concrete, the existing concrete was cut (slotted) to receive these pre-placed dowels. In the other three slabs, dowels were retrofitted after placement of the slabs.

The thickness of the precast slabs was 8.5 in. (216 mm), which is less than the thickness of the old pavement to accommodate the subbase preparations. The mixture proportions for the concrete used in the slabs are given in Table 1. Concrete for the slabs was Class A3, which has a minimum 28-day compressive strength of 3,000 lbf/in$^2$ (20.68 MPa), and was air entrained. The grout used in both methods of dowel installation was commercially available general purpose high-strength grout (*2*). The 7-day compressive strength was expected to exceed 4,000 lbf/in$^2$(27.58 MPa), and the 7-day bond strength was expected to be greater than 1,000 lbf/in$^2$ (6.90 MPa) when tested in accordance with Virginia Test Method 41 (*8*).

After the removal of the old patch, the existing subbase was leveled with gravel. Then, approximately 2 in. (51 mm) of flowable fill was used to level the base. The precast slabs were lifted at four preselected points and placed in the location using an excavator.

The difficulty in placing the precast patches involved connecting the new patch to the existing concrete. The joints were sealed with silicone over the backer rod and grout was poured in the places with dowels. For the slabs with preinstalled dowels, the receiving end in the existing slab was slotted before the placement of the precast slab. After placement, some areas were not level.

**Table 1**
**Mixture Proportions**

| Ingredients | lb/yd$^3$ |
|---|---|
| Cement | 496 |
| Class F fly ash | 124 |
| Fine aggregate | 1,072 |
| Coarse aggregate | 1,851 |
| Water–cementitious material ratio | 0.46 |
| Air (fl oz/yd$^3$) | 6.4 |
| Retarder (fl oz/yd$^3$) | 12.5 |

### Load Transfer Efficiency and Ride Quality

Approximately 2 weeks after construction, the LTE and ride quality were measured. The LTE tests were performed using an FWD on the right wheelpath. The testing protocol described in VDOT Materials Division's *Manual of Instructions* (*9*) was followed for the FWD tests. A series of four load levels (approximately 6,000, 9,000, 12,000, and 16,000 lbf/in$^2$ [41.37, 62.05, 82.74, and 110.32 MPa]) with three consecutive drops of each was used for each of the six patch locations. Ride quality was measured with a high-speed profiler at the same time FWD testing was performed. One of the measured properties from the profiler is the International Roughness Index (IRI), which indicates the smoothness of the pavement.

### Condition Survey

The condition of the pavement was determined through a visual survey of the cracks in the patches and grouted areas and spalls in the grouted areas about 1.5 years after placement.

## Results

### *Fabrication and Installation*

Concrete slabs with satisfactory strengths were cast. The compressive strengths for two cylinders at 27 days were 4,720 lbf/in$^2$ (32.54 MPa) and 4,706 lbf/in$^2$ (32.45 MPa). Although flowable fill was used to level the slabs, the patches had a differential height difference up to 0.25 in. (6.4 mm) in limited areas, necessitating greater attention to leveling. This difference in height greatly affected the measured ride quality (IRI data) when the patches were completed.

In the survey at 1.5 years, the contractor indicated that during installation of the slabs with prefabricated dowels, difficulties were encountered in aligning and centering the dowels. There is also some evidence of misalignment as indicated by cracks initiating at the corners of the dowel slots. The joint locations and dowel retrofit areas were exhibiting the problems and required more attention during construction. Specifically, in the first two patches, the grouted area was continuous between the new slab and the old pavement. The joint was not cut at that location, as shown in Figure 1. Thus, the joints at the slots were filled with grout instead of silicone. Three of the dowels in Slab 1 and all 12 in Slab 2 were reset or reinstalled within 2 months of initial construction. It is speculated that the slots were not cleaned well before grouting during the initial construction.

### *Load Transfer Efficiency and Ride Quality*

For each patch, LTE was measured using four load levels as mentioned previously. The results varied from 12 to 70 percent, with five of six patches scoring below 50 percent. According to the 1993 *AASHTO Guide for Design of Pavement Structures* (*10*), LTE is divided into three categories: below 50 percent, 50 to 70 percent and above 70 percent. An LTE above 70 percent is assumed to provide satisfactory performance. The LTE values for the patches were obtained within 2 weeks of construction and deemed inadequate for such construction. Therefore, the dowel bars were probably not secured properly from the beginning and were not providing adequate load transfer between old and new slabs. Improper construction techniques may have contributed to these poor LTEs and may have resulted in the early deterioration of the grout used in securing the dowel bars. The grout may also have been a problem by not attaining the specified early strength.

Although the profiler was run for the entire 0.85-mi (1.4-km) section of the road, the IRI values presented in Table 2 are only for the patch locations as identified by the operator at the time of the test. Although patches are only 6 ft (1.8 m) long, the IRI values are an average for 15 to 20 ft (4.6 to 6.1 m) around the patch area. All IRI values were higher than 110 in/mi (1,760 mm/km), which was the allowable limit for the noninterstate roadways in accordance with VDOT specifications at that time; for IRIs above this value, a \$2 per yd$^2$ pay adjustment or a corrective action was needed (*2*). In most cases, the patch locations showed higher IRI (rougher pavement) relative to the overall average for the entire section. The recent field observations also revealed rougher joints at the patches.

**Figure 1. Discontinuous joint at dowel retrofit.**

**Table 2**
**IRI Values for Precast Patch Locations (Test Date 03/24/04, Average Speed 40.6 mph)**

| Patch Type | Patch No. | Average Distance (mi) | IRI Values on Wheelpath (in/mi) | | |
|---|---|---|---|---|---|
| | | | Left | Right | Average |
| Retrofitted dowel bar | 1 | 0.004 | 137 | 386 | 261 |
| | 2 | 0.003 | 103 | 157 | 130 |
| | 3 | 0.003 | 223 | 216 | 220 |
| Preinstalled dowels | 4 | 0.003 | 116 | 179 | 147 |
| | 5 | 0.004 | 289 | 251 | 270 |
| | 6 | 0.002 | 155 | 175 | 165 |
| Project average | | | 134 | 156 | 145 |

*Condition Survey*

The field survey at 1.5 years, summarized in Table 3, provides more information on the lack of proper jointing between old and new slabs. According to the field survey, Patches 2 and 3 exhibited the worst grout conditions with more cracking. Patches 4, 5, and 6 (preinstalled dowels) were in relatively better condition than Patches 1, 2, and 3 (retrofitted dowels). Table 3 provides the number of cracked or spalled grout areas. In all three slabs cast with dowels, cracks were observed propagating into the patch because of the presence of dowel, as shown in Figure 2. In all patches, there were grouted areas with cracks. All except one of the slabs had spalled joint areas; in one area, the dowel was visible, as shown in Figure 3. In two of the patches cast with dowels, cracks were noticed propagating between the wheelpaths in a region without dowels, as shown in Figure 4. In limited areas, the silicone joint material was missing or its surface was depressed up to 1 in. (25 mm) below the top of the slab as shown in Figure 5. This also indicates the need for better construction practices.

**Table 3**
**Condition Survey Results**

| Patch Type | Patch No. | Condition of Slab | Condition of Grouted Area (No. of Dowels of Total 12) | |
|---|---|---|---|---|
| | | | Crack | Spall |
| Retrofitted dowel bar | 1 | No distress | 9 | 6 |
| | 2 | Minor edge break | 12 | 0 |
| | 3 | No distress | 12 | 9 |
| Preinstalled dowels | 4 | Cracks from dowels | 3 | 2 |
| | 5 | Cracks from dowels and at mid-width | 2 | 1 |
| | 6 | Cracks from dowels and at mid-width | 7 | 1 |

**Figure 2. Cracks propagating into patch cast with dowel.**

**Figure 3. Exposed dowel.**

**Figure 4. Crack propagating between wheelpaths in patch with cast-in dowel.**

**Figure 5. Missing silicone joint sealer.**

## NEW DEMONSTRATION PROJECT

VDOT has planned another demonstration project in a location with a very high volume of traffic where repair with precast slabs would be an appropriate application because of shorter construction windows and the high cost of construction-related traffic congestion and user delay. This project is near the Nation's capital, Washington, D.C., on I-66. It will facilitate a comparative evaluation of three repair options for concrete pavement:

1. Precast prestressed concrete slabs
2. Precast concrete slabs without prestressing
3. Conventional cast-in-place repair.

The precast prestressed concrete slabs will be used in a 1,000-ft (304.8 m) section on four lanes of I-66 west of Jermantown Road. Precast slabs without prestressing will be included for 2,000 ft (609.6 m) on the right lane of the ramp from I-66 westbound to Route 50 westbound. The conventional repair with cast-in-place slab will be used on the portion of the same lane and left lane (total is more than 2,000 ft [609.6 m]) on the ramp for comparison. The VDOT specification requires a 1-year warranty on a conventional cast-in-place patch. There is a requirement of 2,000 lbf/in$^2$ (13.79 MPa) compressive strength before the lane is opened to traffic; most contractors use high early strength concrete for such repairs. Several features of precast slab placement that will be carefully documented including the removal of the deteriorated concrete, the placement and leveling of the new slabs, the connection details with the old pavement, and the connection detail between the slabs and between the lanes. The slab thicknesses would vary between 9 in. (229 mm) and 11 in. (279 mm) for all three options.

This project was awarded incentive funding from FHWA's Highways for LIFE program as the technology and location satisfy the program's goal of advancing "Longer-lasting highway infrastructure using Innovations to accomplish the Fast construction of Efficient and safe highways and bridges."

The field demonstration will involve close collaboration with FHWA. The FHWA-designated consultants will provide the technology and expertise to instrument, cast, place, and post-tension the precast prestressed slabs. The slabs will be prestressed at the plant and post-tensioned at the jobsite. Although traffic slowdown and congestion cannot be avoided, the disruption in continuous traffic flow is not expected since only half the width of the I-66 mainline (two lanes) is planned for rehabilitation at one time. The same advantage is also expected on the ramp, where only the right lane will be repaired. On the right lane of the ramp (I-66 west to route 50 west), some slabs will be precast without prestressing, and some will be cast-in-place. All slabs will be placed on a base material that can provide uniform support (leveling course) with minimal friction.

The concrete mixtures used in the slabs will be evaluated. The testing will be conducted in the fresh and hardened states. In the fresh state, concrete will be tested for slump (ASTM C 143), air content (ASTM C 231), temperature (ASTM C 1064), and unit weight (ASTM C 138). Compressive strength will be determined at 28 days, 56 days, and 1 year. The elastic modulus, splitting tensile strength, and permeability (ASTM C 1202) will be measured at 28 days. Drying shrinkage will be measured for 6 months.

Several features of precast slab technology will be addressed in this demonstration project. These are based on the lessons learned in US-60 field trial, the experience of successful trials in other State departments of transportation, and the recommendations of AASHTO TIG Lead State Team (*12*). They primarily address the leveling and jointing of the slabs. Here are some of the important features:

- *Proper connection between the old pavement and the new slab and between the slabs (both longitudinal and transverse) is the most important issue using a precast slab.* An LTE of more than 80 percent is required where LTE is measured using an FWD when differential deflection ($d_{loaded} - d_{unloaded}$) exceeds 0.005 in. (0.125 mm) for a drop load of 9,000 lb (40 kN) on the wheelpath. In addition to the LTE requirement, the following are specified:

  — The encasement material (grout fill) for pavement hardware (dowel bars) should be used in accordance with manufacturer's written instruction.

  — Completeness of placement at the encasement area must be demonstrated through drilling, retrieving, and inspecting at least two cores (6-in. [152-mm] diameter) from randomly selected hardware encasement locations (e.g., through dowel bars).

- *Precast slabs should be reinforced with a maximum center-to-center bar spacing of 18 in. (457 mm) in each direction. The minimum required steel to concrete ratio is 0.0014 in. (0.0356 mm) with a minimum cover of 2 in. (51 mm).*

- *An allowable tolerance for dimension is specified between 0.125 to 0.250 in. (3.2 to 6.4 mm) except keyway dimension tolerance of 0.0625 and 3 in. (1.6 and 76.2 mm) for* *the position of lifting anchors.* The tolerances are provided for length, width, thickness, squareness, horizontal alignment, vertical alignment, deviation of ends (horizontal and vertical batter), position of strands (prestressed systems), position of posttensioning ducts at mating edges (post-tensioned systems), vertical and horizontal dowel alignment, dowel location, dowel embedment, location of reinforcing steel, straightness of expansion joints, initial width of expansion joints, and dimensions of blockouts. Diamond grinding is recommended for an elevation difference of more than 0.25 in. (6.4 mm) between old and new pavements.

- *Slabs could be placed on a precisely graded bedding layer and stabilized in place (underslab grouting) using cementitious grout to fill any small isolated voids.* The following features of the grout are specified:

  — Underslab grouting should be performed within 7 days of the placement of precast slabs.

  — Preapproved prepackaged nonshrink grout could be used if the manufacturer's recommendations are followed.

  — A nonshrink grout consist of a mixture of portland cement, a fluidifier, fly ash, and water could be used if initial set time of less than 4 hours and efflux time of 11 to 20 seconds are satisfied.

  — Stabilizing grout must develop a minimum compressive strength of 200 lbf/in$^2$ (1.38 MPa) within 24 hours.

- *The slabs could also be directly placed on cementitious support grout or urethane polymer foam.* Cementitious support grouts must develop a minimum compressive strength of 200 lbf/in$^2$ (1.38 MPa) before opening to construction or service traffic. On the other hand, urethane polymer materials must be fully cured in accordance with the manufacturer's recommendation. A complete support after slab placement should be demonstrated during trial installation by retrieving and inspecting at least three cores (6-in. [152-mm] diameter) from random locations.

- *The posttensioning tendon grout should be a prepackaged nonshrink grout conforming to the requirements for Class C grout specified by the Post-Tensioning Institute's Specification for Grouting of Post-Tensioned Structures* (11). The minimum compressive strength should be 3,000 lbf/in$^2$ (20.68 MPa) at 7 days and 5,000 lbf/in$^2$ (34.47 MPa) at 28 days.

The performance of the slabs will be monitored for at least 1 year primarily through a visual distress survey. The joint LTE, using the FWD, and smoothness (ride quality), using profiler, will be determined at least annually. Temperature and moisture gages will be embedded in the slabs to monitor the temperature and moisture of the slab during fabrication and over the life of the pavement. Temperature and moisture sensors will be located 1 in. (25 mm) from the top surface of the panel, at mid-depth, and at 1 in. (25 mm) from the bottom of the panel. Wire gages located 1 in. (25 mm) from the bottom surface of the slab will be considered to measure the in-service stresses. These instrumentations depend solely on coordination with the contractor and manufacturer of the precast slab.

## CONCLUSIONS

- *Experimental work on precast patches on Route 60 showed that the precast patches with quality concrete can be placed in a short period of time.* Particular construction issues related to jointing, leveling the slabs, and sealing the joints require special attention. In this limited study, the problems with aligning the dowels, consolidating grout around the dowels, and achieving good jointing were evident. The LTE tests revealed poor results, supporting the poor condition of the jointing that was evident in the condition surveys.

- *The grout material at the dowel locations was insufficient and needs improvement.* It must be durable, strong, and nonshrink to provide longevity.

- *The ride quality was poor mainly because of joint areas.*

- *Precast patches may provide contractors another option for limited lane closures if construction problems are resolved.*

- *The new demonstration project will document and present information on placement and performance and enable comparison of cast-in-place, precast, and precast prestressed patches.*

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