Hawaii Demonstration Project:

Precast Concrete Pavement System along a Section of Middle Street, Honolulu, HI

Draft Technical Brief
June 2015

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

U.S. Department of Transportation
Federal Highway Administration

FOREWORD

The purpose of the Highways for LIFE (HfL) pilot program is to accelerate the use of innovations that improve highway safety and quality while reducing congestion caused by construction. **LIFE** is an acronym for **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges.

Specifically, HfL focuses on speeding up the widespread adoption of proven innovations in the highway community. Such “innovations” encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

Although innovations themselves are important, HfL is as much about changing the highway community’s culture from one that considers innovation something that only adds to the workload, delays projects, raises costs, or increases risk to one that sees it as an opportunity to provide better highway transportation service. HfL is also an effort to change the way highway community decision makers and participants perceive their jobs and the service they provide.

The HfL pilot program, described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1502, includes funding for demonstration construction projects. By providing incentives for projects, HfL promotes improvements in safety, construction-related congestion, and quality that can be achieved through the use of performance goals and innovations. This report documents one such HfL demonstration project.

Additional information on the HfL program is at www.fhwa.dot.gov/hfl.

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16. Abstract
As a part of the Federal Highway Administration (FHWA) Highways for LIFE initiative, a Federal grant of $3,000,000 was awarded to the Hawaii Department of Transportation (DOT) to demonstrate the use of a proven, innovative precast concrete pavement (PCP) system in conjunction with traditional pavement restoration and concrete overlay on an important multilane highway. The project represents Hawaii DOT's effort to introduce two different PCP systems, a construction option that is easy to build, easy to install, easy to maintain, and will have a long service life. One system to be used is a jointed PCP system, and the second system is a posttensioned PCP system. This demonstration project will provide Hawaii DOT the opportunity to experience two different PCP systems and to compare this innovative paving technology with traditional concrete paving.

This progress report details the planning for the project. The project was bid and awarded during 2014, and panel fabrication and panel installation is expected to take place during the summer of 2015.

17. Key Words	18. Distribution Statement
Highways for LIFE, PCP, precast pavements, posttensioned PCP, jointed PCP	No restriction. This document is available to the public through the Highways for LIFE website: http://www.fhwa.dot.gov/hfl/

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Unclassified	Unclassified	17	

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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
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m^2
		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
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela per square meter	0.2919	foot-Lamberts	fl
		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)

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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ABBREVIATIONS AND SYMBOLS

DOT	department of transportation
FHWA	Federal Highway Administration
HfL	Highways for LIFE
IRI	International Roughness Index
NPCA	National Precast Concrete Association
OBSI	onboard sound intensity
OSHA	Occupational Safety & Health Administration
PCI	Precast/Prestressed Concrete Institute
PCP	precast concrete pavement
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

Highways for LIFE (HfL) is the Federal Highway Administration's (FHWA) initiative to advance longer-lasting and promote efficient and safe construction of highways and bridges using innovative technologies and practices. The HfL program provides incentive funding to highway agencies to try proven but little-used innovations on eligible Federal-aid construction projects. The HfL team prioritizes projects that use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the applicant State has never or rarely used, even if it is standard practice in other States. Recognizing the challenges associated with deployment of innovations, the HfL program provides incentive funding for up to 15 demonstration construction projects a year. The funding amount typically totals up to 20 percent of the project cost, but not more than $5 million.

The HfL program promotes project performance goals that focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. The goals are categorized into the following categories:

1. **Safety**
   a. Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
   b. Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported on Occupational Safety and Health Administration (OSHA) Form 300.
   c. Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.
2. **Construction Congestion**
   a. Faster construction —Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
   b. Trip time during construction — Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
   c. Queue length during construction—A moving queue length of less than 0.5 miles in a rural area or less than 1.5 miles in an urban area (in both cases at a travel speed 20 percent less than the posted speed).
3. **Quality**
   a. Smoothness—International Roughness Index (IRI) measurement of less than 48 inches/mile.
   b. Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.
4. **User Satisfaction**

a. An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4 or more on a 7-point Likert scale.

PROJECT OVERVIEW

The Hawaii Department of Transportation (DOT) was awarded a $3,000,000 HfL grant to demonstrate the use of a proven, innovative precast concrete pavement (PCP) system in conjunction with traditional pavement restoration and concrete overlay on an important multilane highway. The project represents Hawaii DOT's effort to introduce two different PCP systems, a construction option that is easy to build, easy to install, easy to maintain, and will have a long service life. One system to be used is a jointed PCP system, and the second system is a posttensioned PCP system. This demonstration project will provide Hawaii DOT the opportunity to experience two different PCP systems and to compare this innovative paving technology with traditional concrete paving.

This progress report details the planning for the project. The project was bid and awarded during 2014, and panel fabrication and panel installation is expected to take place during the summer of 2015.

PROJECT DETAILS

PROJECT BACKGROUND

The 0.51-mile project is located along a section of Middle Street in Honolulu, near Honolulu International Airport. It is a four-lane roadway with turn lanes along the median. Middle Street connects Nimitz Highway and King Street and is home to both a bus storage facility and a heavy trash transfer station. The project location is shown in figure 1. A view of the existing roadway along Middle Street is shown in figure 2.

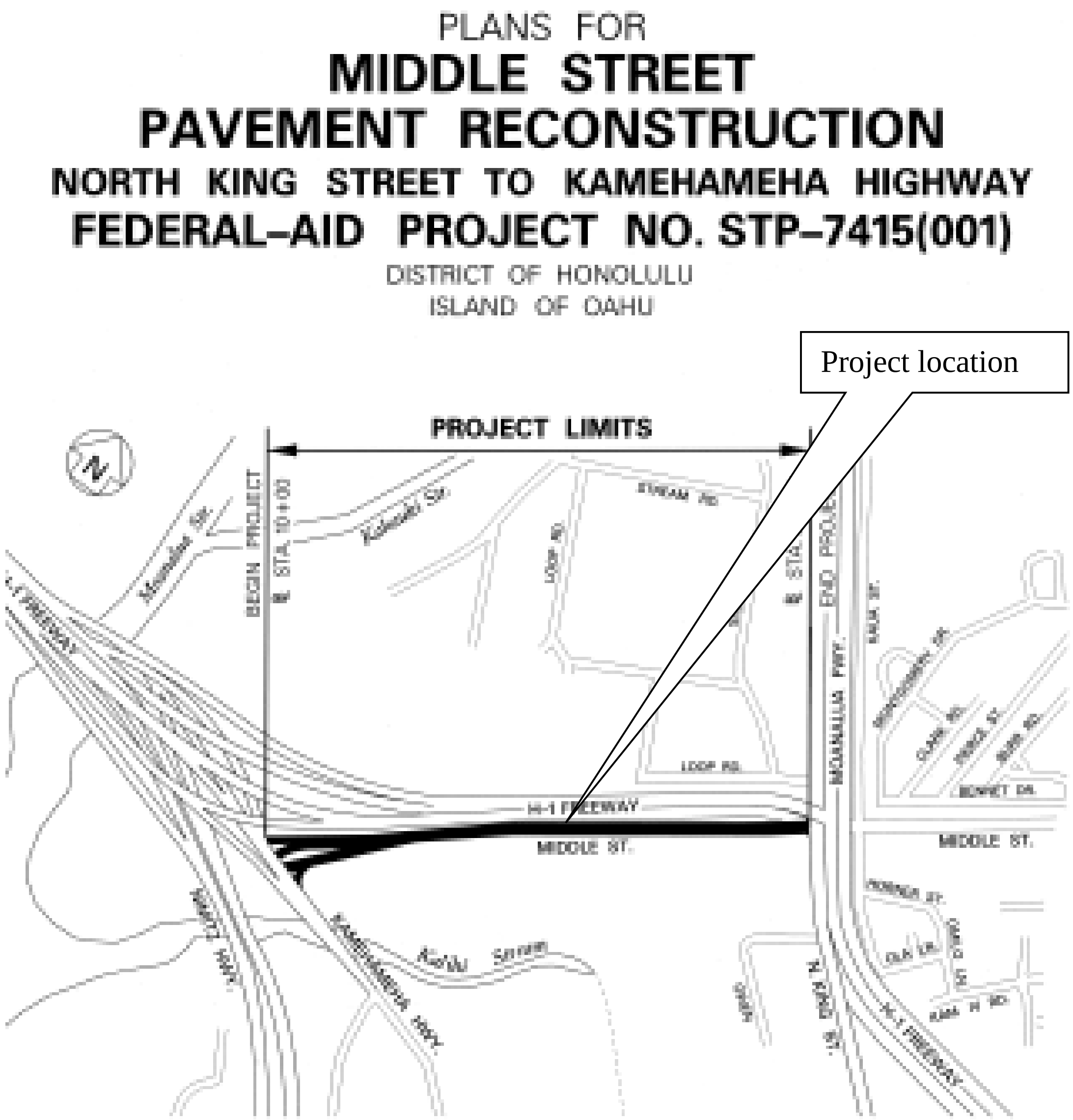

Figure 1. Map. Project location.

Figure 2. Photo. View of Middle Street.

The road experiences heavy bus and truck traffic 24 hours a day. Precast concrete construction will minimize inconvenience to users that need access at all times, and the PCP system is expected to provide a durable, long-lasting surface.

The scope of the project includes rehabilitation of the existing asphalt pavement in both directions. Two different PCP systems will be used, and a control section using a conventional concrete paving technique is also included in the project. While PCP technology is not new to many States, this project was the first of its kind planned for Hawaii.

The Engineer's estimates for the two PCP sections were as follows:

1. Jointed PCP: $930,000.
2. Posttensioned PCP: $900,000.

The proposed layout of the PCP and control sections is shown in Figure 3. The blue sections in the figure are jointed PCP, red sections are posttensioned PCP, and yellow sections are conventionally paved jointed concrete pavement.

The Middle Street layout is shown in Figure 4.

Figure 5 summarizes relevant traffic data for the subject section of Middle Street.

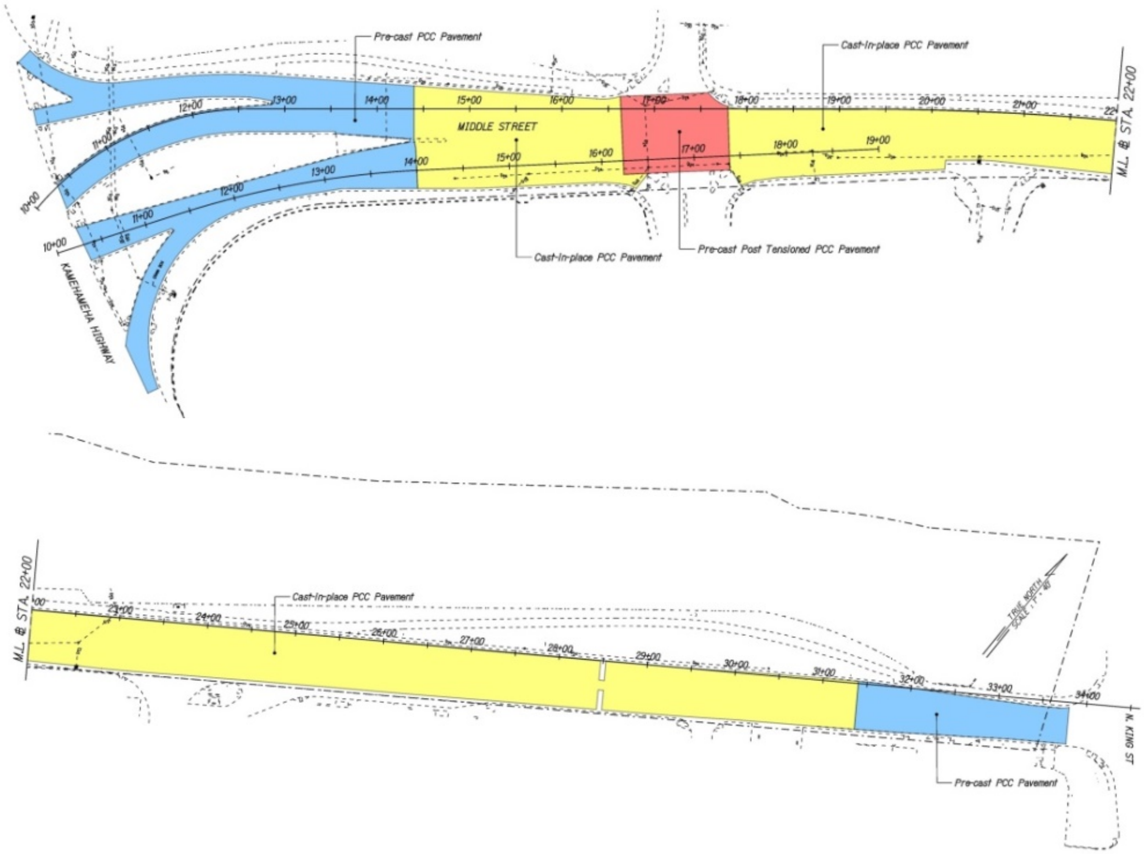

Figure 3. Diagram. Proposed test section layout.

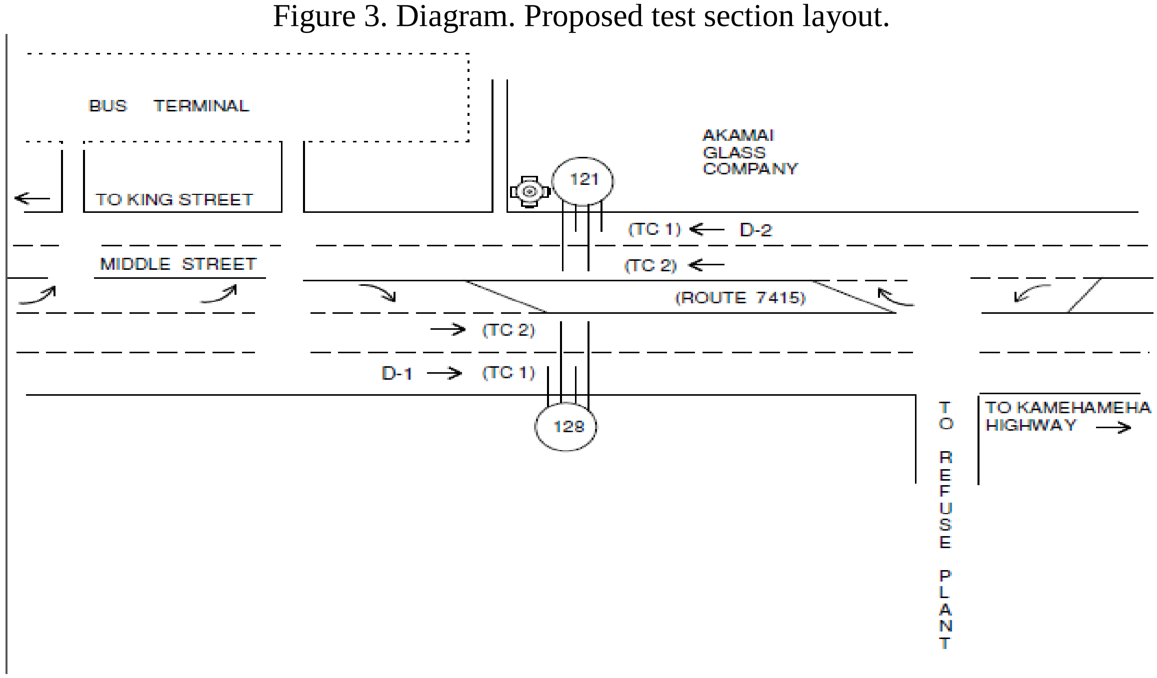

Figure 4. Diagram. Middle Street layout.

Run Date: 2013/03/12

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2012

Site ID: B72741500000 Route No: 7415 Date From: 2012/11/27 0:00
Town: Oahu Direction: +MP Date To: 2012/11/28 23:45
Location: MIDDLE ST, 0.25 MILE N.E. OF KAM Hwy - K

Functional Classification: 16 URBAN:MINOR ARTERIAL
REPORT TOTALS - 48 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	1048	3.85%	2096
PC	19437	71.40%	38875
2A-4T	4558	16.74%	9116
LIGHT VEHICLE TOTALS	25044	91.99%	50087
HEAVY VEHICLES			
Bus	631	2.32%	1578
SINGLE UNIT TRUCK			
2A-6T	1013	3.72%	2026
3A-SU	332	1.22%	996
4A-SU	7	0.03%	28
SINGLE-TRAILER TRUCKS			
4A-ST	57	0.21%	228
5A-ST	96	0.35%	480
6A-ST	30	0.11%	180
MULTI-TRAILER TRUCKS			
5A-MT	0	0.00%	0
6A-MT	0	0.00%	0
7A-MT	15	0.06%	105
HEAVY VEHICLE TOTALS	2181	8.01%	5621
CLASSIFIED VEHICLES TOTALS	27225 (A)	100.00%	55708 (B)
UNCLASSIFIED VEHICLES TOTALS	-1	-0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.977

ROADTUBE EQUIVALENT(B/2) = 27854 (C)

PEAK HOUR VOLUME : 1066 2012/11/27 07:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	59	(65A-1) 5.97%	927	12400	(65A-2) 7.48%	8.60%
COMBINATION (TYPE 8-13)	10	(65B-1) 1.01%	92		(65B-2) 0.74%	8.60%

Figure 5. Middle Street traffic data summary.

PAVEMENT DETAILS

The following two PCP systems will be installed:

1. Jointed PCP – The as-designed system requires panel installation using leveling bolts and setting the panels at the designated elevation. The system incorporates the following:
    a. Panel length: 12 ft typical.
    b. Panel width: 12 ft typical.
    c. Placement of a rapid setting lean concrete base. Compressive strength at time of panel placement to be greater than 500 psi.
    d. Use of a rapid setting bedding grout under the panel, typically about 1 inch thick. Compressive strength at time of opening to traffic of 500 psi.
    e. Use of a leveling system to set the panels at the designated elevation.
    f. Use of a bedding grout containment system, typically using a plastic sheet.
    g. Use of a load transfer system, incorporating a slot on one side of the panel and a circular/elliptical hole on the other side of the panel.
    h. Use of a dowel bar plug to hold the dowel bar in proper alignment.
    i. Use of latex modified grout for load transfer slot and holes. Compressive strength at 1 hour to be not less than 3,000 psi.
2. Posttensioned PCP – The as-designed system requires installation of a number of panels and posttensioning the panels together. The posttensioning results in a midsection prestress of about 150 to 200 psi, depending on the prestressing system design and the number of panels included in the posttensioned section. The system incorporates the following:
    a. Panel length: 12 ft typical.
    b. Panel width: 10 ft typical.
    c. Panel thickness: 10 inches.
    d. Posttensioned section length, longitudinal: 120 ft (10 panels).
    e. Posttensioned section length, transverse: 50 ft (5 panels).
    f. Panels to be pretensioned in longitudinal and transverse directions.
    g. Placement of a rapid setting lean concrete base. Compressive strength at time of panel placement to be greater than 500 psi.
    h. Use of a panel/base interlayer, typically a plastic sheet.
    i. Use of prestressed (pretensioned) panels, depending on the panel length.
    j. Use of a prestressing system, consisting of ducts in the panel, prestressing tendons (0.6 inches in diameter), anchorage plates, gaskets at intermediate joints (between panels), and grout for the ducts.
    k. Expansion joint system, consisting of dowel bars for load transfer and a sealant that can accommodate the seasonal expansion and contraction of the posttensioned segments.

The rest of the project will use cast-in-place jointed concrete pavement with transverse joint spacing ranging from 12.5 to 15 feet.

CONSTRUCTION DETAILS

The project specifications require construction of a test strip, at least 60 feet long for each pavement type, within the project area. Also, precasting plants are required to hold current certification by the National Precast Concrete Association (NPCA) or the Precast/Prestressed Concrete Institute (PCI) as applicable to the type of reinforced panel being fabricated. Tolerances for panel dimensions are shown in table 1.

Table 1. PCP panel tolerances.

Dimension	Tolerance
Length	±1/4 inches
Width	±1/4 inches
Thickness	±1/8 inches
Difference in diagonal	±1/4 inches
Edge squareness	±1/8 inches in 12 inches
Blackout dimensions	±1/4 inches
Local smoothness of any surface	±1/4 inches over 10 feet in any direction
Location of lifting inserts	± 1/2 inches

Other key construction details for the PCP sections include the following:

1. Concrete compressive strength shall be at least 2,500 psi before stripping panels.
2. Acceptance requirements:
    a. Panel elevation difference across any edge of the panel shall not exceed 0.125 inch.
    b. Contractor shall replace all damaged or defective panels before final acceptance. Damaged or defective panels include panels whose manufacture, material, or installation does not conform to the contract documents at the time for acceptance. The Engineer may allow repair of minor defects by accepted methods.
    c. Cracked panels shall not be accepted except as determined by the Engineer that the cracks pose no loss of quality or durability of the panel. Cracks shall be sealed as directed by the Engineer.

Key construction details for the posttensioned PCP include the following:

1. Grout for bonding the posttensioned strand shall be a prepackaged Post Tensioning Institute Class B grout designed for bonding of posttensioned structures. The grout shall meet or exceed the testing requirements of PTI M55.1, Specification for Grouting of Post-Tensioned Structures, except as modified per the specification.
2. Mortar to fill anchor head blackouts in panels shall be a two component, polymer-modified, cementitious, non-sag mortar such as Duraltop Gel or Sikatop 123 or accepted equal. Mortar shall contain a migrating, amine-carboxylate corrosion inhibitor.

3. Bonding agent for the mortar to fill the anchor head blackouts shall be a three component, solvent-free, epoxy modified, cementitious bonding agent and anticorrosion coating such as Duralprep AC or Sika Armatec 110 Epocem or accepted equal.
4. Material for joint gasket shall be a closed cell foam material that is secured around the duct at the joint that provides an air tight seal. The gasket shall allow up to 1/8 inch misalignment and 6 degrees deviation from perpendicular. The gasket shall be compatible with prestressing steel, concrete, grout, and duct material and not interfere with panel assembly.
5. Epoxy resin for interior joints of prestressed, posttensioned PCP slabs shall be thermosetting and composed of 100 percent solids, no solvents, and comply with the requirements of ASTM C881, Type VI, Grade 3. The epoxy resin shall be designed to function as a joint lubricant during the placement and posttensioning operation and fill any gaps in the joint while providing a durable water tight bond in its hardened state. The epoxy bonding agent shall be moisture tolerant and exhibit high bond strength, good water resistivity, low creep characteristics, and tensile strength greater than the concrete.
6. All prestressing components, including duct, grout caps, and anchors, shall conform to the requirements of PTI M50.3-12 Chapter 4, Material and Performance Requirements. Section 4.3.7- Heat-shrink sleeves shall not be allowed.

CURRENT STATUS

A pre-bid conference was held during August 2014, and the project was bid during the same month. Bids were opened on September 5, 2014. The winning bid was submitted by Goodfellow Brothers, Inc. The project includes:

1. Reconstruction of Middle Street concrete and asphalt pavements.
2. Constructing cast-in-place jointed concrete pavement, jointed PCP, posttensioned PCP, and sidewalk and driveway improvements.
3. Installing hot mix asphalt overlay for shared use path, guardrails, end treatments, concrete curbs and gutters, highway lighting, loop detectors, traffic signal backplates, pavement markings, and vehicle overload detection system.
4. Cleaning existing culverts.
5. Traffic control.

The bids for the PCP projects were as follows:

1. Jointed PCP (10 inches thick; 370 cy): $875,000.
2. Posttensioned PCP (260 cy) - $700,000.

The 10-inch-thick cast-in-place jointed concrete pavement (2,350 cy) was bid at $475,000.

As of mid-May 2015, the contractor’s construction schedule indicates the following:

1. Conventional JCP paving: begin June 2015 and continue through November 2015.
2. Jointed PCP: Begin July 2015 and continue through February 2016.
3. Posttensioned PCP: During February 2016.

ACKNOWLEDGMENTS

The project team acknowledges the invaluable insights and guidance of Highways for LIFE Team Leader Byron Lord and Program Coordinator Ewa Flom, who served as the technical panel on this demonstration project. Their vast knowledge and experience with the various aspects of construction, technology deployment, and technology transfer helped immensely in developing both the approach and the technical matter for this document. The team also is indebted to Hawaii DOT engineers Paul Santo and Pratt Kinimaka and FHWA Engineer Domingo Galicinao, for their advice and assistance during this project.