

**Mid-Atlantic QA Workshop
Dover, Delaware – February 14, 2018**

**RAPID/OVERNIGHT RENEWAL OF HIGH VOLUME
ROADWAYS USING PRECAST CONCRETE PAVEMENT
TECHNOLOGY**



*Shiraz Tayabji, Ph.D., PE
Advanced Concrete Pavement Consultancy LLC
Fulton, Maryland
stayabji@gmail.com; Phone: 410-707-4902*

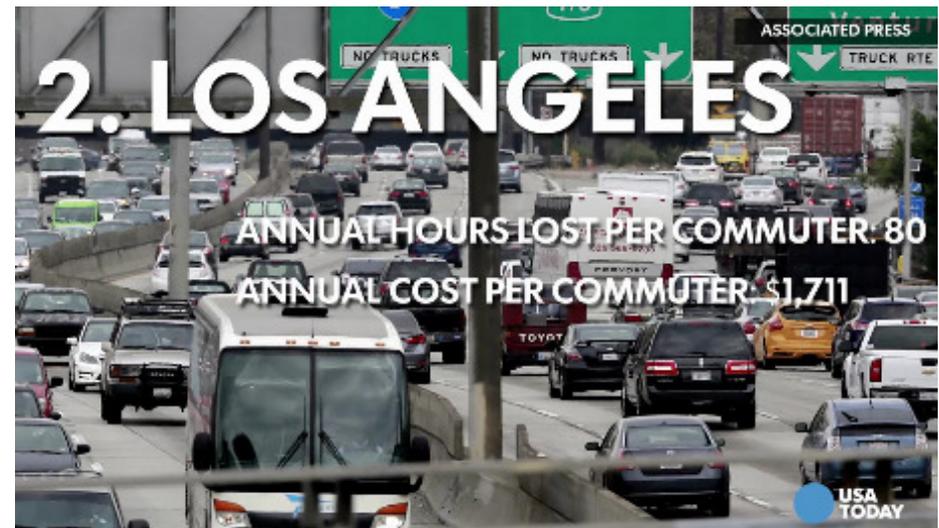
(On behalf of Evan Gurley, NPCA)

The Problem

- Thousands of miles of concrete pavements were constructed during the Interstate construction during 1960's and 1970's and many thousands before that and after that
- Many of these concrete pavements and also asphalt pavements are in need of repair/rehabilitation or reconstruction
- In high traffic urban areas, we cannot afford to close lanes to perform the repairs/rehab – the work has to be done during short night-time work windows

Pavement Rehab Under Heavy Traffic

A very serious issue throughout urban US

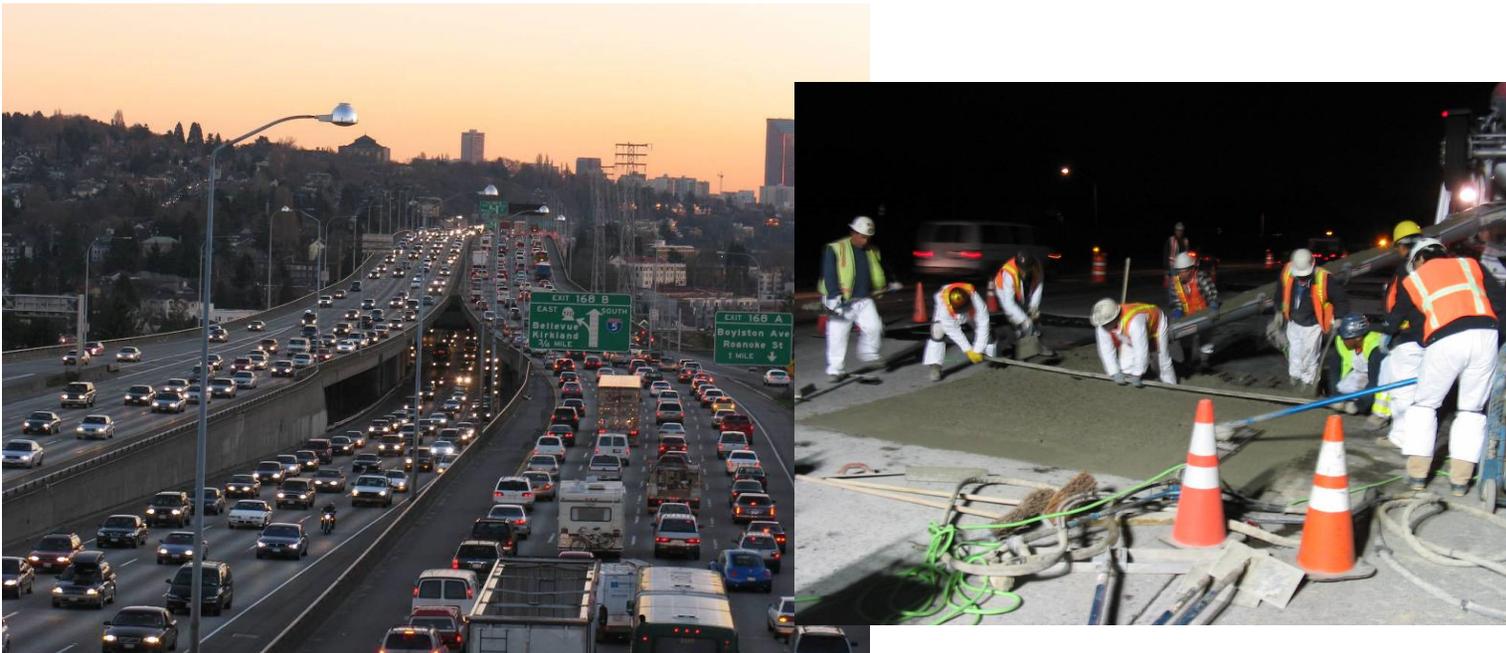


Congestion problem relates to capacity, but we as pavement engineers and technologists should not compound the problem by designing and constructing poorly performing pavements and repair/rehabilitation

- **No More Fix the Fix**

Serious Need - Rapid & Longer Lasting Rehab Under Heavy Urban Traffic

A very challenging issue throughout urban US



Conventional shorter closures may possibly lead to shorter service life
& longer service life techniques typically require longer lane closures

Serious Need - Rapid & Longer Lasting Rehab Under Heavy Traffic

The challenge: shorter lane closure & longer service life

The use of precast concrete pavement addresses this challenge



For pavement repair & rehabilitation, shorter life cannot be accepted as the price of rapid renewal

Traffic Congestion - 2040

**A problem waiting for a solution!
And it is getting worse every year!**



To Summarize the Need

- In the US, short lane closures for pavement repair/rehab using cast-in-place concrete **has not consistently** resulted in durable concrete or long-term well performing treatments
- **On high volume roadways, we can no longer risk/afford using treatments that are not durable**
- Use of precast concrete pavements (PCPs) addresses this concern/limitation
 - A rapid repair/rehabilitation technology that incorporates durable concrete and is long-lasting.

An Industry Question

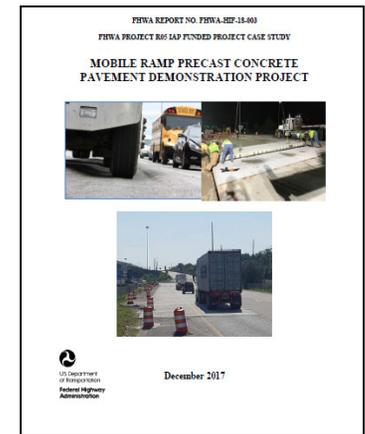
How Big is the PCP Market?

- All metro area in the US – high volume of traffic over 50,000 vpd
 - Any area with rush hour congestion or all day congestion
 - Areas where alternate routes/detours are not possible
 - Where repairs can only be done at night
- Potential
 - We are barely scratching the surface today
 - Note: 1 lane-mile rehab needs about 350 panels
 - We have thousand of miles of the interstate and primary highway systems to rehab/reconstruct over the next 10 years
 - **A problem waiting for a “precast concrete” solution!**
 - **And, we have not even started serious applications at airports/airfields**

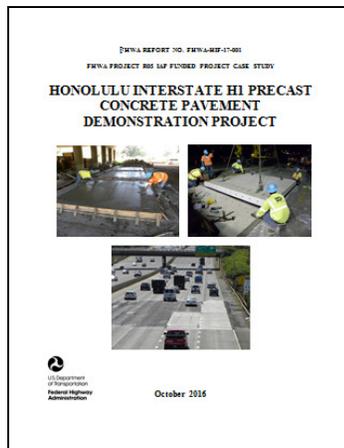
Outline

- Background
- FHWA SHRP2 Implementation Assistance Program
- Case Studies
 - 2015 – Hawaii, Kansas, Wisconsin
 - 2016 – Connecticut, Texas
 - 2017 – Alabama
 - 2018 – Florida, Louisiana, Pennsylvania
- Summary

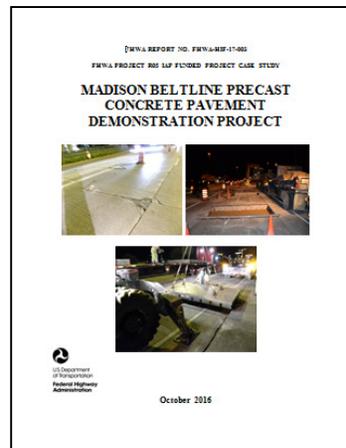
Alabama



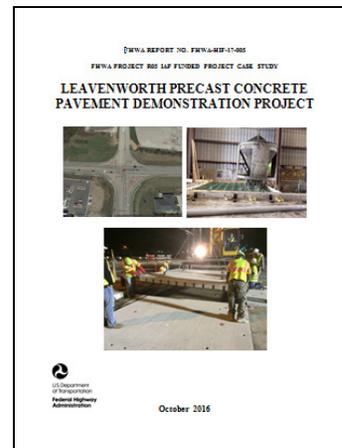
Hawaii



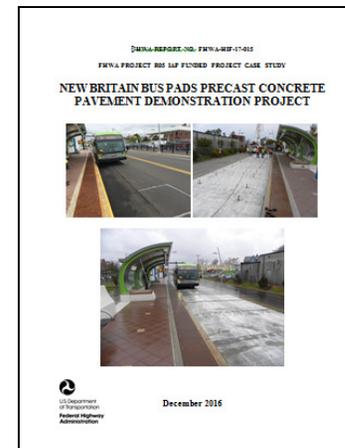
Wisconsin



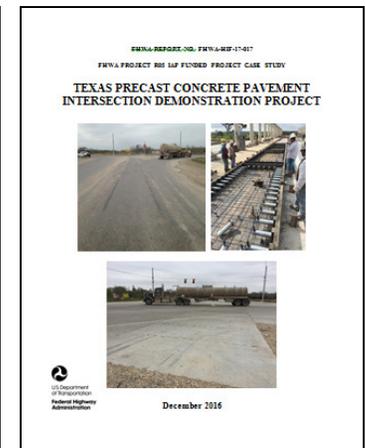
Kansas



Connecticut



Texas



Precast Concrete Pavement

- A Definition

- Precast concrete pavements (PCPs) incorporate precast concrete panels that are fabricated or **assembled off-site**, transported to the project site and installed over a prepared foundation (new or re-graded existing base).
- The pavement components require **minimal field curing or time** to achieve strength before opening to traffic.
- PCPs are primarily used for **rapid repair, rehabilitation and reconstruction** of asphalt and concrete pavements where work can only be done **night-time short lane closures**

A Typical Repair Installation

NJ I-295

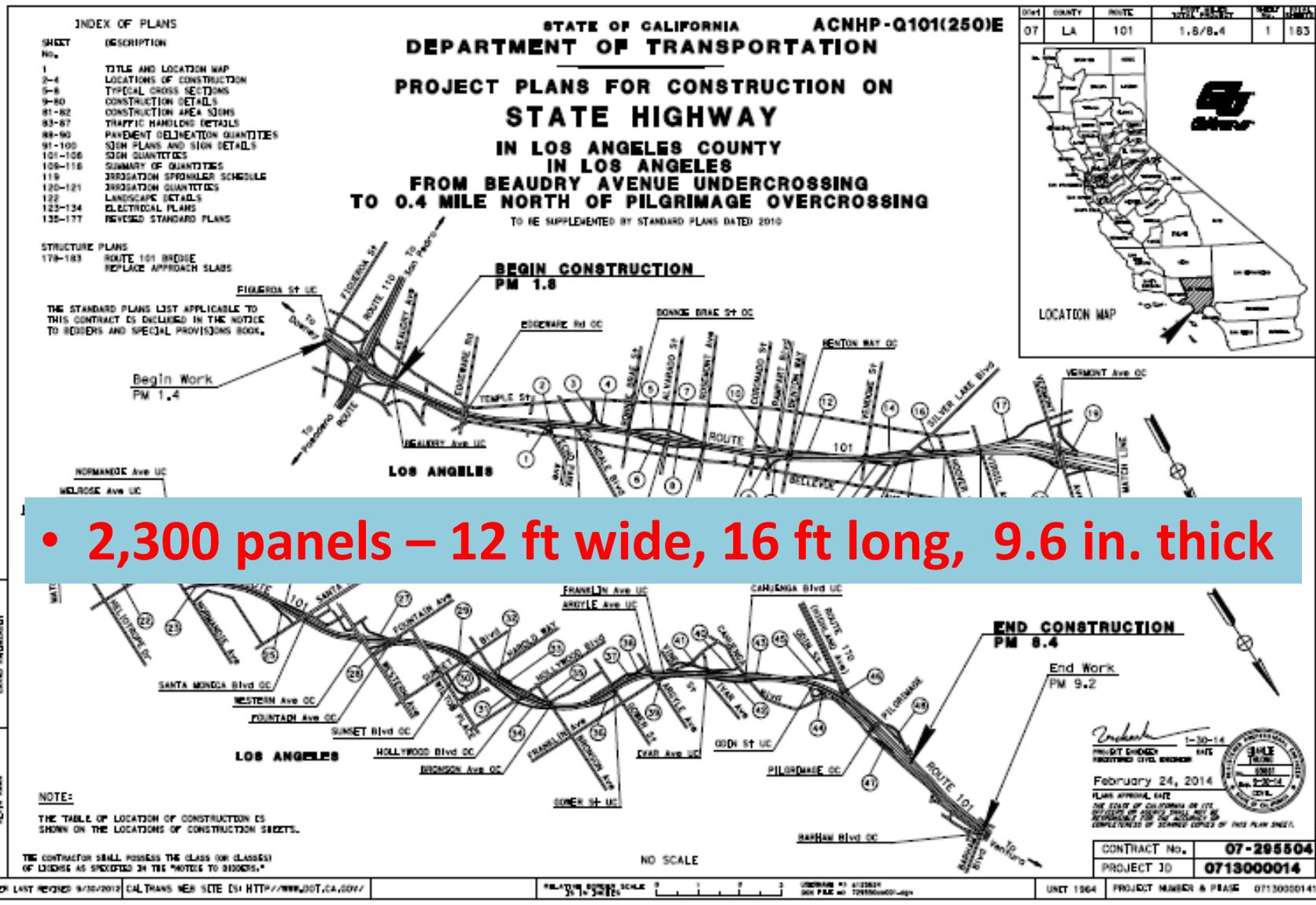


FIRST NIGHT

**SAME
OR
NEXT
NIGHT**

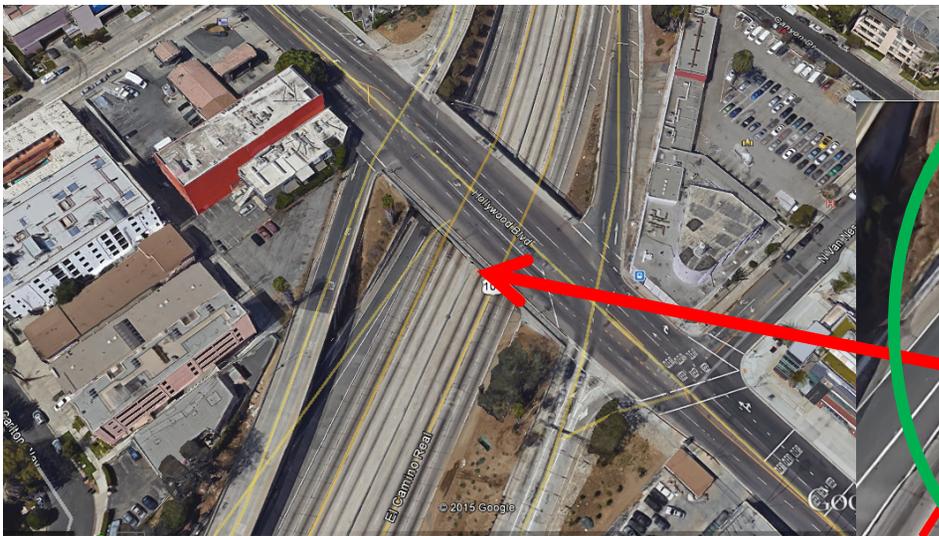


A Typical California Continuous Installation The SH101 Project (Los Angeles Downtown)

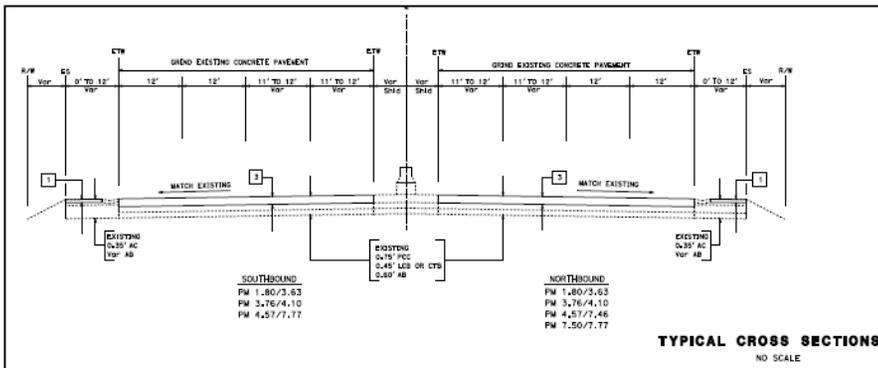


SH 101 Site Views

(typically 4 lanes in each direction; work in outside two lanes; heavy traffic; challenging work areas)



<< At Hollywood Blvd

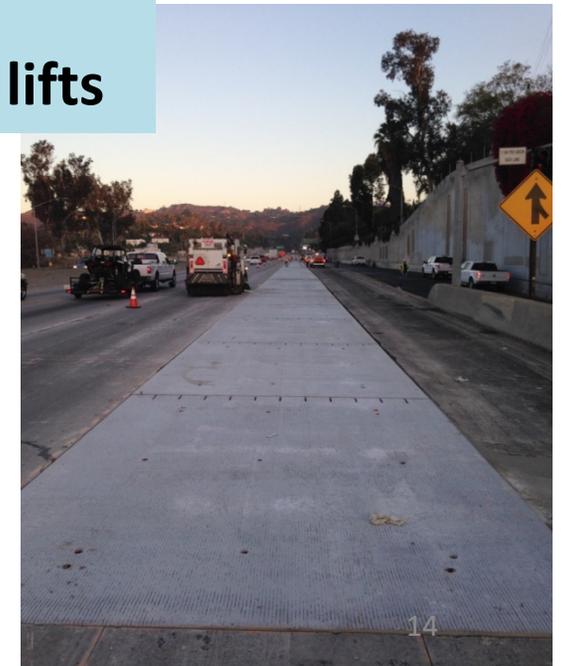
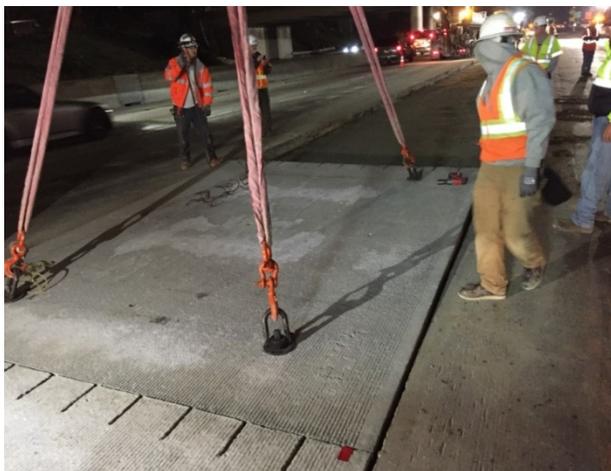


Near Benton Way >>

SH 101 Panel Installation



- Weekend nights only; up to 50 panels/night
- New rapid setting Lean Concrete Base; leveling lifts



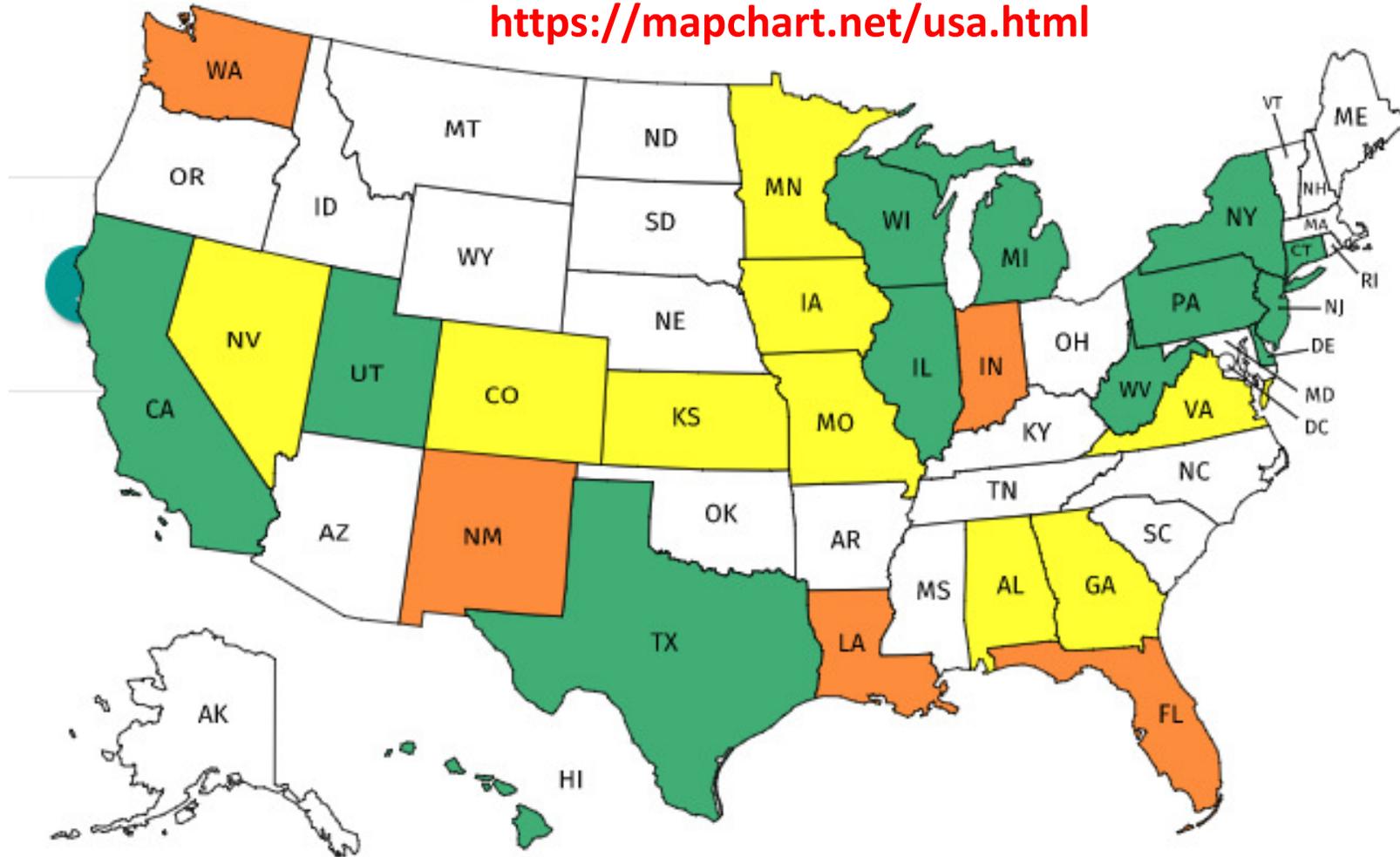
PCP Initiatives in the US

(Actively undertaken since mid-1990's)

- **FHWA (since mid-1990's)**
- **Highway and airport agencies (since 2001)**
- **Industry (since 2001)**
- **AASHTO TIG (mid-2000's)**
- **SHRP2 Project R05 (2008 – 2012)**
 - **Guidelines for PCP developed**
- **FHWA/AASHTO - SHRP2 Project R05 products implementation program (2013 - current)**
 - **Active technical support for wider implementation of PCP**
 - **Financial support to a few highway agencies for demo projects and for implementation support**

US PCP Use

<https://mapchart.net/usa.html>



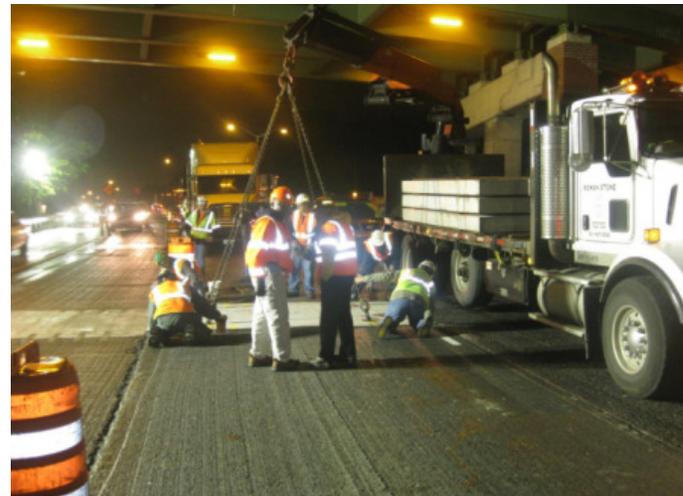
PRODUCTION USERS

DEMO STATES

2018 PROJECTS

PCP Background

- PCP is a recent technology – in use since 2001
- Used primarily for RAPID repair & rehabilitation & longer-lasting treatments
 - Panels fabricated off-site, transported to project site & installed on a prepared foundation
 - Only minimal field curing time required
- Typically, night-time work & short work windows
- Typically, repair/rehab along a single lane
 - Multiple-lane repair/rehab possible based on site constraints



Where to Use Precast Pavement?

(Open to Traffic the Next Morning!!!)

➤ Primary Applications (90%+ use)

- Heavily-traveled main line interstate/primary system & urban roadways - A critical need on US's aging system
- Interstate/primary system & urban ramps - Often no alternative routes and heavy traffic
- Intersections - Where traffic needs to be maintained

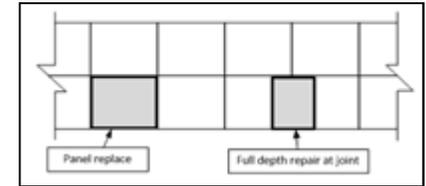
➤ Special Applications

- Bridge approach slabs - A large no. of approach slabs across country need to be rehabilitated under traffic
- Bus pads/bus lanes - Where alternative bus stop locations or re-routing are not acceptable, bus pads/bus lanes can be replaced overnight

PCP Applications

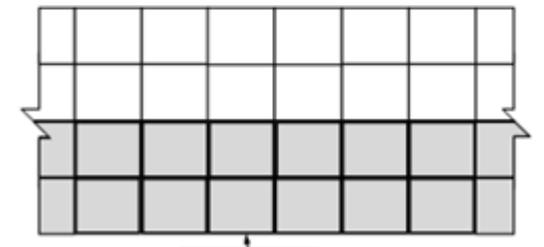
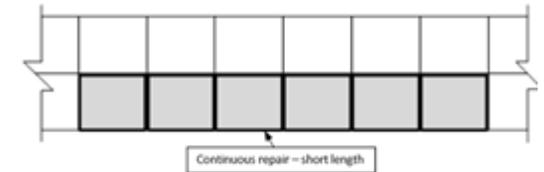
➤ Intermittent repairs

- Nominally reinforced panels (common)
- Prestressed panels (typically longer/wider panels)



➤ Continuous Applications

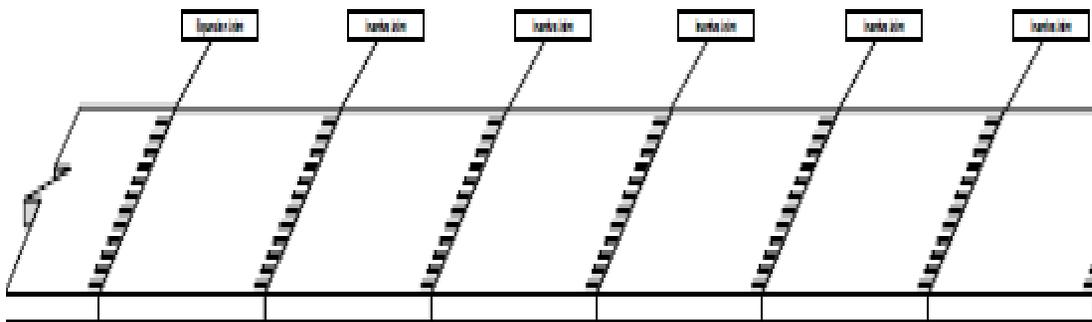
- Jointed PCP systems (JPrCP)
 - Nominally reinforced panels
 - Prestressed panels (typically longer/wider panels)
- Post-tensioned systems (PPCP) - fewer active joints; longer sections
 - Nominally reinforced panels
 - Prestressed panels (typically longer/wider panels)



PCP Applications



Repair Panels – A current concept



From FHWA



Conventional Jointed PCP System – top or bottom dowel slots

State of Practice - Jointed Systems

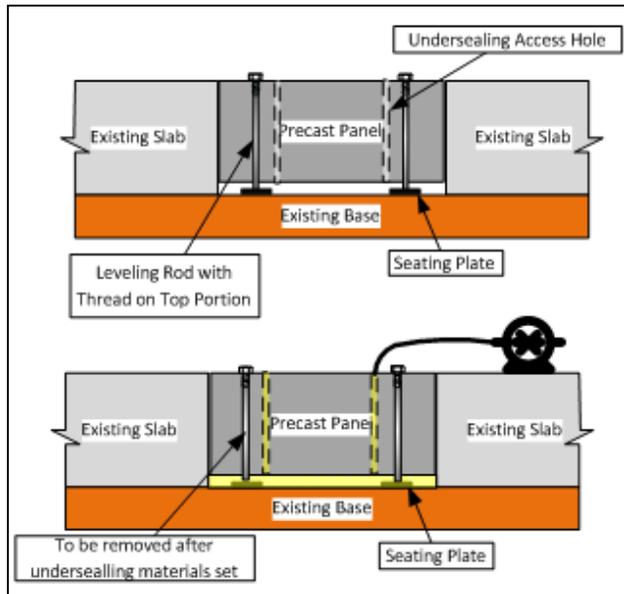
Overall Approaches for PCP Systems

Support Condition

- 1. Grade supported** - panels are placed directly on grade
 - Cemented bedding layer may be used (**<1/2 in.**)
 - Surface grinding almost always required
- 2. Bedding grout supported** - panels are set above base grade using leveling bolts (or shims) and high strength bedding grout is used to fill gap under the panel (**Gap > 1/4 in. & typically < 1 in.**)
 - Surface grinding may not be necessary

Panel Installation Options

(Bedding Grout Supported - Repair & Continuous)
Using Levelling Bolts & Thicker Bedding (1/4 to 1/2 in)



La Guardia Airport
- 16 in., 12.5 by 25 ft panels
- Generic levelling bolt/plate system & cementitious grout

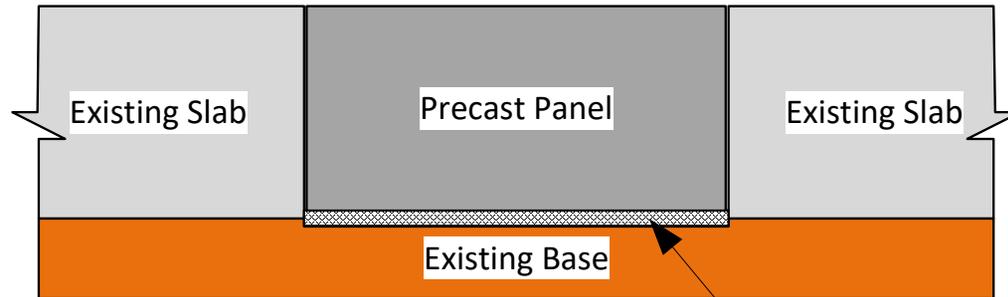


California current
-- proprietary levelling bolt/plate system & high strength rapid setting cementitious bedding

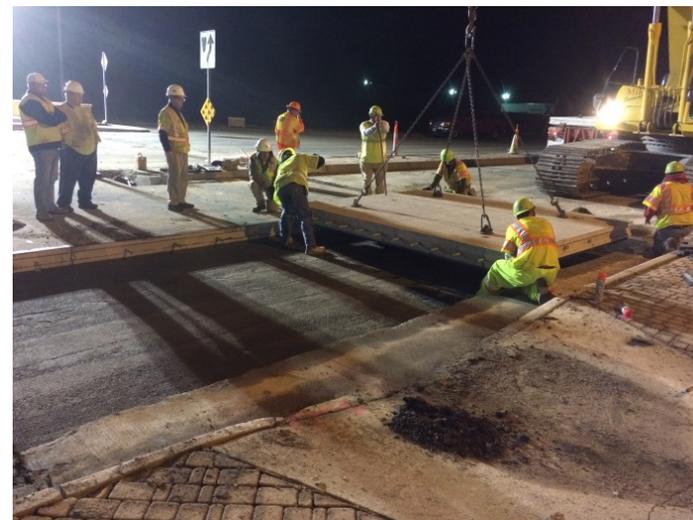


Panel Installation Options

(Grade Supported - Repair & Continuous)
Use of thin granular bedding over finished base



Recommend use of cemented sand bedding layer



PCP Load Transfer

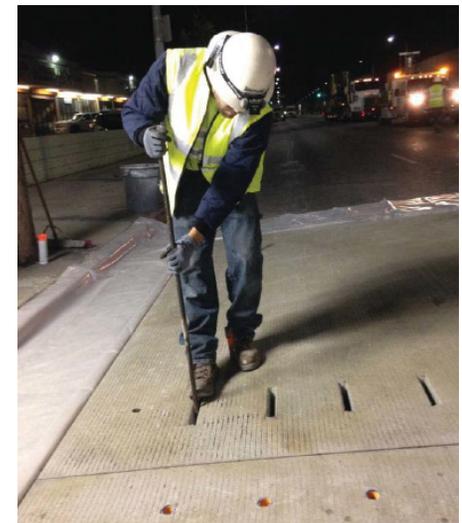
- All PCPs require use of
 - Dowel bar slots, or
 - Ducts (Barra Glide system & recent TxDOT project)
- Two approaches for slots
 - Top slots (generic)
 - SHRP2 R05 narrow-mouth top slots (one sided or two-sided)
 - Illinois Tollway version of narrow-mouth top slots for repairs (one-sided)
 - Caltrans version of narrow-mouth top slots (one sided)
 - Bottom slots (proprietary – Fort Miller Co.)

State of Practice - Jointed Systems

Overall Approaches

Load Transfer System

- 1. Using slots at the panel surface (several generic variations)**
- 2. Using slots at the panel bottom (one patented system)**
- 3. Using duct/slot combination (generic & patented systems)**



PCP Technical Considerations

- a. General Details
- b. Concrete Requirements
- c. Jointing and Load Transfer
- d. Support Conditions
- e. Surface Characteristics (smoothness & texture)

DIFFERENT SYSTEMS SHARE
MANY COMMON FEATURES AND
REQUIREMENTS

BUT, THIS IS WHERE THEY DIFFER

ONCE INSTALLED, PCPs BEHAVE SIMILAR TO CONVENTIONAL CONCRETE PAVEMENTS.

❖ Only the method of construction is different

THE CONCRETE & THE PANELS CAN BE VERY DURABLE

However, uniform support condition & good load transfer at joints are critical



Panel Fabrication (Current Jointed) - Reasonably Standard & Routine 6 to 8 panels/day



Forms stripped at ~ 16 hours



The Panel Fabrication Process (Current)

- *Prestressed Panels for Jointed PCP*
- *15+ panels/day (300+ ft long prestressing beds)*



Typically, steam cured –
precaster option

Panel Production vs. Installation Rates

- Panel fabrication rate
 - 6 to 8 panels per day (inside plant)
 - 15+ panels using 300+ ft long prestressing beds
- Panel installation rate
 - Repair – 15 to 20 repairs/night
 - Jointed continuous – 40 to 50 panels/night (600 to 800 ft)
- So, several weeks (or months) of back-log of panels is necessary before installation can begin

NEAR FUTURE EXPECTATIONS

**REPAIR APPLICATION – 30 TO 40 REPAIRS PER NIGHT
CONTINUOUS (JOINTED OR PPCP) – 1,000 + FT/NIGHT**

Construction Considerations

Base preparation

- **Existing bases**
 - Granular
 - ATB
 - CTB/LCB
- **New base**
 - Granular
 - Rapid setting LCB (Mobile Mixture)



The final base surface should be graded to a smooth finish

- Panels will be grade-placed over a thin cemented bedding layer, or
- Placed over higher strength thicker bedding grout using leveling lifts

PCP Performance

- Some early installations exhibited some panel cracking early on but the reinforcement keeps the cracks tight and so no impact on performance
- **No structural performance issues at projects constructed in the last 5 to 10 years with refined PCP systems and installed well**
 - Good deflection response at joints (low deflections indicating good load transfer across transverse joints)
 - Good load transfer = Very low risk of joint faulting
 - Grinding and use of grout supported systems result in smooth surface
- **However, some poor quality installations continue to result in performance issues**



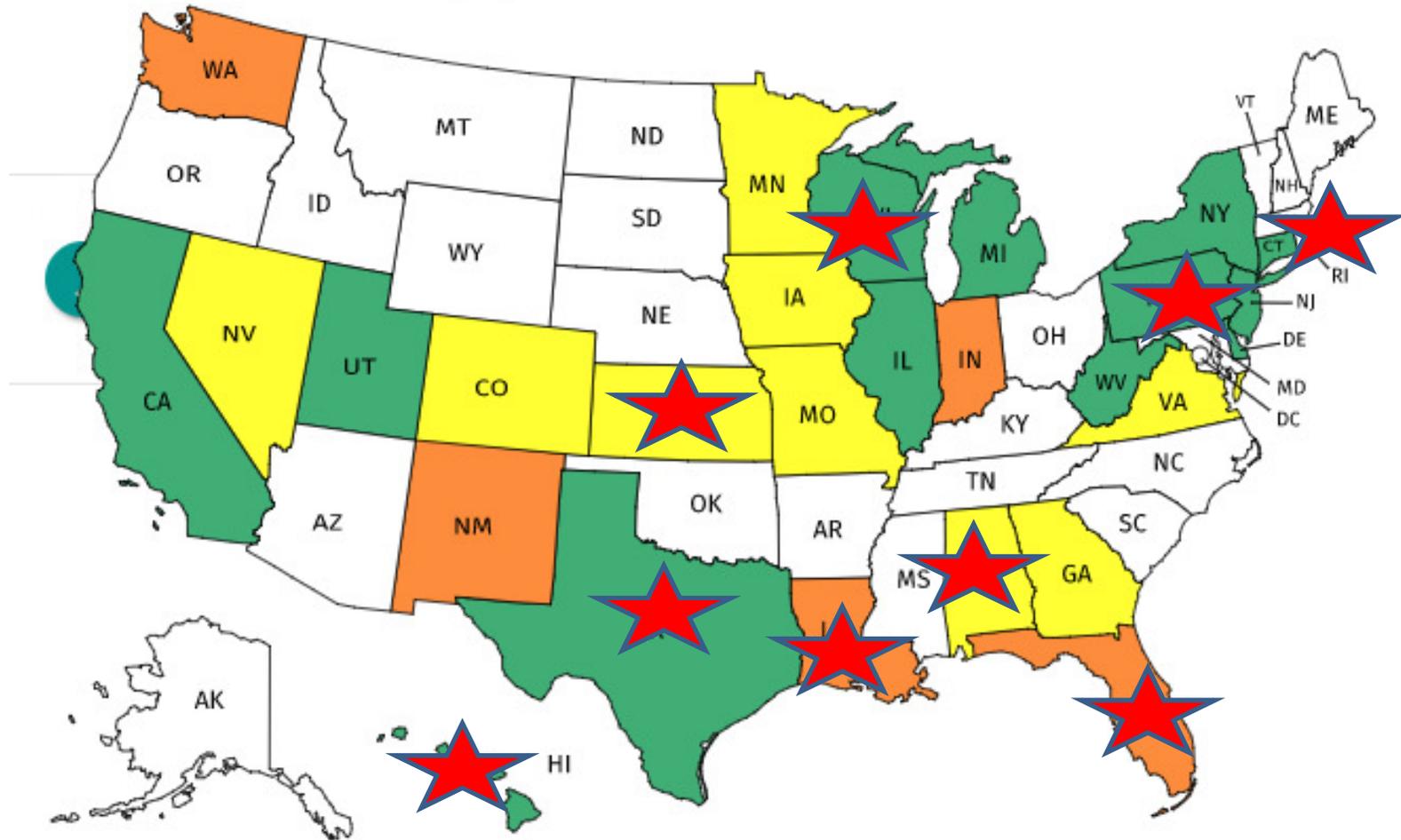
PCP Cost

- Cost of implementing/using PCP is NOT high
- In 2001, about \$900/sy
- Today (2017), costs range from \$350 to \$450/sy depending on project size and other logistics
 - So, a 12 ft by 15 ft long panel (20 sy) may cost \$7,000 to \$9,000 installed
 - For 50 panel installations/night, the price would be \$350,000 to \$450,000
- More and more, new projects involve hundreds to thousands of panels
- And, with continued innovations and refinements to existing systems, costs are expected to decrease

SHRP2/FHWA Supported PCP Projects

- In 2013, FHWA and AASHTO created the SHRP2 Implementation Assistance Program (IAP) to help State DOTs implement SHRP2 products
 - 7 rounds of funding
 - For R05 (PCP), funding of \$300,000 provided under Rounds 3 and 7 to support PCP demo projects
 - Also, some agencies received \$75,000 user incentive funds for PCP technology transfer activities
- Round 3 States – HI, KS, TX, WI
- Round 7 States – AL, FL, LA, PA, plus CT at \$150,000

SHRP2/FHWA IAP Funded States



PRODUCTION USERS

DEMO STATES

2018 PROJECTS

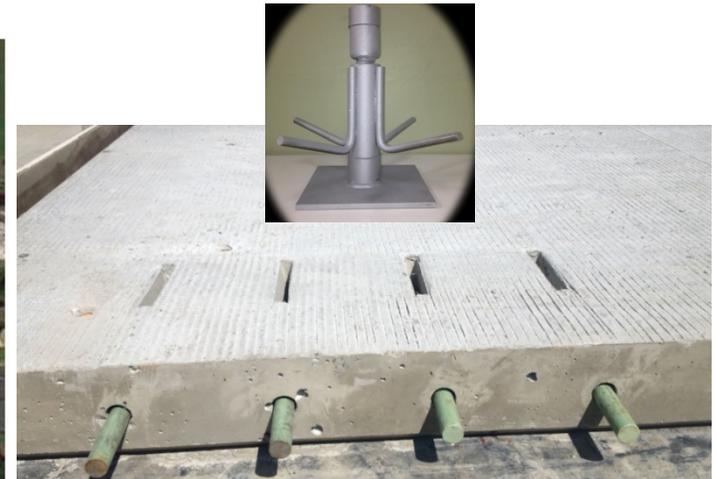
SHRP2 R05 IAP Supported Projects

- 2015
 - Hawaii: Hawaii H1 – **Settled PCCP rehabilitation**
 - Kansas: Leavenworth – **Intersections & bridge approach slab**
 - Wisconsin: Madison bypass – **Slab replacements**
- 2016
 - Texas: Energy sector **AC intersection rehabilitation**
 - Connecticut: New Britain **AC bus pads rehabilitation**
- 2017
 - Alabama: Mobile I-165 **AC ramp rehabilitation**
- 2018
 - Louisiana: Shreveport – Distressed **PCCP ramp rehabilitation**
 - Florida: I-10 distressed **bridge approach slab replacement**
 - Pennsylvania: Norristown **distressed intersection rehabilitation**

Hawaii PCP Project (2015)

Hawaii H1 settled PCCP

- Replacement of settled 200 ft of PCC pavement – 6 lanes
- Feathered overlaid with AC
- 84 PCP panels, 12 ft by 12 ft by 10 in.; Rapid Roadway panels with leveling lifts
- New rapid-setting CTB



Hawaii PCP Project (2015)

Hawaii H1 settled PCCP

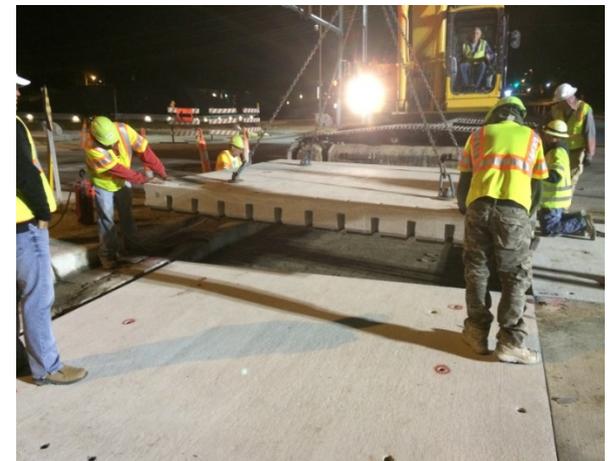


Kansas PCP Project (2015)

Leavenworth



- Rehab of two intersections and a bridge approach along US 73 in Leavenworth
- Used Fort Miller Super slab system with cemented base & planar and non-planar panels
- 294 panels, 9-1/8 in. thick
- Precast panel length: Varies (6-13 ft)
 - Precast panel width: Varies (6-16 ft)
- Base: 4 in. thick cement treated base
- Bedding layer over base: Cemented granular material



Wisconsin PCP Project (2015)

Madison Bypass



- Madison Beltline Highway (US 12)
- Distressed PCC pavement
- Intermittent repairs using the Fort Miller Co.'s Super Slab system
- 623 panels, 12 ft wide, 10 in. thick. Variable length
- Completed September 2015



Wisconsin PCP Project (2015)

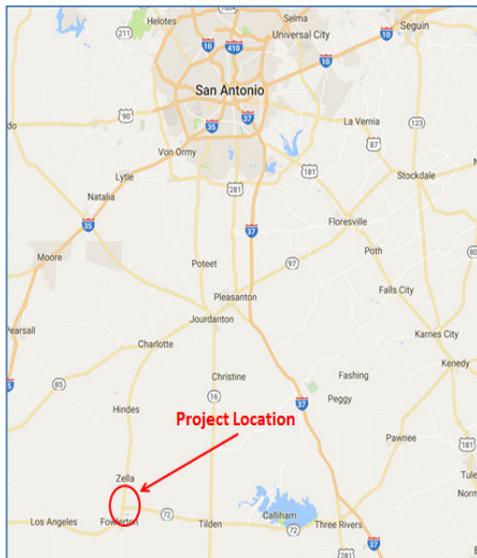
Madison Bypass



Texas PCP Project (2016)

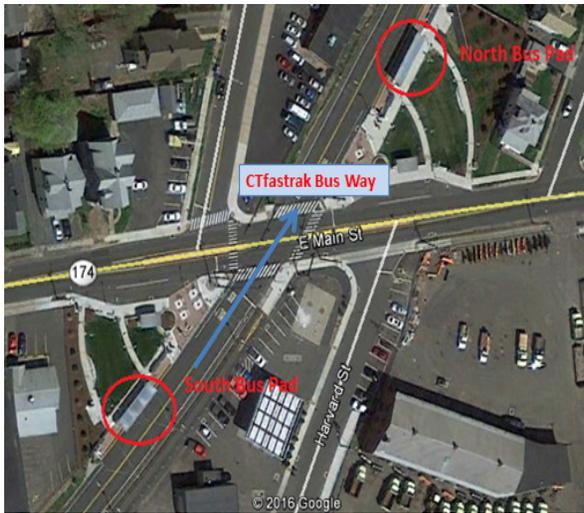
Texas SH 97/SH 72 Intersection (Energy sector)

- Challenge: Excessive rutting in AC pavements & intersections due to heavy energy sector truck traffic
- Demo: Rehab of rutted AC intersection at SH 97/SH 72
- Texas DOT specified generic PCP system
- 235 12-in. thick prestressed panels over new AC base
 - SH 97 panels: 12 & 18 ft wide and 8 ft long
 - SH 72 panels: 8 ft wide and 18 ft long
- Contractor developed duct-based load transfer system



Connecticut PCP Project (2016)

New Britain Bus Pads

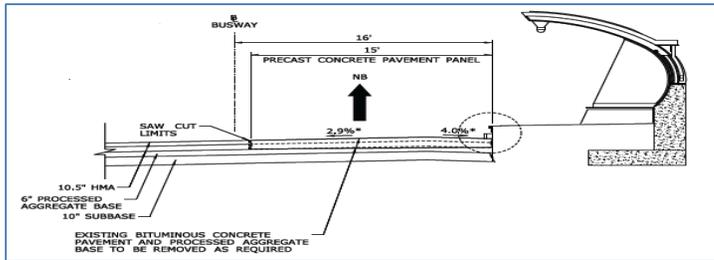
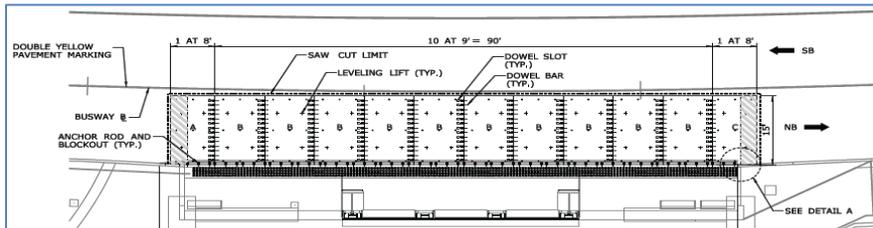


- Rehabilitation of two recently constructed rutted AC bus pads along the CTfastrak busway in New Britain; **rutting prevented bus doors to open**
- Custom designed system with bottom slot panels and leveling lifts, 24 panels
- Panels – 15 ft wide, 9 ft long. 10 in. thick; End panels – 8 ft long
- Completed November 2015 over a weekend



Connecticut PCP Project (2016)

New Britain Bus Pads



Connecticut PCP Project (2016)

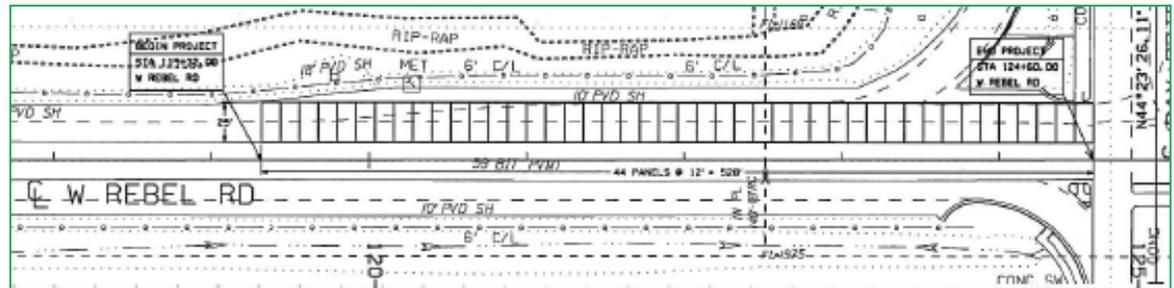
New Britain Bus Pads



Alabama PCP Project (2017)

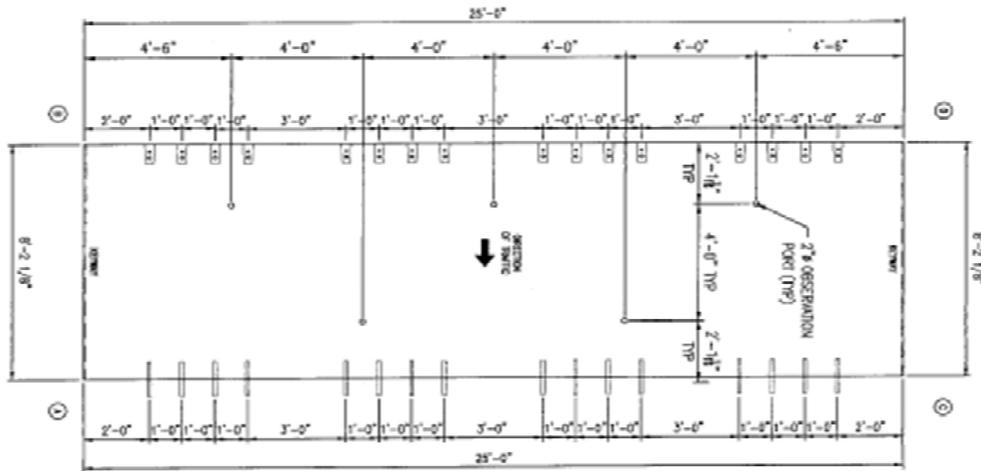
I-165 Ramp, Mobile

- Rehabilitation of rutted AC ramp off Exit 2, two left-turn lanes
- Panels with bottom slots and leveling lifts
- Panels – 25 ft wide (2 lanes), 8 ft 2-1/8 in. long., 9 in. thick
 - Four dowels per wheelpath



Alabama PCP Project (2017)

I-165 Ramp, Mobile



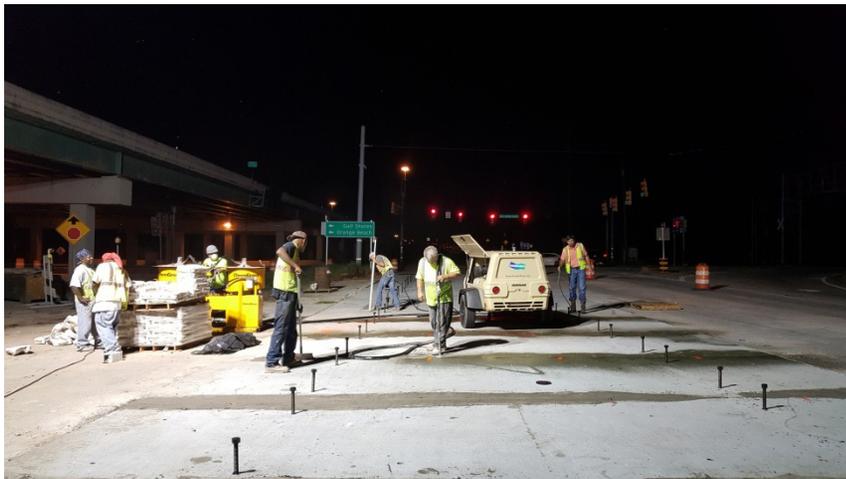
Alabama PCP Project (2017)

I-165 Ramp, Mobile



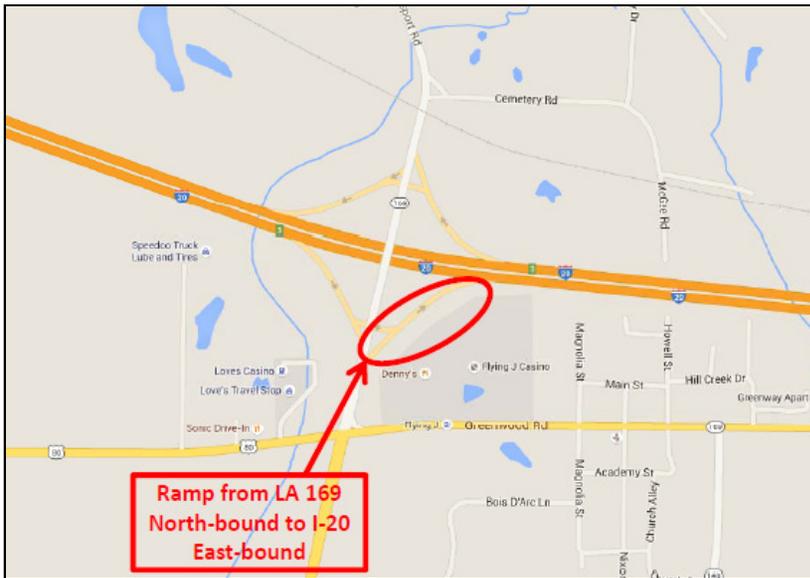
Alabama PCP Project (2017)

I-165 Ramp, Mobile

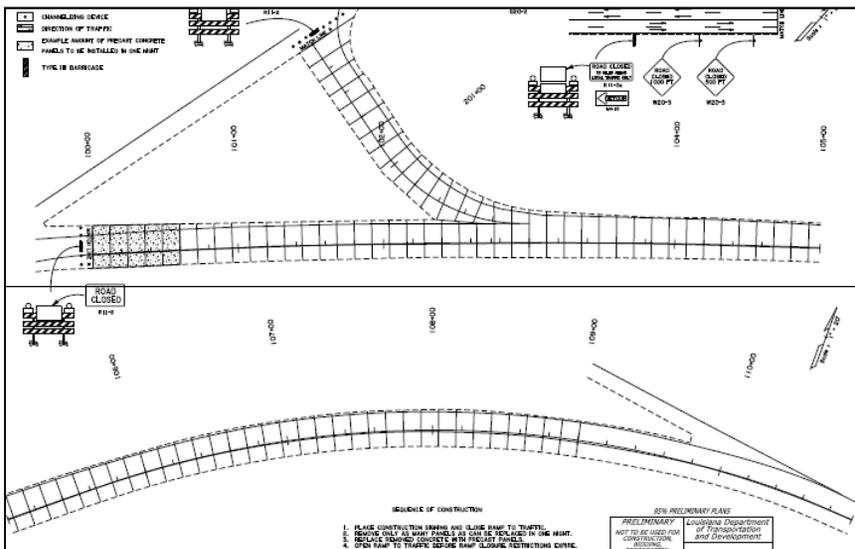


Louisiana PCP Project (2018)

I-20 Ramp, Shreveport



- Anticipated installation –2018
- Panel production ongoing
- Bottom slot panels & leveling lifts
- Panels:
 - Planar & non-planar
 - 10 in. thick
 - Variable dimensions



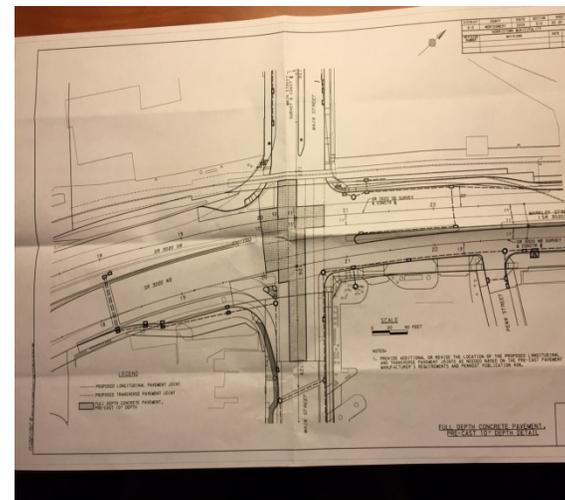
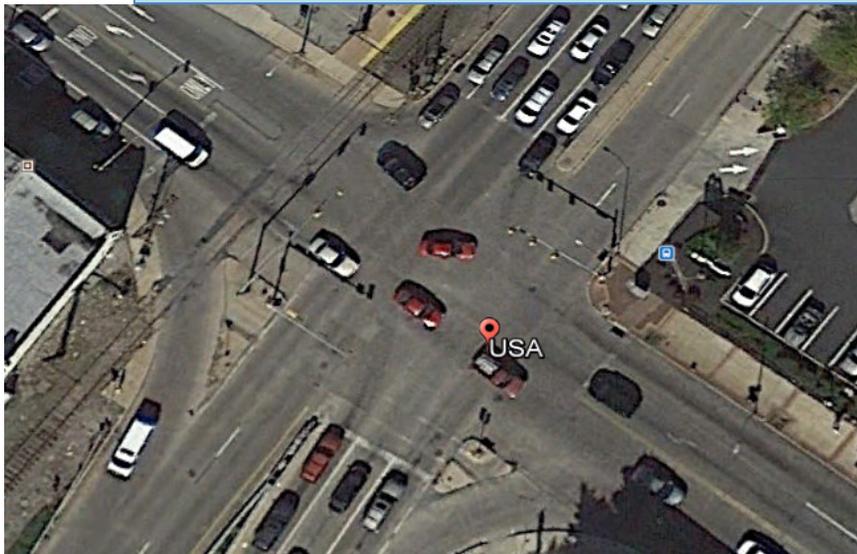
Florida & Pennsylvania Projects (2018)

Chipley, FL I-10 bridge Approach Slab -



- Location - I-10 west bound over Apalachee North Railroad, on the east end of the west bound bridge.
- Year Built = 1976
- Condition: Slab cracking and slab settlement
- Slab layout/size: Skew at abutment; length: ~ 25 to 28 ft; 2 lanes and two shoulders
- Four 12 ft wide panels, to be postensioned transversely

Norristown, PA – Distressed Intersection



Lessons Learnt

- All agencies happy with the end product
- Some initial startup issues, but after a few days, the panel placement proceeded smoothly and productively
 - New contractors must be trained & ready to go
 - Test sections are specified to show the contractor can perform the work effectively. **Test section cannot be used to train contractor staff**
- Need for generic PCP description for specification purposes

Generic PCP Specification

- Provide a precast concrete pavement that will incorporate the following:
 - Panel dimension: Precast panels will conform to the dimensions shown on the project plans
 - Panel reinforcement: Precast panels may be reinforced or prestressed
 - Load transfer at transverse joints: Precast panels will have provisions to accommodate load transfer at transverse joints using round epoxy-coated dowel bars. The load transfer mechanism using dowel bars may include use of slots at the panel surface, slots at the panel bottom or ducts.
 - Panel support: Panels will be supported over the prepared base/bedding layer using a cementitious grout and an adjustable leveling system fabricated integrally with the panel at the panel bottom.

Generic PCP Specification

- Provide a precast concrete pavement that will incorporate the following:
 - Panel dimension: Precast panels will conform to the

- **NO NEED TO REFER TO PCP AS A SYSTEM OR TO SPECIFY PAST PERFORMANCE REQUIREMENTS**
- **Specific requirements related to the load transfer, in terms of slot location/dimensions, and panel support to be included within the specification.**

integrally with the panel at the panel bottom.

Summary

- Most agencies participating in the FHWA/SHRP2 IAP are considering additional PCP projects where work can only be performed at night
- There is **room for innovations and refinements** to improve speed of installation & construction quality and reduce costs
 - **COMPETITION drives innovations & refinements!**

Summary

- PCP Technology is ready for production implementation and is being implemented on a production basis by many agencies

- Although less cost-effective and can be expected to provide long-term service

Thank You!

stayabji@gmail.com

- This is a ripe area for innovations to improve productivity, efficiencies in design, and reduce cost – well suited for industry/academia involvement