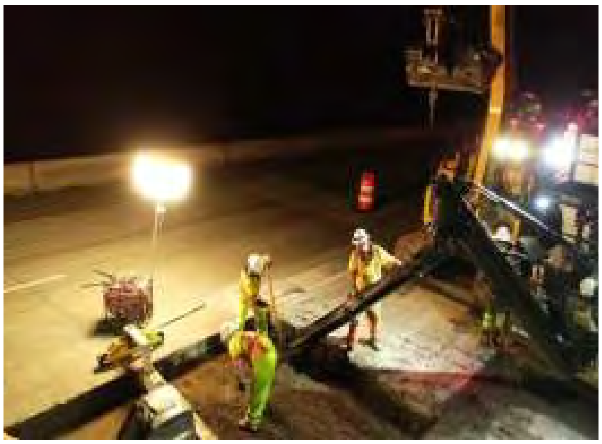
FHWA REPORT NO. FHWA-HIF-19-026

WASHINGTON STATE I-90 PAVEMENT REHABILITATION USING PRECAST CONCRETE PAVEMENT



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16. Abstract

Repair and rehabilitation of the aging highway infrastructure continues to be a challenging endeavor for all U.S. highway agencies. Thousands of miles of highway pavements need rehabilitation, and many of these highways carry over 100,000 vehicles/day, including a large percentage of trucks. Extended lane closures must be avoided to prevent compounding congestion—which means rehabilitation work must be completed rapidly. While many projects have been completed using rapid-setting concrete, results have been inconsistent. Precast concrete pavements (PCPs) have been shown to be promising alternatives. The production use of PCP has come a long way over the last 17 years. The technology is gaining wider acceptance in the U.S. for rapid repair and rehabilitation of concrete pavements as well as for heavily trafficked asphalt concrete pavements and intersections. Several U.S. highway agencies have implemented the PCP technology, and other agencies have constructed demonstration projects. In the U.S., the PCP technology is being used for intermittent repairs (full-depth joint repairs or full panel replacement) and for continuous applications (longer length/wider area rehabilitation) with service life expectations of at least 20 years for intermittent repairs and at least 40 years for continuous applications, without significant future corrective treatment.

The Strategic Highway Research Program 2 (SHRP2) Project R05 was conducted from 2008 to 2012 to develop technical information and guidelines that would encourage the rapid and successful adoption of PCP technology. Since 2013, the Federal Highway Administration in partnership with the American Association of State Highway and Transportation Officials has been supporting transportation agencies with implementation of PCP. During 2017, the Washington State Department of Transportation .WSDOT) was awarded a grant of $1,000,000 under FHWA's Accelerated Innovation Deployment (AID) Program to help offset the cost of constructing a PCP project.

This case study report provides details of the 2019 PCP use for rehabilitation of the distressed eastbound concrete pavement along sections of I-90 near Issaquah, Washington. WSDOT has a critical need to develop effective, longlasting concrete pavement rehabilitation tools that can be rapidly applied along sections of heavily-trafficked I-5 in the Seattle metropolitan area. The experience gained with the implementation of PCP along I-90 will guide WSDOT as to how use of PCP can be optimized for use along I-5 in the Seattle area.

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ABBREVIATIONS AND ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt concrete
AID	Accelerated Innovation Deployment
DOT	Department of Transportation
DOTD	Department of Transportation & Development
FHWA	Federal Highway Administration
FWD	Falling weight deflectometer
IUOE	International Union of Operating Engineers
PCP	Precast concrete pavement
SHRP2	Strategic Highway Research Program 2
WSDOT	Washington State Department of Transportation

PHOTO CREDITS

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Figures 6-7, 14, 15, 19, and 20 - Washington State DOT.

INTRODUCTION

Repair and rehabilitation of the aging highway infrastructure continues to be a challenging endeavor for all U.S. highway agencies. Thousands of miles of highway pavements need rehabilitation, yet many of these carry over 100,000 vehicles/day, including a large percentage of trucks. Extended lane closures must therefore be avoided to prevent compounding congestion—which means rehabilitation work must be completed rapidly. While many projects have been completed using rapid-setting concrete, results have been inconsistent. Precast concrete pavements (PCPs) have been shown to be promising alternatives.

The production use of PCP has come a long way over the last 17 years. The technology is gaining wider acceptance in the U.S. for rapid repair and rehabilitation of concrete pavements as well as for heavily trafficked asphalt concrete pavements and intersections. Several U.S. highway agencies have implemented PCP technology—including the Illinois Tollway and the California, Illinois, New Jersey, New York, and Utah departments of transportation (DOTs)—and other agencies have constructed demonstration projects. Since the early PCP installations in 2001, there have also been many advances in the design, panel fabrication, and panel installation aspects of PCP technology.

In the U.S., the PCP technology is being used for intermittent repairs (full-depth joint repairs or full panel replacement) and for continuous applications (longer length/wider area rehabilitation) with service life expectations of at least 20 years for intermittent repairs and at least 40 years for continuous applications, without significant future corrective treatment. Implementation of PCP technology can significantly reduce traffic impacts of roadway repair and reconstruction projects, particularly on heavily traveled routes. The technology is applicable to small segments, enabling flexibility in construction phasing, as well as for use in corridor-wide pavement reconstruction.

SHRP2 Project R05 Background

Because the information on PCP technology was not well documented, in 2007 the Strategic Highway Research Program 2 (SHRP2) initiated Project R05 to develop the necessary technical information and guidelines that would encourage the rapid and successful adoption of this new technology. The Project R05 study was conducted from 2008 to 2012. The final report, Precast Concrete Pavement Technology, is available at http://www.trb.org/main/blurbs/167788.aspx. The study demonstrated that the PCP technology is ready for wider implementation and that many of the PCP systems available in the U.S. can meet the needs of highway agencies for rapid renewal of their highway systems. The following products were developed under SHRP2 Project R05:

- Overall findings related to viability of the PCP technology.
- Findings based on SHRP2 field testing.
- Guidelines for PCP project selection.
- Guidelines for PCP system acceptance.
- Guidelines for design of PCP systems.
- Guidelines for PCP fabrication.

- Guidelines for PCP installation.
- Implementation plan for PCP technology.
- Long-term monitoring plan for PCP projects.
- Model specifications.

A review of projects constructed in the U.S. and the SHRP2 field testing indicated that sufficient advances have been made to reliably design and construct PCP systems to achieve five key attributes of successful pavements, as follows:

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

In 2013, the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) created the SHRP2 Implementation Assistance Program (IAP) to help State DOTs, metropolitan planning organizations, and other interested organizations deploy SHRP2-developed products to deliver more efficient, cost-effective solutions to meet complex challenges. Seven rounds of the IAP were offered between February 2013 and April 2016. The following transportation agencies received implementation and technical assistance awards to help offset the cost of constructing a PCP project that would provide a learning environment for operations such as fabricating panels, setting panels, installing dowel bars, grouting under panel areas, and other related activities needed to implement precast panel installations:

- Alabama DOT: I-165 AC ramp rehabilitation in Mobile
- Connecticut DOT: AC bus pads rehabilitation in New Britain
- Florida DOT: Distressed bridge approach slab replacement along I-10
- Hawaii DOT: Settled concrete pavement rehabilitation along a section of Hawaii H1
- Louisiana DOTD: Distressed concrete pavement ramp rehabilitation(eastbound I-20 ramp near Shreveport)
- Kansas DOT: Intersections & bridge approach slab along US 73 near Leavenworth
- Texas DOT: Energy sector AC intersection rehabilitation (Texas SH 97/SH 72)
- Wisconsin DOT: Slab replacements along Madison Bypass (US 12)

During early 2017, WSDOT applied for an award under FHWA's Accelerated Innovation Deployment (AID) Demonstration Project to support construction of a PCP test project to educate and acquaint WSDOT and local contractor staff with the best processes for constructing PCP. In their award application, WSDOT noted the following:

- WSDOT manages over 2,100 lane-miles of heavily trafficked concrete pavements. Over 50% of these pavements are over 40 years old and require rehabilitation. Also, about 1,000 lane-miles of concrete pavements will need to be reconstructed under challenging conditions, especially along I-5 in the Seattle area.
- The traffic congestion in congested urban areas does not allow concrete pavement rehabilitation and reconstruction using conventional methods since often the work needs to be carried out during short nighttime work windows.
- WSDOT usually makes use of concrete for their concrete pavement rehabilitation and reconstruction when all lanes along a roadway are not being replaced.
- In order to minimize the risk inherent in implementing a new technology, WSDOT proposed constructing a PCP test section along a section of eastbound I-90, near Issaquah, about 20 miles east of Seattle. The proposed I-90 location has 3 to 4 lanes that would facilitate work zone planning.

During April 2018, WSDOT was awarded an AID grant of $1,000,000 by FHWA to support implementation of the PCP a test project. This case study report provides details of the PCP implementation by WSDOT to rehabilitate the distressed concrete pavement along the eastbound lanes of I-90 near Issaquah. The work was performed during April and May 2019.

I-90 PROJECT DETAILS

WSDOT selected the distressed concrete pavement along the eastbound lanes of I-90 near Issaquah (about 20 miles east of downtown Seattle) for implementation of the PCP technology. The eastbound direction of I-90 at this location carries heavy truck traffic during the afternoon rush hour. Figure 1 shows the general locations of the project. The existing concrete pavement along this location exhibited slab cracking and several sections of the roadway had been designated for rehabilitation.

The project, Contract 9213 (I-90 East Sunset Way to 436th Avenue Pavement Repair), was bid during early 2018 and the contract was awarded on March 14, 2018. The contract included repair of concrete pavement along eastbound I-90 using 1,660 sy of precast concrete panels. The repair work consisted of fabricating, furnishing, and installing precast concrete panels in accordance with the project plans and specifications. The project specification required the use of a grout-supported PCP system and allowed use of panels with top or bottom dowel slots for load transfer across transverse joints. The grout-supported systems typically use a leveling system to set the panels at the desired elevation while maintaining a minimum gap of about 1/2 inch (13 mm) between the panel bottom and the base surface. The gap is filled with a rapid-setting high-strength grout material. Panels included non-planar (trapezoidal) and planar (rectangular) panels. The contractor selected use of panels with top dowel bar slots and full-depth slots and fitted with leveling lifts.

Figure 1. Map. I-90 Project Location, just east of Issaquah. (The map is the copyright property of Google® Earth™ and can be accessed from https://www.google.com/earth.

The contracted work included the following:

1. Performing a field survey.
2. Preparing the required submittals.
3. Removing the existing concrete pavement and AC base.
4. Placing new granular base layer.
5. Placing precast panels.
6. Setting panels at the designated elevation using leveling lifts.

7. Installing grout bedding under the panels.
8. Installing patching material in the dowel bar slots.
9. Performing finishing activities.

Precast Concrete Pavement Requirements

WSDOT developed a new Special Provisions for the PCP to be used for the demonstration project and included in the contract documents. The Special Provisions covered the qualifications for the PCP system to be used and the furnishing of the submittals, including shop drawings. The following key requirements were specified:

1. System performance: PCP to not exceed relative deflection of 2 mils (0.002 inch (0.05 mm) at transverse joints when tested with a falling weight deflectometer (FWD) using a nominal load of 9,000 lbf (40 kN).
2. Panel dimensions: Panels to be at least 6 ft (1.8 m) long and no more that 15 ft (4.6 m) long
3. Non-planar panels: Non-planar panels to be used where the grade and cross-slope would result in any corner of a planal plan deviating more than ¼ inch (6 mm) from the required grade. This requirement would apply to panels to be used along curved sections.
4. Panel reinforcement: A minimum reinforcement of 0.18 percent of the panel cross-section in both directions, uniformly distributed at a spacing not to exceed 12 inches (250 mm). Reinforcing bars to be No. 4 or larger and epoxy-coated. However, panels were allowed to be pretensioned in lieu of reinforcing bar use.
5. PCP trial installation: A trial installation was required outside the project limits. The trial installation was required to meet the same requirements as the project PCP. A minimum of four panels were specified for the trial installation.
6. Project test section: A test section, consisting of a minimum of five panels, was required to be constructed within the project limits. Production work for the panel installation was to proceed only after approval of the test section.
7. Just-in-time-training (JITT): A 4-hour JITT was required to provide joint training to the contractor and WSDOT staff who would be involved in the I-90 PCP project. The JITT was to be provided by an independent instructor experience in PCP construction methods, materials, and testing.
8. Panel support: Use of a bedding grout-supported system capable of being adjusted to grade using a set of leveling bolts and supported by these bolts during the placement of cementitious bedding grout between the panel bottom and the base. The thickness of the bedding grout was specified to be at least ½ inch (12 mm). The bedding grout compressive strength at time of opening to traffic was specified to be 500 psi (3.4 MPa)/
9. Transverse joint load transfer: Use of epoxy-coated bars, 1-1/2-inch (38-mm) in diameter and 14 inches (355 mm) long. Use of dowel bars in the wheel paths only permitted. Also, use of a ½-inch (13-mm) expansion cap was required for each dowel bar. Use of panels with top or bottom slots for installing dowel bars was permitted. The dowel slot grout (or patching material) was required to have attained a minimum compressive strength of 2,500 psi (17.2 MPa) at the time of opening to traffic.

10. Panel fabrication: Concrete to conform to WSDOT Section 6-02 Class 4000 concrete and also meet the flexural strength requirements of WSDOT's Standard Construction Specification Item 5-05.3(1) Part 2. The concrete strengths were designated as follows:
    a. 14-day flexural strength: 650 psi (4.5 MPa).
    b. Opening to traffic compressive strength: 2,500 psi (17.2 MPa).
11. Panel installation plan: Plan to include detailed description of equipment, materials, and processes to install the panels, including:
    a. Panel installation sequence.
    b. Transverse joint gap treatment.
    c. Longitudinal joint gap treatment.
    d. Contingency plan to allow roadway to open to traffic if the planned number of panels cannot be installed before the required lane opening time.

Precast Concrete Pavement Details

The details of the I-90 PCP project are as follows:

- Existing concrete pavement.
    - Slab thickness: 9.0 inches (229 mm).
    - Asphalt concrete (AC) base: 4 inches (100 mm).
- Total number of panels installed: 87.
    - Panel thickness: 12 inches (250 mm).
    - Panel width: 12 feet (3.65 m.
    - Panel length: 15 feet (4.57 m)), nominal.
    - Panel type:
        - Trapezoidal panels along a curve (continuous placement) – 53 panels
        - Planar (rectangular) panels along straight sections, both for continuous and single panel applications – 34 panels.
    - Panels to be set over the prepared base using leveling lifts.
- Support under the panel.
    - Crushed stone base course: 4 inches (101 mm) minimum.
    - Existing subbase.
    - Subgrade.
- Panel concrete – Precaster concrete mix design No. 507.
    - Precaster specified 42-day compressive strength or shipping strength with at least 14 days of curing at the precast plant: 6,000 psi (41.3 MPa).
    - Precaster specified prestressing strand cutting compressive strength: 4,000 psi (27.6 MPa).
- Joint load transfer.
    - Use of top slots for interior panels.
    - Use of full-depth slots with narrow surface and bottom openings for end panels and intermittent (single) repair panels.
    - Dowel bars:
        - Use of 1-1/2 inches (38 mm) diameter, 14.0-inch-long (355-mm-long) corrosion-resistant dowel bars in accordance with WSDOT Standard Specifications.

    - Use of expansion cap for each dowel bar, allowing a minimum of ½ inch (13 mm) expansion.
    - Four dowel bars per wheel path, spaced at 14 inches (355 mm).
    - Note: The contractor elected to use the Simplex Armour-coated dowel bars, with factory-applied techtyl coating.
- Longitudinal joint: No tie-bars used between lanes.
- Surface grinding: All repaired sections were required to be ground.
- Joint sealing: All joints were required to be sealed after completion of grinding.

As noted earlier, the project included use of both planar (rectangular) and non-planar (trapezoidal) panels. The panels were used as follows:

1. Continuous applications.
    a. Section starting at MP 20.679 in Lane 1: 53 panels along a curve.
    b. Section starting at MP 21.154 in Lane 2: 24 panels.
2. Intermittent Repairs.
    a. Between MP 21.036 and MP 21.679 in Lanes 1, 2, and 3: 10 panels.

Dowel Slot Grout/Patching Material Requirements

A high-strength dowel bar grout or patching material was specified to fill the top and full-depth slots. The project specification required the slot grout to achieve compressive strength of 2,500 psi (17.2 MPa) at the time of opening to traffic and a minimum compressive strength of 5,000 psi (34.4 MPa) at 28 days. The contractor elected to use the Rapid Set DOT Repair Mix, a high-performance concrete repair material and extended it 100% by weight with pea gravel. This grout, when extended 100% by weight with aggregate, can achieve compressive strength of 2,500 psi (17.2 MPa) at 1 hour and 4,200 psi (29.0 MPa) at 3 hours.

Bedding Grout Requirements

The project specifications required the use of rapid-hardening, free-flowing cementitious grout. The grout was required to achieve a compressive strength of 500 psi (3.4 MPa) at the time of opening to traffic and a minimum compressive strength of 2,500 psi (17.2 MPa) at 7 days. The contractor elected to use the Rapid Set Ultraflow 4000/8 non-shrink precision grout that was supplied in 1,000 lb (453 kg) bulk bags. This grout has an initial set time of 90 minutes and can achieve a compressive strength of 4,000 psi (27.6 MPa) at 8 hours and 8,500 psi (58.6 MPa) at 28 days.

PANEL FABRICATION

The contractor elected to use prestressed panels incorporating top dowel bar slots for interior panels and full-depth slots for end panels and for intermittent repair panels. The initial transfer force per 0.5 inch (12.5 mm) diameter prestressing strand was required to be 31,000 lbf (138 kN). A total of 10 strands were used per panel at a spacing ranging from 12 inches (300mm) to 24 inches (600 mm) for the middle two strands. The strands were placed over transverse reinforcing bars (No. 5 bars spaced at 14 inches (355 mm)), placed at mid-depth.

The full-depth slots are shown in figure 2. The slot, in the shape of a bowling pin, has a surface opening of 1-1/8 inches (28 mm) and a bottom opening of 2-1/2 inches (64 mm). The middle of the slot flares out to a width of 3 inches (76 mm). The top slots are shown in figure 3. The top slot design is similar to the design used at several PCP projects in California. The slot, in the shape of a tear drop, has a surface opening of 1-1/8 inches (28 mm) and flares out to a width of 2-7/8 inches (73 mm) at mid-depth.

Figure 2. Photo. Full-depth dowel slots.

Figure 3. Photo. Top Dowel Slots.

The following panel types were used:

1. Panel Type SR (Designated as Panel No. 431-001): Single run panels for intermittent repairs.
    a. Full-depth slots along both transverse sides of the panel.
2. Panel Type S (Designated as Panel No. 431-002/431-005): Starting panel for a continuous section.
    a. Full-depth slots at the transverse side adjacent to the existing concrete pavement. The existing concrete side incorporates drilled and grouted dowel bars.
    b. Top slots along the opposite transverse side.
3. Panel Type M (Designated as Panel No. 431-003/431-006): Middle panels for a continuous section.
    a. Embedded dowel bars incorporating expansion caps along the transverse side adjacent to the side with top slots in the previously placed panel.
    b. Top slots along the opposite transverse side.
4. Panel Type SE (Designated as Panel No. 431-004/431-007): Second to end panel for a continuous section.
    a. Embedded dowel bars incorporating expansion caps along both transverse sides of the panel.
5. Panel Type E (Designated as Panel No. 431-001/431-008): End panel for a continuous run, same as Panel Type SR.

Panels designated as Panel Nos. 431-001 to 431-004 are planar (rectangular) panels and panels designated as Panel Nos. 431-005 to 431-008 are non-planar (trapezoidal) panels. The non-planar panels are 15 ft (4.6 m) long along the outside longitudinal edge and are short by 1-1/4 inch (31 mm) along the inside longitudinal edge.

The project specifications required the panels to meet the tolerances listed in table 1.

Table 1. Panel geometric tolerances.

Length and width	± ¼ inch (+/-6 mm)
Nominal Thickness	± 1/8 inch (+/-3 mm)
Local smoothness of any surface	± ¼ inch (+/-6 mm) over 10 ft in any direction
Dimensions of blockouts (if applicable)	± ¼ inch (+/-6 mm)

The panels were fabricated at a precast plant located in Spokane, Washington, about 260 miles from the project site. The panels were fabricated based on shop drawings prepared by the precaster and approved by WSDOT. As part of the panel fabrication process, the concrete was regularly tested for fresh properties and for strength. The concrete typically exceeded the design flexural strength of 650 psi (4.5 MPa) at 28 days and typically exceeded 4,000 psi (27.6 MPa) at the time of prestressing strand cutting and form stripping.

The panels were fabricated between September and November 2018 and stored at the precast plant over a period of several months because the panel placement previously planned for late 2018 was delayed due to a strike by the International Union of Operating Engineers (IUOE), Local 302, which prevented the work from being completed before winter weather set in. When the panel installation work started in mid-April 2019, panels were delivered to the project site during the daytime for each night of panel placement.

PANEL INSTALLATION

Panel Installation Tolerances

The project specification required the panels to be installed within the tolerances listed in table 2.

Table 2. Panel installation tolerances.

Longitudinal surface smoothness	1/8 inch in 10 ft (3 mm in 3.05 m)
Transverse surface smoothness	1/4 inch in 10 ft (6 mm in 3.05 m)
Transverse joint width	½ inch (13 mm) max
Longitudinal Joint width	½ inch (13 mm) max

Panel Installation Steps

The following are the typical installation steps for the PCP at the I-90 project:

1. Mark repair limits and provide full-depth sawcut along the perimeter of the repair area a few nights before panel installation.
2. Remove existing concrete pavement and the AC base.
3. Prepare the base layer. Add new approved granular base material as needed and grade and compact using rollers and tamping plates as needed.
4. Drill and epoxy-grout dowel bars in the existing concrete pavement transverse side.
5. Place panels over the prepared base layer.
    a. For continuous sections, place the panels in the following sequence:
        i. Place the staring panel, Panel Type S.
        ii. Place the middle panels, Panel Type M, as needed.
        iii. Place the second to end panel, Panel Type SE.
        iv. Place the end panel, Panel Type E (same as Panel Type SR).
    b. For the intermittent repairs:
        i. Place the single-run panel, Panel Type SR.
6. Maintain the transverse and longitudinal joint widths as specified.
7. Use leveling bolts to raise the panels to planned elevation.
8. Apply the bedding grout.
9. Apply dowel slot patching material in the slots. Prevent the patching material from running into the transverse joint gap.
10. Remove the leveling bolts.
11. Perform finishing activities.
12. Open to traffic by the designated opening to traffic time.

Trial Section Installation

The contractor installed a trial section on September 19, 2018 at an off-site location. A total of four panels were installed over a prepared granular base. The panels delivered for the trial section exhibited surface cracking and spalling at some of the slots. The contractor was directed by WSDOT staff to improve the concrete mixture design and the panel fabrication process to ensure similar quality issues did not develop in the panels to be used for production work. Other than the panel quality issues, the trial section installation was considered acceptable by WSDOT.

Production Panel Installation

Production panel installation began during the night of April 15, 2019. As noted previously, panels for use during a night were shipped during the daytime from the precast plant in Spokane to a staging area along the Exit 20 ramp from Highpoint Way entering the eastbound I-90.

The panel installation was carried out during 8 nights over a period of two weeks. The panel placement had to be postponed several nights due to weather (rainy) conditions. The panel placement was as follows:

1. First continuous section – 53 panels.
    a. Night 1 Monday, (April 15, 2019) – 10 panels.
    b. Night 2 (Wednesday, April 17, 2019) – 10 panels.
    c. Night 3 – 16 panels.
    d. Night 4 – 16 panels.
    e. Night 5 – 1 end panel.
2. Intermittent repairs
    a. Night 5 – 8 panels.
    b. Night 6 – 2 panels.
3. Second continuous section – 24 panels.
    a. Night 6 – 12 panels.
    b. Night 7 – 11 panels.
    c. Night 9 (Tuesday, April 30, 2019) – 1 end panel.

During each night of panel placement, two-lane closures began at about 8 pm and work started with the removal of the existing concrete pavement and the AC base. The panel installation typically began after midnight. For the first night's work, the lane closures were extended till early afternoon of the next day as allowed by the contract and the bedding grout and the dowel slot patching material application was done during the morning.

The typical panel installation activities are summarized next.

Production Panel Installation – Continuous Sections

1. Full-depth perimeter saw-cutting of the work area and intermediate slab saw-cutting, as shown in figure 4, was performed a few nights before each night's panel placement.

Figure 4. Photo. Intermediate sawcuts within the lane 1 repair area.

2. Removal of the broken concrete slab and the AC base using excavator equipment with a bucket, as shown in figure 5.

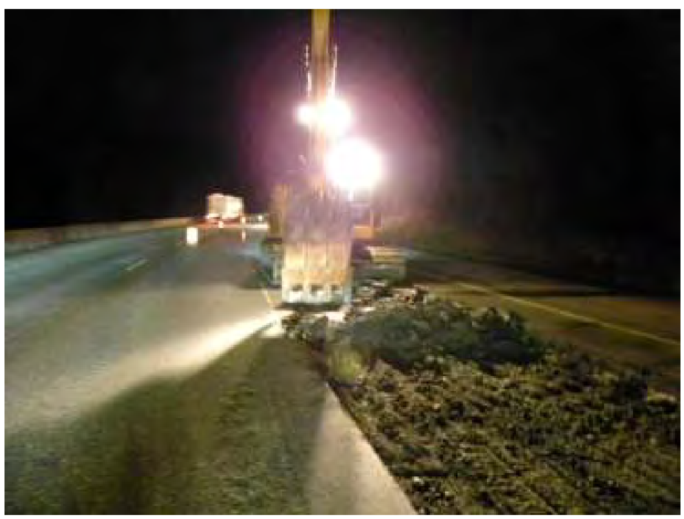

Figure 5. Photo. Existing concrete pavement demolition.

3. Placing about 2-to 3-inch (50-to 76-mm) thickness of new granular base material. A mobile mixer, shown in figure 6, was used to apply a controlled amount of the base material to speed up the base grading operation. Figure 7 shows the base being graded using a contractor-developed screed template. Figure 8 shows the graded base being roller compacted. The base compaction was monitored using a nuclear gauge, as shown in figure 9.

Figure 6. Photo. Mobile mixer used for placing thin layer of aggregate base.

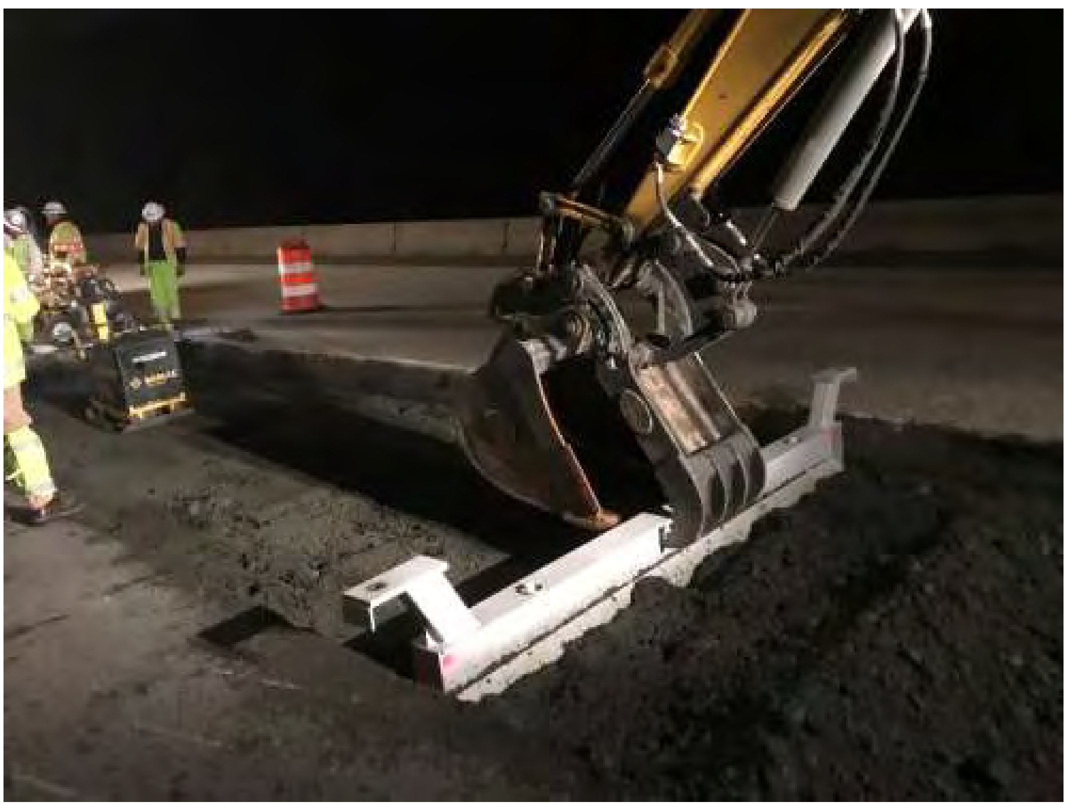

Figure 7. Photo. Base grading.

Figure 8. Photo. Base compaction.

Figure 9. Photo. Base compaction testing using a nuclear gauge.

4. After the base grades were confirmed, the panel placement began. Figure 10 shows the existing pavement joint face incorporating epoxy-grouted dowel bars. The epoxy used for anchoring the dowel bars was Adhesive Technology's Ultrabond 1 anchoring epoxy. At this location, the contractor did not place expansion caps at the exposed end of the epoxy-grouted dowel bars. The first panel installation adjacent to the existing concrete pavement is shown in figure 11. Figure 12 shows the installation of the second panel, viewed from the top-slots side. Figure 13 shows the installation of the second panel, viewed from the embedded-dowels side.

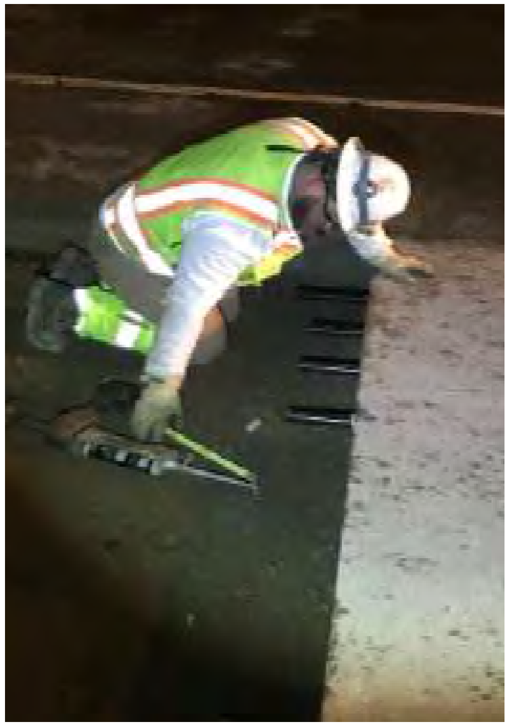

Figure 10. Photo. Epoxy-grouted dowel bars at existing pavement joint face.

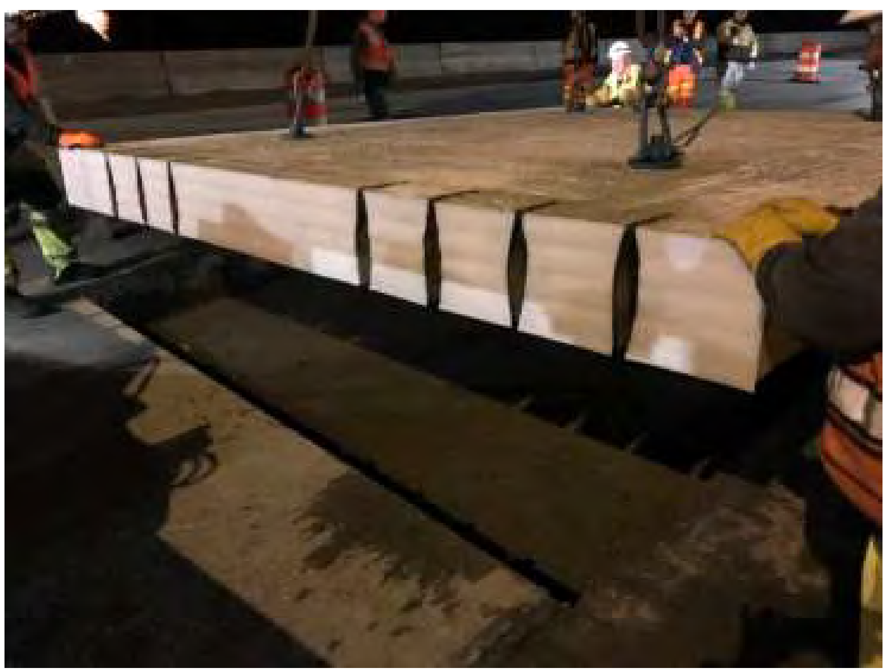

Figure 11. Photo. Installation of the first panel adjacent to the existing concrete pavement.

Figure 12. Photo. Installation of the second panel, view of the top-slots side.

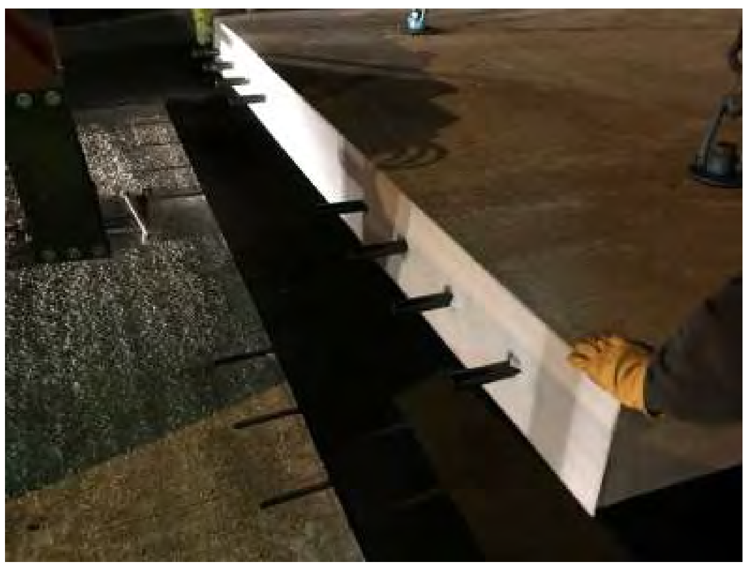

Figure 13. Photo. Installation of the second panel, view of the embedded-dowels side.

5. Continue panel placement. After all panels for a given night were placed, the leveling bolts, four per panel, were installed. The leveling bolts were used to adjust the panel surface elevation, typically creating a gap of ½ inch (12 mm) below the panel bottom.
6. Soon after all panels for the night had been set at the desired elevation, the bedding grout application was initiated. The bedding grout mixer was prepared using a grout mixture shown in figure 14. The bedding grout was applied thru the port holes, as shown in figure 15.

Figure 14. Photo. Bedding grout mixer.

Figure 15. Photo. Bedding grout application.

7. After the bedding grout application was completed, the dowel slot pocket patching was started. The patching material was mixed in 5 gallon (19 liter) buckets and hand-poured into the slots. Generally, the dowel slot patching operation proceeded well. Care was taken to ensure that the patching material did not run into the transverse joint gap. Figure 16 shows the top dowel slots with the patching material application completed. During the first night of panel placement, the transverse joint gap was not maintained at a uniform width and generally exceeded ¼ inch (6 mm) width which was the thickness of the polyfoam material used at the transverse joints. As a result, the contractor had to use shims at the slot locations to prevent the patching material from entering the wider joint gaps, as shown in figure 17.

Figure 16. Photo. Top dowel slots patched.

Figure 17. Photo. Shims used at top slot locations.

8. A view of a continuous section after application of the dowel slot patching material is shown in figure 18. After the slot patching material had set, the leveling bolts were removed, and the completed repair area cleanup was carried out.

Figure 18. Photo. A continuous section after application of the dowel slot patching material.

Bedding grout and slot patching material testing was performed before the start of the panel installation to verify that the two materials to be used could achieve strength levels needed for opening to traffic and at the specified age of 28 days. The testing was performed using cube samples during each night of panel installation. The testing indicated that project specification requirements were met for both materials for opening to traffic.

Production Panel Installation – Single Repair Panels

The single panels were installed in a manner similar to the installation of panels along the continuous sections. As noted earlier, the panels for intermittent repairs incorporated full-depth slots along both transverse sides of the panel. The length of each existing pavement work area was about 15 ft (4.6 m) (nominal panel length) plus about 1 inch (25 mm) extra length to accommodate panel placement within the work area.

For single repairs, the repair activities included the following:

1. Removal of the distressed existing concrete pavement and the AC base.
2. Placement of new granular aggregate base using the mobile mixer, as shown in figure 19.
3. Grading and compaction of the base.
4. Drilling and epoxy-grouting of dowel bars along both transverse sides of the existing pavement.
5. Placing the single panel, matching the full-depth slots over the dowel bars along both sides of the existing pavement, as shown in figure 20.
6. Inserting leveling bolts and adjusting the surface elevation of the panel to match the surface elevation of the existing pavement.
7. Applying the bedding grout.
8. Applying the dowel bar slot patching material.
9. Removing the leveling bolts.

10. Performing cleanup at each repair site.
11. Opening to traffic.

Figure 19. Photo. Placement of new granular aggregate base.

Figure 20. Photo. Single panel installation.

Finishing Activities

The finishing activities included the following:

1. Surface grinding along the repair areas that incorporated precast panels.
2. Sealing of the transverse joints.

3. The shoulder-side longitudinal joint was filled with a hot-applied asphalt-based joint sealant after the shoulder was reconstructed with a new hot-mixed asphalt surface. The gap along the Lane 1 and Lane 2 longitudinal joint was filled/sealed as follows:
    a. Using hot-applied asphaltic mastic sealant for joint gaps greater than 1 inch (25 mm) wide.
    b. Using a hot-applied asphalt-based joint sealant (same as that used for the shoulder longitudinal joint) for joint gaps 1 inch (25 mm) or less wide.

Deflection Testing at Transverse Joints

The project specification required deflection testing at the joints of the trial section panels. As of mid-May 2019, the falling weight deflectometer (FWD) testing of the of the I-90 panels had not been conducted.

SUMMARY

This project was an important first step in the implementation of PCP technology by WSDOT. As part of getting ready for the first PCP project, the WSDOT carried out several activities, as previously discussed and summarized below:

- Participation in FHWA-sponsored workshops on PCP best practices.
- Development of a provisional specification for PCP.
- Participation in the FHWA Expert Task Group on PCP Implementation.
- Participation in the Just-in-Time-Training conducted to train the WSDOT, I-90 project contractor, and the precaster staff on the best practices to ensure a successful PCP project.

Based on the experience gained at the I-90 PCP project, the WSDOT expects to review the provisional PCP specification and incorporate appropriate modifications to improve the efficiency and quality of panel placement. The use of the PCP technology on a production pavement rehabilitation project was an important step for WSDOT. This was the first application of the PCP technology by the WSDOT, and they expect to use the experience and findings from this demonstration project to refine specifications and plans for production use of PCP technology at future pavement repair and rehabilitation projects along roadways with high traffic volumes, where work can only be performed during nighttime lane closures and where treatments need to provide long-life service.

Also, the contractor indicated that after the slow progress during the first night of installation, the work generally proceeded well and that on future projects, they would use the panel design similar to the I-90 project but with a different leveling lift system. They would also use a backup mixer for the bedding grout to speed up the bedding grout placement. The contractor also noted that placing rectangular shaped panels along a non-uniform (after sawing) curved existing Lane1/Lane 2 longitudinal joint presented difficulties in establishing uniform and tight longitudinal joint gap.

The I-90 concrete pavement rehabilitation project near Issaquah is considered a successful implementation and learning opportunity of the PCP technology on a production basis by an agency that had not constructed a PCP project previously.

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