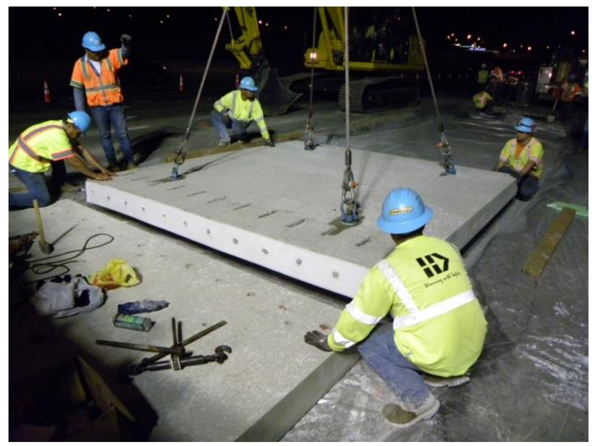
FHWA REPORT NO. FHWA-HIF-17-001

FHWA PROJECT R05 IAP FUNDED PROJECT CASE STUDY

HONOLULU INTERSTATE H1 PRECAST CONCRETE PAVEMENT DEMONSTRATION PROJECT



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16. Abstract
The production use of precast concrete pavement (PCP) has come a long way over the last 15 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, including Caltrans, Illinois Tollway, and the New Jersey, New York, and Utah State Departments of Transportation (DOTs), 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. In 2013, the SHRP2 Implementation Assistance Program (IAP) was created to help State DOTs, metropolitan planning organizations, and other interested organizations deploy SHRP2-developed products order to deliver more efficient, cost-effective solutions to meet the complex challenges facing transportation agencies. On March 28, 2014, as part of round 3 of the IAP, four lead adopters were selected to receive financial support from the Federal Highway Administration for implementation of PCP technology. Hawaii Department of Transportation, one of the agencies selected as a lead adopter, received an award of $300,000 to help offset the cost of the implementation of PCP technology in the State.

This case study report provides details of the 2015 PCP implementation on a concrete pavement rehabilitation project along a section of Interstate H1 in the Honolulu area.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
(none)	Mil	25.4	micrometers	µm
in	Inches	25.4	millimeters	mm
ft	Feet	0.305	meters	m
yd	Yards	0.914	meters	m
mi	Miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	Acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	Gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	Ounces	28.35	grams	g
lb	Pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	Poundforce	4.45	Newtons	N
lbf/in^2 (psi)	poundforce per square inch	6.89	kiloPascals	kPa
k/in^2 (ksi)	kips per square inch	6.89	megaPascals	MPa
		DENSITY		
lb/ft^3 (pcf)	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m^3
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
µm	Micrometers	0.039	mil	(none)
mm	Millimeters	0.039	inches	in
m	Meters	3.28	feet	ft
m	Meters	1.09	yards	yd
km	Kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	Hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	Milliliters	0.034	fluid ounces	fl oz
L	Liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	Grams	0.035	ounces	oz
kg	Kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE		
°C	Celsius	1.8C+32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	Newtons	0.225	poundforce	lbf
kPA	kiloPascals	0.145	poundforce per square inch	lbf/in^2 (psi)
MPa	megaPascals	0.145	kips per square inch	k/in^2 (ksi)

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ABBREVIATIONS AND ACRONYMS

AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt concrete
CTB	Cement-treated base
DOT	Department of transportation
FHWA	Federal Highway Administration
IAP	Implementation Assistance Program
PCP	Precast concrete pavement
SHRP2	Strategic Highway Research Program 2

INTRODUCTION

The production use of precast concrete pavement (PCP) has come a long way over the last 15 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, including Caltrans, Illinois Tollway, and the New Jersey, New York, and Utah State Departments of Transportation (DOTs), have implemented the PCP technology, and other agencies have constructed demonstration projects. There have also been many advances in the design, panel fabrication, and panel installation aspects of the 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.

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.

The 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:

1. Constructability—Techniques and equipment are available to ensure acceptable production rates for the installation of PCP systems.
2. Concrete durability—Plant fabrication of precast panels results in excellent concrete strength and durability.
3. 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.
4. Panel support—Techniques to provide adequate and uniform base support conditions continue to be improved.
5. Efficiency—Panels are thinner than standard cast-in-place concrete and last longer because of prestressing and/or reinforcing elements in the PCP system.

SHRP2 PROJECT R05 PRODUCT IMPLEMENTATION PROGRAM

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 order to deliver more efficient, cost-effective solutions to meet the complex challenges facing transportation agencies. Seven rounds of the IAP were offered between February 2013 and April 2016.

On March 28, 2014, as part of round 3 of the IAP, four lead adopters were selected to receive financial support from the Federal Highway Administration for implementation of PCP technology. Hawaii DOT, one of the agencies selected as a lead adopter, received an award of $300,000 to help offset the cost of the implementation of PCP technology in the State. The objective of the award was to allow Hawaii DOT to construct a demonstration project that would provide a learning environment for operations such as fabricating panels, setting panels, installing dowel bars, grouting under slab areas, and other related activities needed to implement precast panel installations in Hawaii.

This case study report provides details of the PCP implementation on a concrete pavement rehabilitation project along a section of Interstate H1 in the Honolulu area. The project was constructed between March and June 2015.

PROJECT DETAILS

PROJECT DESCRIPTION

As illustrated in figure 1, eastbound Hawaii Interstate H1 has six lanes at the project location, just east of the Aiea Pedestrian Overpass and parallel to Heleconia Place. At this location, a 165-ft section (from station 183+40 to station 185+05) had settled and had been repeatedly overlaid with asphalt concrete (AC) across all six lanes over the life of the freeway. The maximum settlement was about 3 to 4 inches. Figure 2 shows a view of the existing AC-overlaid section prior to installation of the PCP.

Figure 1. Photo. Location of the project.

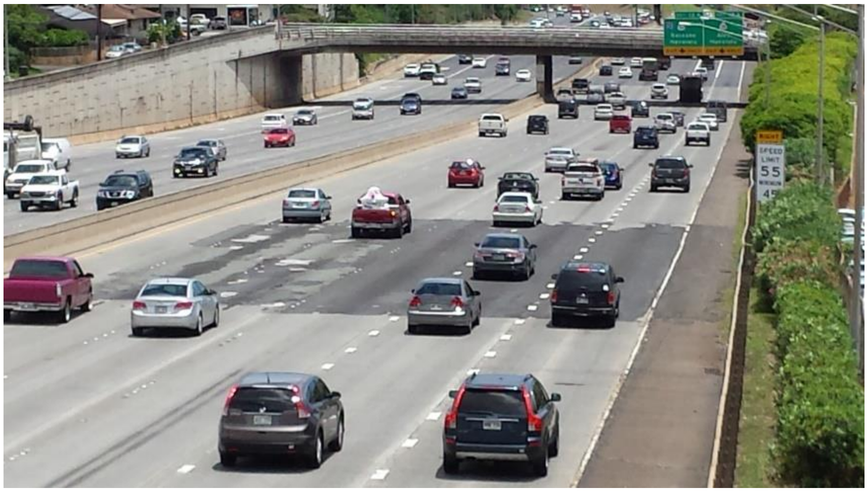

Figure 2. Photo. View of the project.

The eastbound lanes carry a high volume of traffic, with annual average daily traffic (AADT) ranging between 90,000 and 200,000 vehicles, going into Honolulu during the morning rush hour. Any lane closures at this location would result in significant backups during the morning rush hour. In the past, the roadway settlement was corrected by applying an AC surfacing during the nighttime hours. However, Hawaii DOT does not consider the use of the AC surfacing at this location successful. To provide a long-term solution to the settlement problem, Hawaii DOT utilized the SHRP2 IAP funding to investigate the use of PCP to rehabilitate the settled section.

The PCP demonstration project was awarded to Hawaiian Dredging Construction Company, Honolulu, Hawaii, as an added work item to an existing contract (Contract No. F.A.P. NO. NH-H1-1(260) & F.A.P. NO. BR-H1-1(263)). This contract change order (Work Item No. 413.3000) involved installing precast concrete panels, at the lump sum price of $1,111,480.000, along an eastbound section of Hawaii Interstate H1. The work item provided compensation for all design, quality control and quality assurance, and construction costs related to the installation of the precast concrete panels, traffic controls, pavement marking and striping, preparation of “as-built” drawings, and all incidentals necessary to complete the work.

The project team included the following:

- Project owner: Hawaii DOT.
- Prime contractor: Hawaiian Dredging Construction Company (HDCC), Honolulu.
- Pavement design and construction consultant: KSF, Inc., Honolulu.
- Construction management support:
    - Construction management for the State: SSFM International, Honolulu, Hawaii.
    - Quality control on behalf of HDCC: Wesley R. Segawa & Associates, Inc., Honolulu, Hawaii.
- Precast pavement system vendor: Rapid Roadway, Covina, California.
- Bedding and dowel slot grout supplier: Performance Plus Products, Aliso Viejo, California.

PAVEMENT DETAILS

The original pavement, across the six lanes, is a 9-inch-thick jointed concrete pavement that was constructed in the mid-1980s. The joint spacing was random. The details of the rehabilitation are as follows:

- Section length to be rehabilitated: 168 ft.
- Number of panels per lane: 14.
- Number of lanes rehabilitated: six.
- Total number of panels: 84.
- PCP system: Rapid Roadway system, Los Angeles, California.
- Panel dimensions: 12 ft long by 12 ft wide by 10 inches thick.
- New base: Rapid-setting cement-treated base (CTB), maximum thickness about 4 inches (to correct for the settlement).

Figure 3 shows the test section with lanes 5 and 6 (most outside lanes) partially replaced with precast panels.

Figure 3. Photo. Lanes 5 and 6 partially replaced with precast panels.

PRECAST CONCRETE PAVEMENT SYSTEM USED

The Rapid Roadway system used for this project is a proprietary system developed in California in 2013. It consists of the following components:

- Reinforced or prestressed precast panels—The panels are fabricated at an approved precast concrete plant, typically using steel forms. However, as discussed later, for the Hawaii H1 project, the contractor decided to cast the panels at a nearby site using plywood forms.
- Gracie Leveling Lifts (figure 4)—The Gracie Leveling Lift is a patented hardware item that serves a dual purpose. With four Gracie lifts per panel, it is used as a lift insert to handle the precast panels. After the panel has been placed, the same insert is used as a leveler to set the panels at the desired elevation. With its attached bottom plate and a leveling screw, the panel can be leveled to match existing grades and maintain super elevations.
- The Barra Glide load transfer system for load transfer at transverse joints (figure 5)—The Barra Glide is a patented load transfer system. The system incorporates a sliding dowel and surface openings of 1 1/8 inches by 9 1/4 offset, about 9 inches from the joint face. It is used with 1.5-inch by 15- or 18-inch dowel bars. After the dowel has been engaged (pushed into the dowel hole in the adjacent panel), the dowel is encased in a polymer concrete or a rapid setting cementitious grout.
- Performance Plus bedding grout—Performance Plus RH, non-sanded, is a rapid hardening, non-shrink, very free flowing, zero bleed, sand-free, cementitious grout. It is a blend of Type II/V portland cement and admixtures designed to provide maximum flow and shrinkage compensation. The grout achieves a compressive strength of 2,500 psi within 1 hour and 8,000 psi at 28 days. The grout is pumpable and provides bedding support for precast concrete panels. The grout exhibits rheological fluid properties allowing small voids between the base and the precast concrete panels to be filled.

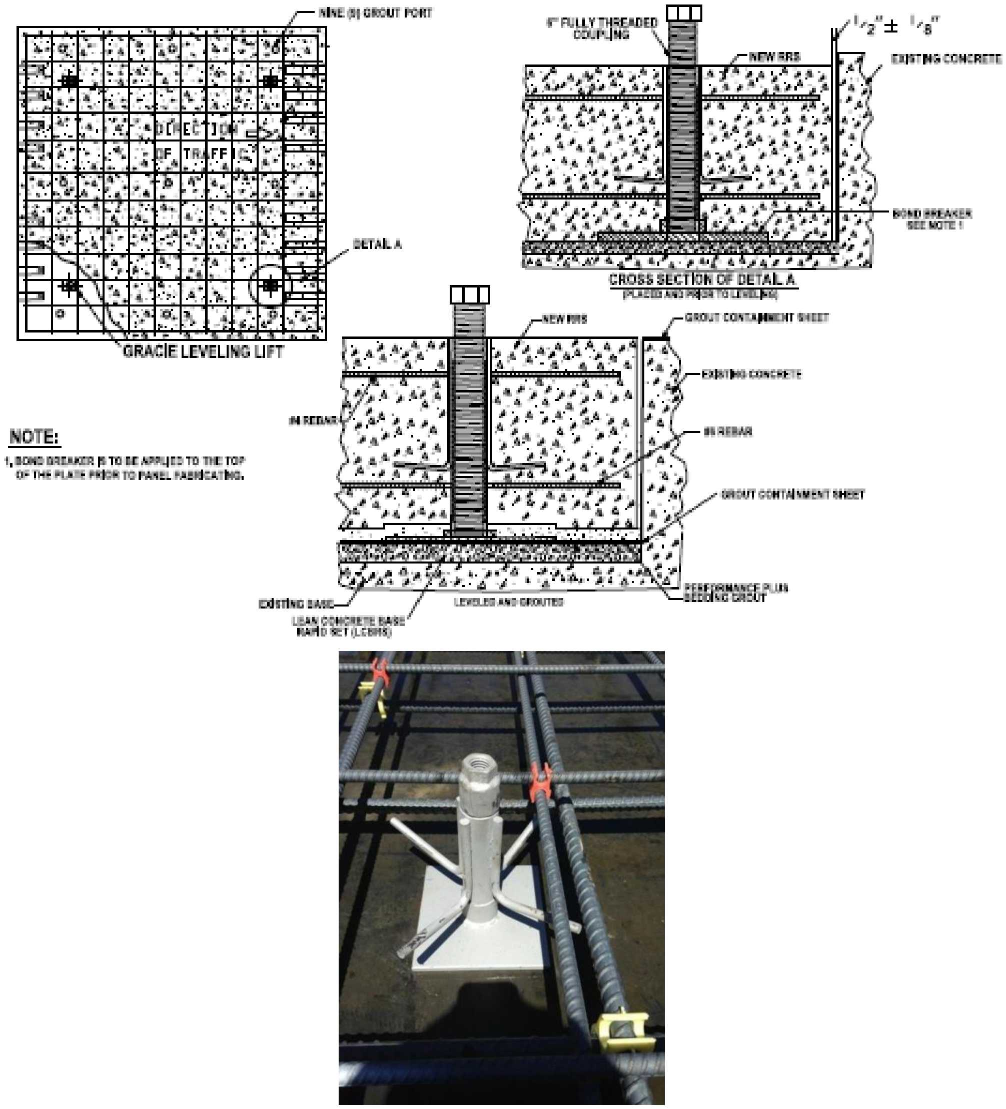

Figure 4. Diagram and photo. Gracie Leveling Lift.

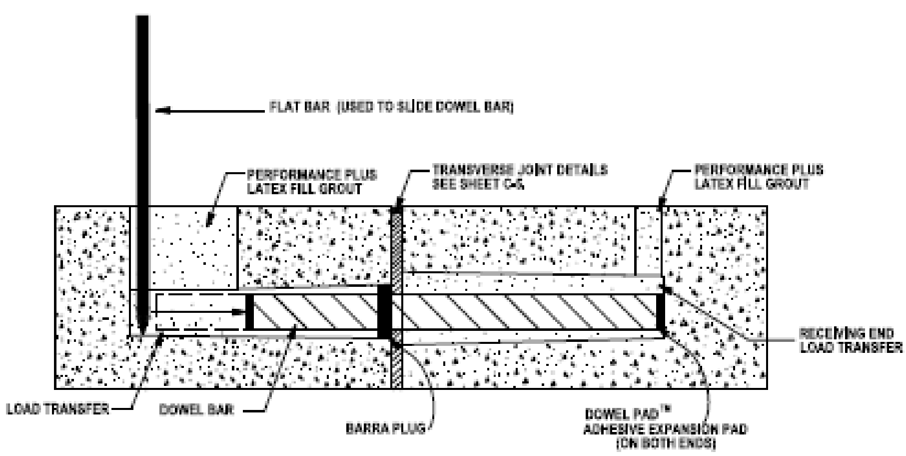

Figure 5. Diagram. The Barra Glide load transfer system after dowel slide.

- Performance Plus RH Latex Fill Grout—This is a rapid hardening, non-shrink, free flowing, zero bleed, sanded, cementitious grout for filling dowel bar slots. The grout achieves a compressive strength of 3,000 psi within 1 hour and 8,000 psi at 28 days.
- Grout Containment system (figure 6)—The Grout Containment system is used to prevent the bedding grout from migrating under existing pavement. As shown in figure 6, it essentially consists of a polyethylene sheet that is placed over the base and the sides of adjacent panels before setting the precast panels.

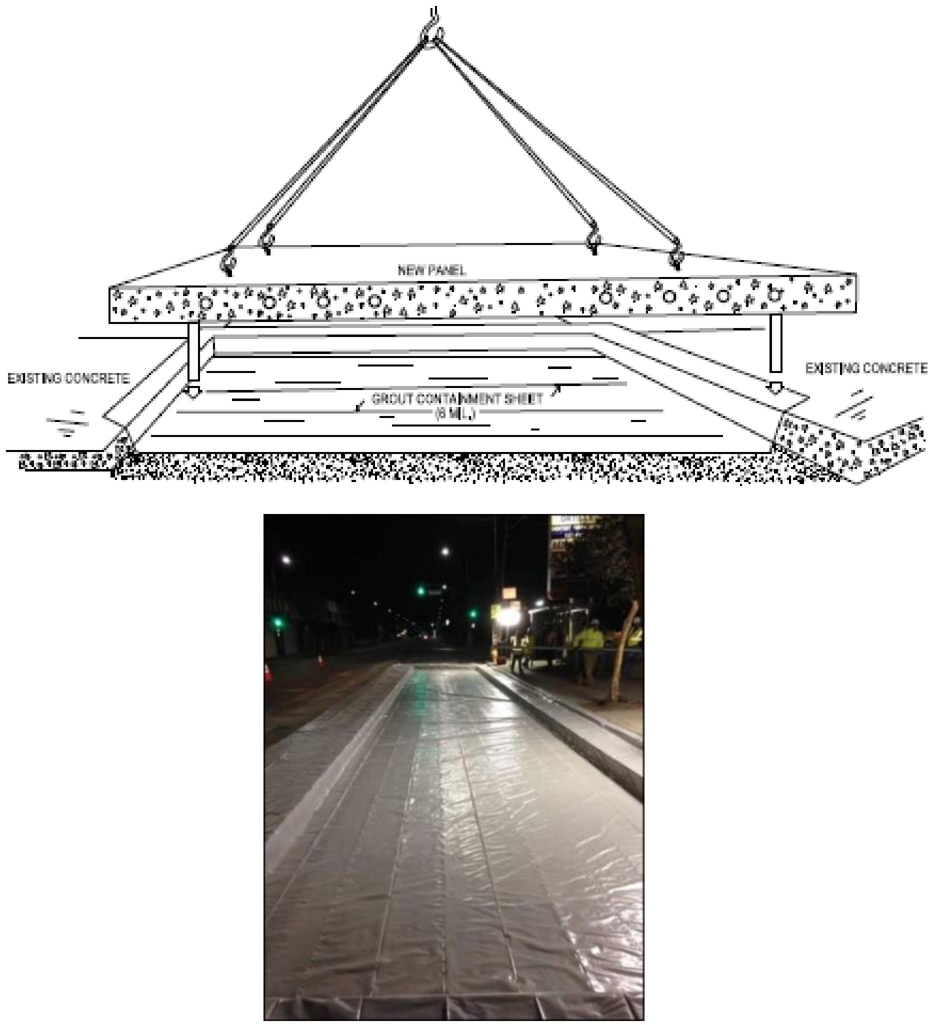

Figure 6. Diagram and photo. The Grout Containment system.

The following are the Rapid Roadway system installation steps:

1. Mark sawcut lines for the area of existing pavement removal (done in advance).
2. Remove existing pavement.
3. Prepare existing base or new base.
4. Place Grout Containment system.

5. Before setting panels on the base, install dowel bars in the Barra Glide slots, using the Barra plug to hold the dowel bars in place in the slots. The Barra plugs used at the Hawaii H1 project were plastic; a newer version of the plug uses harder neoprene material.
6. Prepare the panels. Stick foam pads to the Barra Glide side of the panels. The foam pads help to maintain the transverse joint width.
7. Set the panels, maintaining the transverse joint widths as small as possible (width of the foam pads).
8. Release the Gracie base plates. Level the panels using the leveling bolts and using impact wrenches.
9. Apply bedding grout.
10. Slide the dowel bar halves into the companion holes in the previously placed panels.
11. Fill dowel bar slots and the dowel bar holes using the dowel slot grout.
12. Remove the leveling bolts as soon as the bedding grout has set (reached about 2,000 psi), typically within an hour of grouting.
13. Complete finishing activities.
14. Open to traffic.

The installed Rapid Roadway system is shown in figure 7.

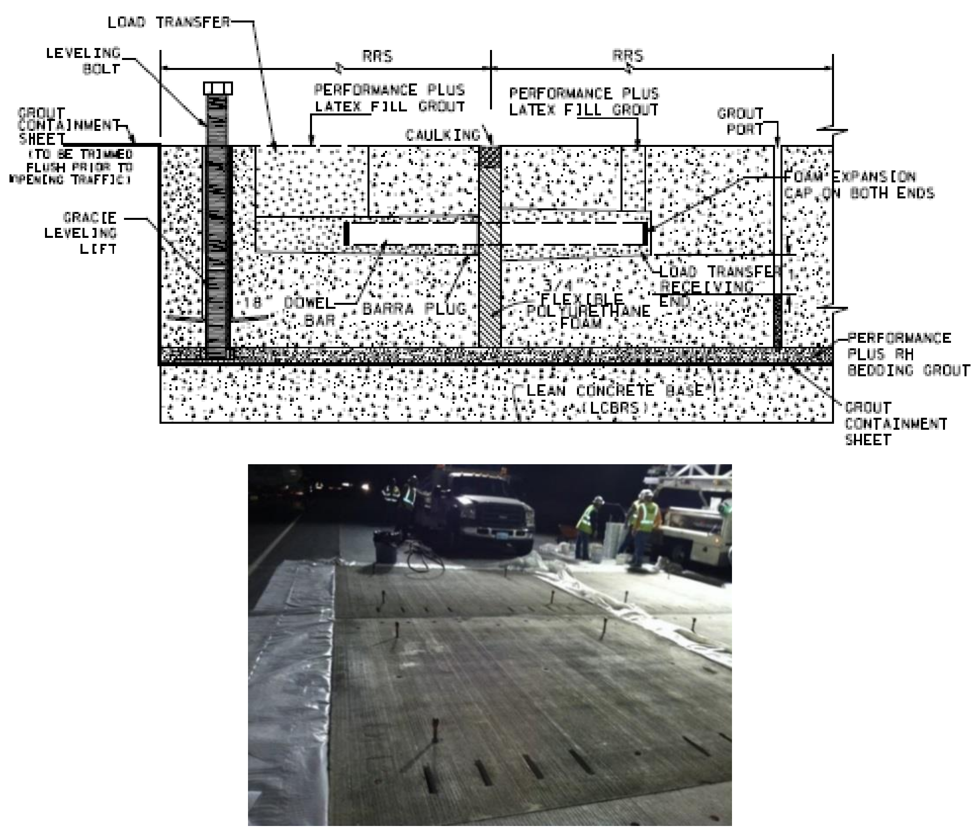

Figure 7. Diagram and photo. The installed Rapid Roadway system.

CONSTRUCTION STAGING AND TRAFFIC-RELATED REQUIREMENTS

For the Hawaii Interstate H1 project, two lanes (including the inside shoulder lane) were made available for traffic during the nighttime work. Installation of precast panels typically requires a minimum of two lane closures—one lane being worked upon and one lane for construction traffic, which includes trucks for removal of the excavated existing pavement, typically the concrete slab pieces and sometimes the existing base material, as well as trucks for delivery of the precast panels. Lane 6 was installed first, followed by lanes 5,4, 3, 2, and 1. Figure 8 shows a typical nightime lane closure.

Figure 8. Photos. Typical nighttime lane closures and traffic flow.

Typically, lane closures started with three lanes at about 6:00 pm, and a fourth lane was closed at about 9:00 pm. Noise variance restrictions took effect at midnight. Panel installation work began about midnight and ended at about 2:30 am to allow for lane closure removal and opening to traffic by about 5:00 am. For the installation of lanes 5 and 6, these two lanes were closed soon after the morning rush hour to allow pavement removal and base preparation work to continue. These lanes remained closed until opening to traffic by about 6:00 am the next day.

Figure 9 shows the morning lane closure and typical traffic flow. Generally, there was no traffic backup due to the nightime lane closures because of the reduced volume of traffic at that time.

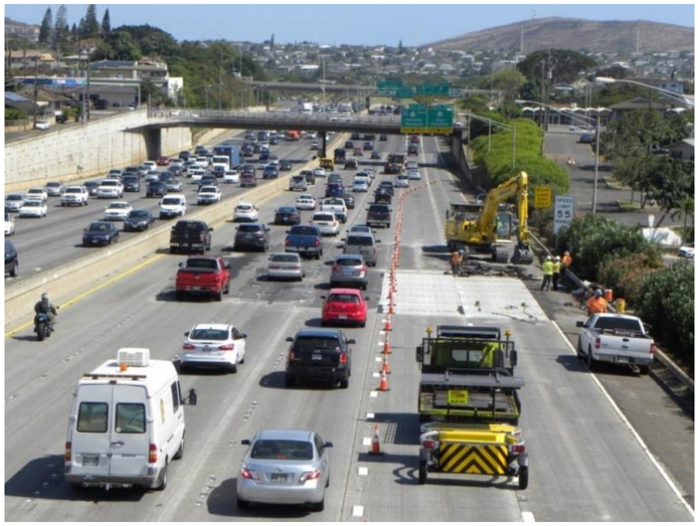

Figure 9. Photo. Daytime closures of lanes 5 and 6.

Before the field installation work started, Hawaii DOT conducted extensive public awareness activities, including posting the project description and regular updates at the DOT’s website. An example of an early posting is given below:

> As part of the H-1 PM Contraflow project, the state Department of Transportation (DOT) will begin repair of an area of longstanding maintenance concern using a proven, pre-cast concrete slab system technology used extensively by other state DOTs to efficiently and cost-effectively repair their highways. Crews will replace approximately 10,000 square feet of concrete pavement in the eastbound direction of the H-1 Freeway in Aiea over a two-week period starting Monday morning, Mar. 23. The work area is a 200-foot section of the H-1 Freeway eastbound, DOT’s contractor will saw-cut and remove the existing pavement, prepare the underlying sub-grade, and install reinforced concrete slabs, constructed at a site in Pearl City, in approximately 12-foot by 12-foot panels. The slabs will be leveled, grouted and secured in place using a dowel and grout system. The installation will allow for a rigid system that can reduce future pavement settlement, be easily installed over a short period of time, and be re-leveled should there be further settlement. The construction schedule will consist of daytime and overnight lane closures. Below is the work schedule on the six-lane freeway:

Monday, Mar. 23 – Thursday, Mar. 26 (Prince Kuhio Day)
10 a.m. – 6 p.m. – Two right lanes closed, four left lanes open
6 p.m. – 9 p.m. – Three right lanes closed, three left lanes open
9 p.m. – 4 a.m. – Four right lanes closed, two left lanes open
Friday, Mar. 27
9 a.m. – 2:30 p.m. – Two right lanes closed, four left lanes open
Monday, Mar. 30 – Thursday, Apr. 2
6 p.m. – 9 p.m. – Three left lanes closed, three right lanes open
9 p.m. – 4 a.m. – Four left lanes closed, two right lanes open

> Using pre-cast concrete panels will allow this repair work to be completed in two weeks versus the six weeks it would take with traditional concrete methods," said Ed Sniffen, DOT Highways Division Deputy Director. "This time-savings is critical to reducing traffic impacts to our motorists and we'll be monitoring this work to determine other locations where pre-cast installations may provide the greatest benefit to the public.

Hawaii DOT also commissioned QMark Research, Honolulu, to conduct an internet-based survey with commuters who regularly drive on the Honolulu-bound Interstate H1 through the Aiea area to assess feedback concerning the use of the PCP repair method being tested. QMark Research sent email invitations using a commercially purchased list and a list provided by Hawaii DOT. The Hawaii DOT list included residents that had contacted Hawaii DOT with questions or concerns related to the planned PCP installation work along Hawaii H1. QMark Research received 332 completed surveys between July 10 and July 19, 2015.

The survey results showed that a solid majority of commuters on this stretch of highway noticed changes for the better as a result of repair work. Fifty-four percent of the respondents indicated that the construction made the road much better than before, and another 36 percent indicated that the repair work resulted in the roadway at least somewhat better. Just 1 percent of the respondents indicated that the work had worsened the roadway conditions. Eight percent indicated that they did not notice any difference.

Appendix A provides more details regarding the survey.

PANEL FABRICATION

The contractor prepared shop drawings for the panels showing the panel fabrication details, including the reinforcement, the leveling lift, and the jointing/load transfer details. The contractor elected to fabricate the panels near the project site, under a Hawaii Interstate H1 flyover that was being worked upon by the contractor. Precast panel casting tables were erected under the flyover, and wood/plywood formwork was used for casting the panels, as shown in figure 10. Six panels at a time were fabricated due the limitation on the availability of the dowel slot blockouts. Casting beds were in the shade under the flyover. The 84 panels were cast over a period of 30 days, requiring about 3,000 man-hours.

As part of the panel fabrication process, the ready-mixed concrete was regularly tested for fresh properties and for strength. The delivered concrete typically exceeded the design compressive strength of 6,000 psi at 28 days. The compressive strength at 24 hours typically exceeded 3,000 psi.

(a) Panel formwork ready for concrete placement

(b) Concrete placement

(c) Panel finishing

(d) Panel storage under the flyover

Figure 10. Photos. Panel fabrication.

PANEL INSTALLATION

The panels were installed between late March and early June 2015. Lanes 5 and 6 panels were installed during late March. Although the work was planned to be completed within a few weeks, it was delayed due to a shortage of bedding grout which had to be shipped from California. Apparently, more bedding grout needed to be used during the panel installation along lanes 5 and 6 because of a larger-than-planned gap between the panel bottom and the base. Panels along other lane 1 to 4 were installed between April and June.

Typically, seven panels were installed per nighttime lane closure. Sawcutting of the existing pavement was performed one or two nights in advance of the panel installation nights. The panel installation, including existing pavement removal, placing the CTB, panel setting, leveling and grouting, and installation of the joint seal required about 3,000 man-hours.

The panel installation process involved removing the existing pavement and placing the panel directly on the grout enclosure system during the first night (stage 1 operation), followed by panel setting to the planned elevation and performing the other follow-up activities during the next lane closure (stage 2 operation). Major sawcutting was done prior to the panel installation lane closures. Sawcutting to the exact length occurred on a nightly basis as the panels were installed. The Rapid Roadway system developer was at the work site during the first few nights of the panel installation and provided guidance on the panel installation process.

The panel installation process was as follows:

- The four left lanes on Hawaii Interstate H1 eastbound at the Aiea Pedestrian Overpass were closed from about 9:00 pm to about 4:00 am.
- The existing concrete pavement, including the AC overlay, was removed (see figure 11). The pavement removal and finishing the base for installation of seven panels, about 84 ft, required about 2.5 hours. The pavement removal was affected by the condition of the existing base. At times, good-quality CTB was encountered, requiring more effort and time to remove an additional 1 inch of the CTB to accommodate the 10-inch-thick precast panel.

Figure 11. Photo. Existing pavement removal.

- The existing base was prepared and graded (see figure 12).

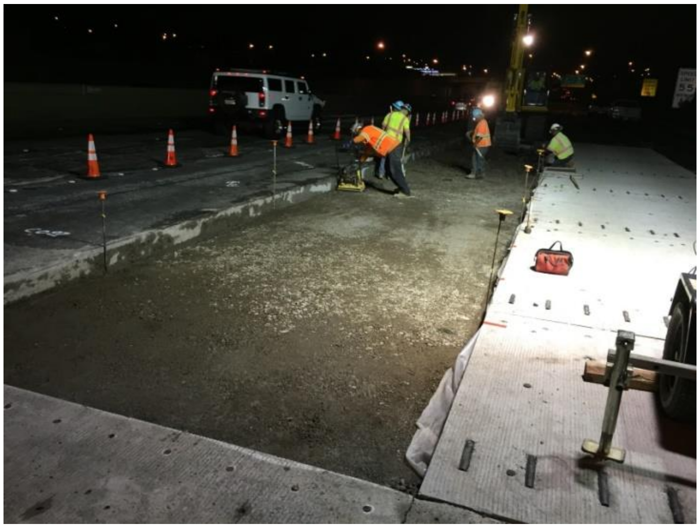

Figure 12. Photo. Existing base grading.

- A mobile mixer was used to place the rapid setting CTB (see figure 13). The CTB placement required about 1 to 2.5 hours. The placement of the lean concrete mix was affected by the quantity required each night. Volumetric mixers (mobile mixers) were used because of the fast setting cement in the mix. Each of the two mixers used was capable of producing 7 to 8 cubic yards of the CTB. When the nightly quantity exceeded the capacity of both mixers, the turnaround time for a third load was about 90 minutes.

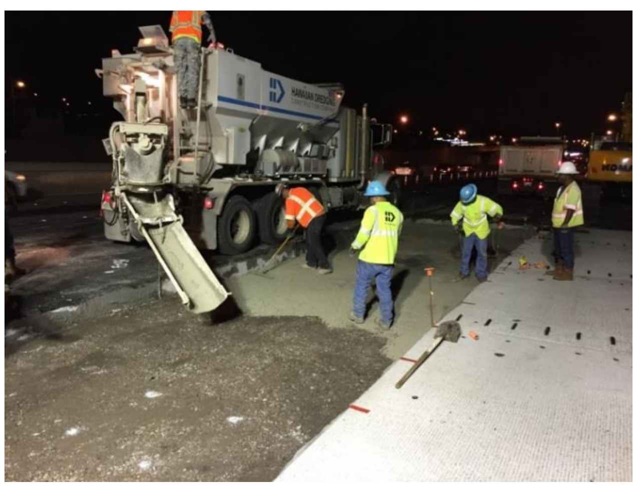

Figure 13. Photo. CTB placement using a mobile mixer.

- A final CTB grading was performed to ensure that the bedding grout use would be minimized. Refinements to the placing and finishing of the lean concrete mix were made, as uneven surfaces during the first few installations required high volumes of the bedding grout. Mechanical screeding of the lean concrete mix produced desired results with respect to the smoothness of the CTB.

- The polyethylene grout enclosure was placed over the prepared CTB and the sides of the adjacent lanes (see figure 14).

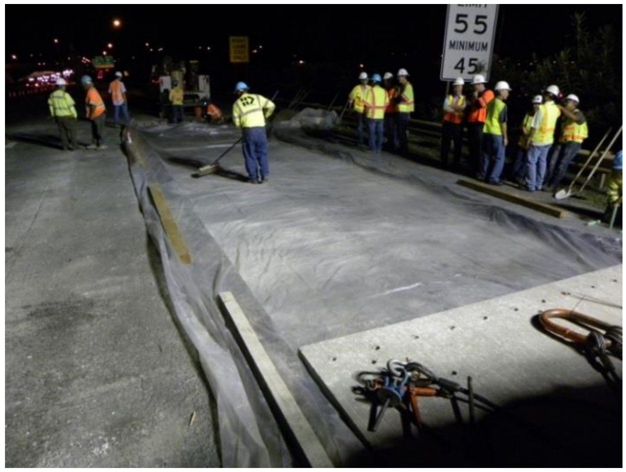

Figure 14. Photo. Placement of the grout enclosure.

- Dowel bar holes were drilled in the existing pavement (leave or approach end).
- Panels were placed as shown in figure 15. Turnbuckles were used to ensure a tight fit between panels (see figure 16). The panel placement took about 1.5 to 2.5 hours.

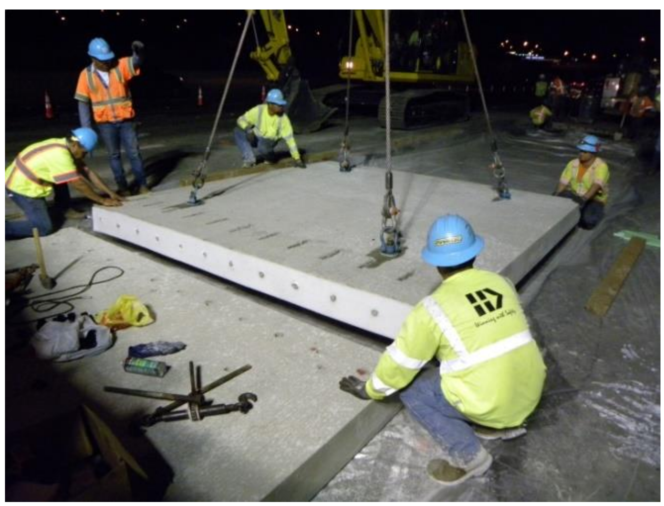

Figure 15. Photo. Panel installation.

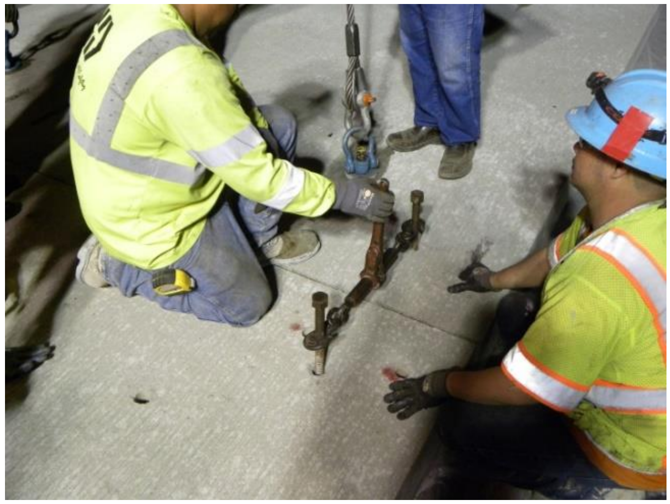
Figure 16. Photo. Turnbuckle use to ensure a tight fit between panels.

- A treatment was applied using an AC mixture to account for the adjacent lane elevation difference. As excavation, bedding preparation and panel placement could take up to 7 hours, bedding grout was not always possible during the lane closures allowed. At these times, AC was used to provide a transition between either adjacent panels or existing pavement.
- Completion of stage 1 operation allowed for traffic to use the repaired lane during peak hour traffic the next morning, as shown in figure 17.
- The stage 2 operation began by engaging the Gracie Leveling system to set panels at the planned elevation.
- The Barra Glide load transfer installation was completed by sliding the dowel bars from the slot into the dowel holes in the adjacent panels.
- Bedding grout was applied. Early applications of the bedding grout took up to 2.5 hours. With proficiency, the application time was reduced to only 1 hour. The installation of the bedding grout depended on the placement of the lean concrete. The contractor took more time and care in the placing of the lean concrete to minimize the quantity and the time needed for the application of bedding grout. Ultimately, a system was devised using a vibratory screed and pipe rails for bridge deck concrete pours to control the elevation and flatness of the lean concrete.
- Finishing operations were performed.
- Completion of stage 2 opening to traffic.

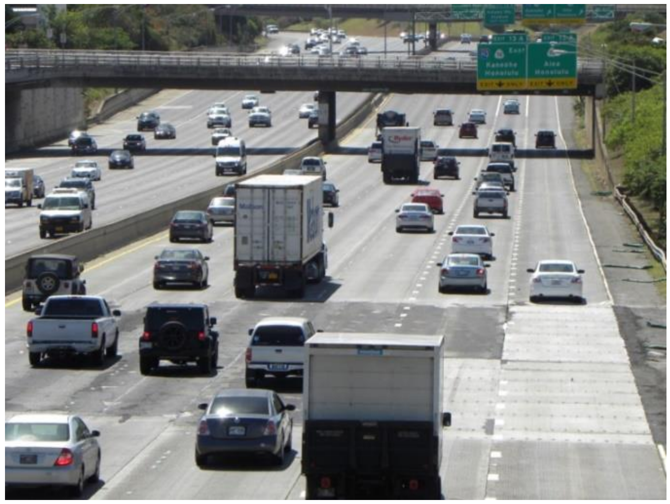

Figure 17. Stage 1 (next morning) opening to traffic.

The noise variance along this section of Hawaii Interstate H1 required noisy activities to cease by midnight. These activities included the placement of the lean concrete and the application of the bedding grout. The contractor was allowed to start lane closures at 6:00 pm. Due to the number of lanes involved in the lane closures, the setup took approximately 30 to 45 minutes. Removal of the lane closures took about 1 hour. The contractor had about 6 to 7 hours of working time during each lane closure.

The CTB and the bedding grout were tested regularly. Typical CTB strength at 2 hours was about 70 psi. Typical bedding grout strength at 1 hour was about 4,000 psi.

For this first installation of PCP in Hawaii, panel installation at some locations did not meet the elevation tolerance of 0.25 in. at the transverse joint between adjacent panels. Spot grinding at these spots provided for a smoother ride that was recognized by the majority of the public surveyed. Figure 18 shows a view of the completed project.

Figure 18. Photo. Completed Hawaii Interstate H1 PCP project.

SUMMARY

The Hawaii Interstate H1 PCP project is considered a successful demonstration of the PCP technology by an agency that had not been exposed to the technology previously. The Interstate H1 has no alternate route with similar capacity. The minimal queues and complaint volume experienced indicated minimal distraction to traffic in the off peak times and no impact during the peak hours traffic. Although the installation period was extended from a few weeks to several months due to the shortage of bedding grout that resulted from a higher volume of the bedding grout used during the initial two lanes of installation, the project progressed smoothly after that. The active interactions by the Hawaii DOT design and construction engineers during the planning phase and during the construction phase led to several refinements on the project. The experience gained by Hawaii DOT engineers and inspectors at this project allowed Hawaii DOT to optimize design and construction details for another PCP project funded under FHWA's Highways for LIFE program. This second PCP project along a section of Middle Street in the District of Honolulu was constructed later in 2015.

As determined from a user survey conducted after the completion of the repair work, a solid majority of commuters on this stretch of highway noticed changes for the better as a result of repair work. Fifty-four percent of the survey respondents indicated that the construction made the road much better than before, while another 36 percent indicated that the repair work resulted in the roadway at least somewhat better. Just 1 percent of the respondents indicated that the work had worsened the roadway conditions. Eight percent indicated that they did not notice any difference.

ACKNOWLEDGMENTS

The support of the following individuals during the data collection for this report and the kind welcome offered during the training workshops and construction site visit is gratefully acknowledged:

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- Glen M. Koki, Hawaiian Dredging Construction Co.

APPENDIX A. USER SATISFACTION SURVEY

Hawaii DOT commissioned QMark Research, Honolulu, to conduct an internet-based survey with commuters who regularly drive on the Honolulu-bound Interstate H1 through the Aiea area to assess feedback concerning the use of new precast concrete pavement repair method being tested. QMark Research sent email invitations using a commercially purchased list and a list provided by Hawaii DOT. The Hawaii DOT list included residents that had contacted Hawaii DOT with questions or concerns related to the planned PCP installation work along Hawaii Interstate H1.

QMark Research received 332 completed surveys between July 10 and July 19, 2015. This represents a margin of error of ± 5.77 percent at the 95 percent level of confidence. The respondents were screened to ensure they met the minimum criteria as far as their use of Interstate H1 (town-bound) and were classified as shown in table 1.

Table 1. How often users drive on H1.

Frequency	Respondents (n=332)
Five days a week or more	95
One or two days each week	105
At least once a month	32

The respondents were also asked to classify themselves into certain transportation categories, as shown in table 2.

Table 2. Driver categories.

Category	Respondents (n=332)
Driver–car/truck	272
Driver–motorcycle	2
Passenger–private vehicle	48
Passenger–public transit	10

The invited respondents were given a unique password and a website link to complete the survey. The resulting data were analyzed using specialized survey research software, SPSS, version 23. The participants were asked for their thoughts on the just-completed Hawaii Interstate H1 (Aiea Area) precast concrete pavement repair project.

The respondents were first asked to read the description about the traditional process for concrete pavement repair and then to read the description of the process used for the first time in Hawaii for the Hawaii Interstate H1 precast concrete pavement repair project. The descriptions of the two repair processes provided to the respondents are shown on the next page.

TRADITIONAL CONCRETE ROAD REPAIRS

The traditional construction and installation of full-depth repairs involve the following steps:

1. Close road to traffic.
2. Define repair boundaries area.
3. Sawcut out the old concrete.
4. Remove the old concrete.
5. Prepare the patch area.
6. Place and finish concrete. Steps involved are:
    a. Forms are built, rebar placed and spaced and then concrete poured on site.
    b. Allow the concrete to cure for 7 days.
    c. Remove forms.
    d. Saw and seal joints.
    e. Open lanes to the travelling public.

PRECAST CONCRETE PAVEMENT REPAIRS

Precast concrete pavement systems do the same thing as steps 1 through 5 in the traditional process. However, for the precast concrete pavement repair, the concrete panels are cast and cured in a controlled environment off-site. The panels are then transported to the project site and installed overnight, allowing traffic to drive on the pavement the next morning. This accomplishes several things:

- Reduces disruption to the traveling public. Lanes are not closed for long periods of time while the concrete cures.
- Reduces the time the construction takes on the project site.
- Increases safety for the workers and traveling public by lessening the exposure to construction.
- Increases the life of the pavement as the pavement construction is taking place in a controlled environment.
- For the reasons stated above, there are savings realized in utilizing less traffic control, less maintenance as pavements last longer and less disruption to the traffic public. The indirect cost savings is difficult to quantify.

Respondents were instructed to quantify their perceptions using a standard 4-point rating scale. The results are given in table 3.

Table 3. User perceptions of PCP repairs.

Response	**Overall %**
Much better (4)	36
Somewhat better (3)	48
NET BETTER	84
Somewhat worse (2)	12
Much worse (1)	5
NET WORSE	17
MEAN	3.14

Respondents were also instructed to quantify their perceptions using a standard 4-point rating scale. The results are given in table 4.

Table 4. User satisfaction ratings.

Response	**Overall %**	**Frequent Highway User % (5+ times a week in area)**
Very satisfied (4)	19	20
Somewhat satisfied (3)	55	43
NET SATISFIED	74	63
Somewhat dissatisfied (2)	18	23
Very dissatisfied (1)	8	14
NET DISSATISFIED	26	37
MEAN	2.84	2.69

Participants were then presented with two videos provided by Hawaii DOT showing a vehicle traversing the stretch of highway in question before work began and after construction. Respondents were instructed to quantify their perceptions using a standard 5-point rating scale. The results are given in table 5.

Table 5. Participant perceptions of Hawaii DOT video.

Response	**Overall %**
Much better (5)	54
Somewhat better (4)	36
NET BETTER	90
Somewhat worse (2)	1
Much worse (1)	0
NET WORSE	1
No difference (3)	8
MEAN	4.42

The survey results showed that a solid majority of commuters on this stretch of highway noticed changes for the better as a result of repair work.