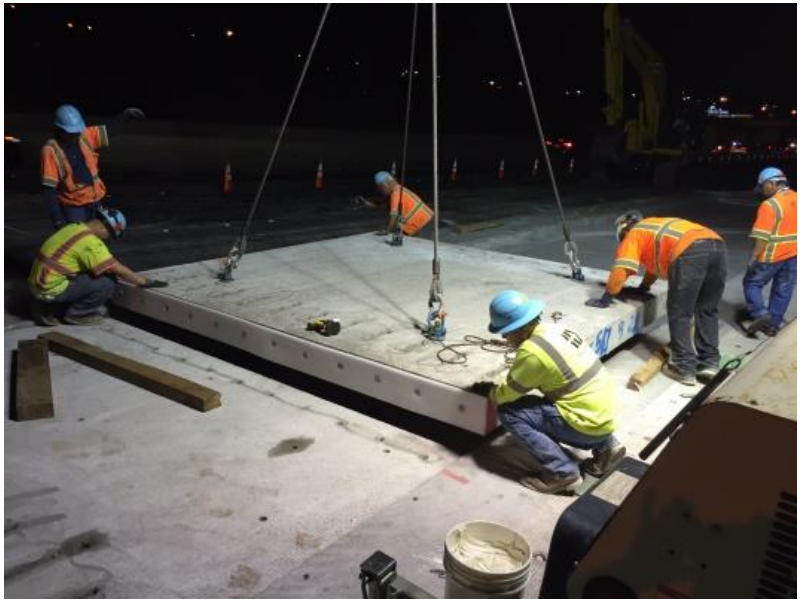
ACI Spring 2015 Convention
Kansas City, Missouri - April 2015

Fast-Track Precast Concrete Pavements for High-Volume Highways



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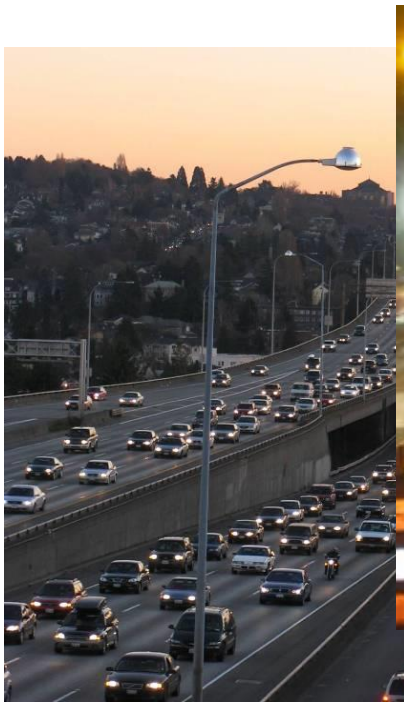
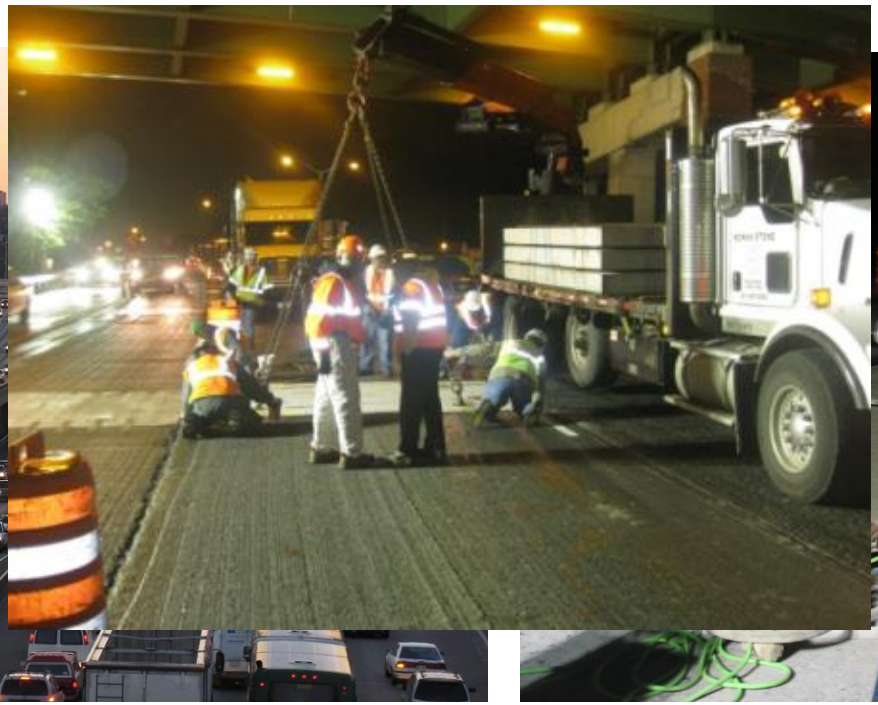
ARA

The Need – Pavement Rehab Under Heavy Urban Traffic

A very serious issue throughout urban US

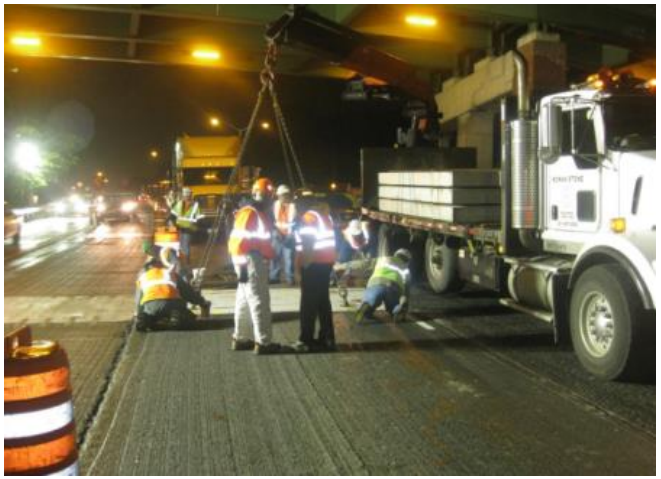




- **Shorter delays using rapid setting concrete, but shorter service life**
- **Longer service life using conventional paving, but longer delay**
- **Need for shorter delays & longer service life – using PRECAST CONCRETE PAVEMENT**

Presentation Outline

- Precast concrete pavement (PCP) background
- PCP Systems & Applications
- Case Studies

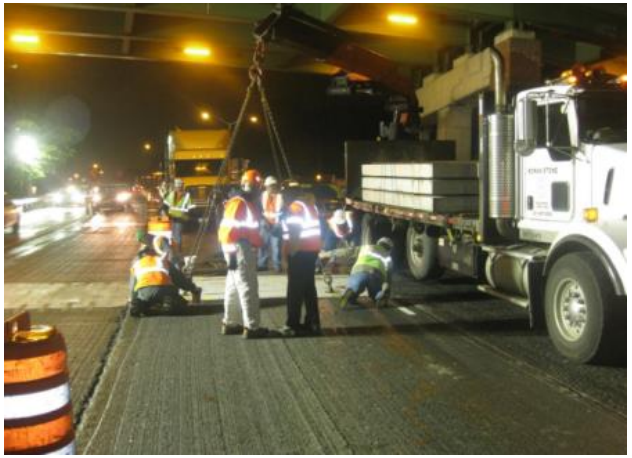


Precast Concrete Pavement Systems - A Definition

- Precast pavement systems are fabricated or assembled off-site, transported to the project site and installed on a prepared foundation (existing pavement or re-graded foundation).
- The system components require **minimal field curing or time** to achieve strength before opening to traffic.
- These systems are application-ready for **rapid repair, rehabilitation and reconstruction** of asphalt and concrete pavements.
- Lane closures at night & open to traffic by 5/6 am

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



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)**
- **FHWA/AASHTO - SHRP2 Project R05 products implementation program (2013 - current)**
  - **Tech Support**
  - **Financial support**

Traffic Considerations

- Traffic volume – is it heavy enough to preclude other pavement alternatives?
  - If fast-track fixed-form or slipform paving techniques are possible, use of precast pavement may not be the best option!

- Alternate routes
  - If traffic can be staged or detoured, use of precast pavement may not be the best option!

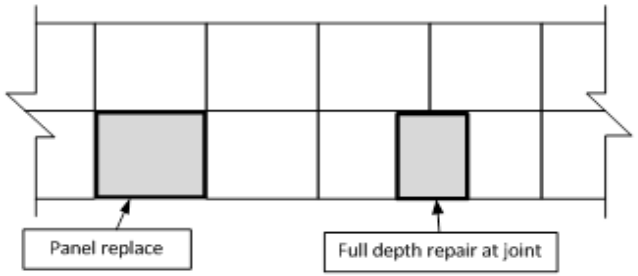
But, if you have only 8 hours or less of lane closures to perform the repair/rehab work, you need to strongly consider precast pavement

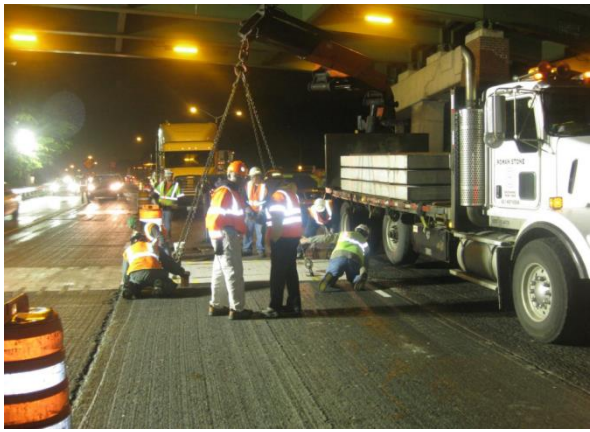
Where to Use Precast Pavement?
(Requires Opening to Traffic the Next Morning!!!)

- 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
- Special Applications
  - Intersections - Where traffic needs to be maintained
  - Bridge approach slabs - A large no. of approach slabs across country need to be rehabilitated under traffic
  - Bus pads - Where alternative bus stop locations are not acceptable, bus pads can be replaced overnight
  - Airfield Applications - A developing market
  - Underpasses - Where height restrictions may limit rehab options
  - Utility "bridges" - Over failed drainage pipes & culverts

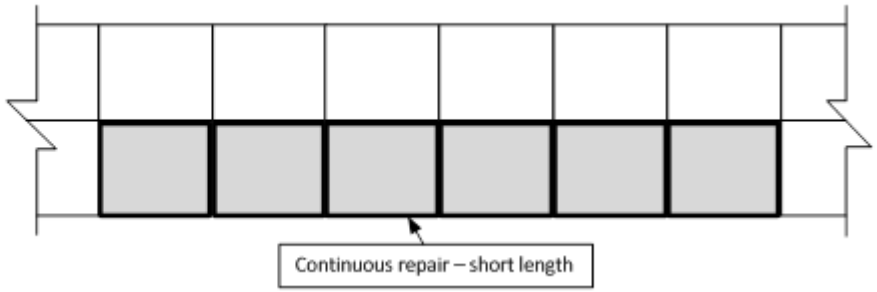
PCP Applications

Intermittent Repairs

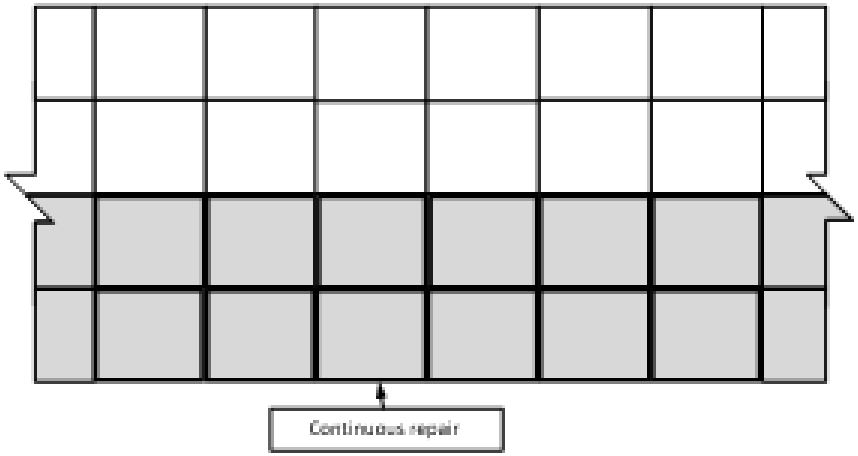




Shorter Length Rehab

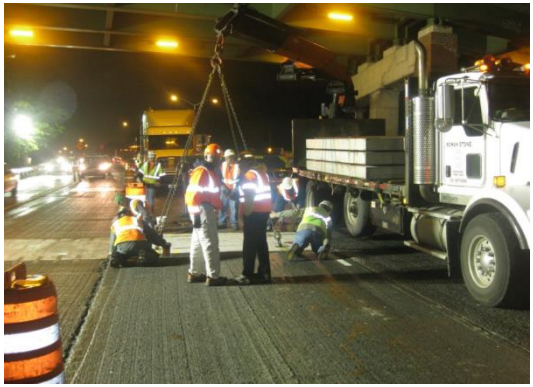


Longer length, Multi-Lane Rehab



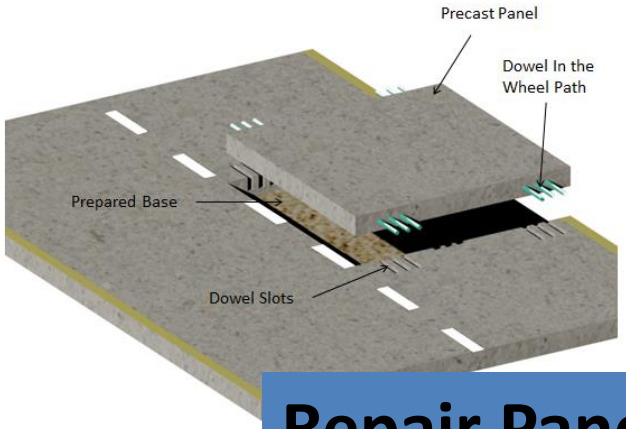
PCP Systems

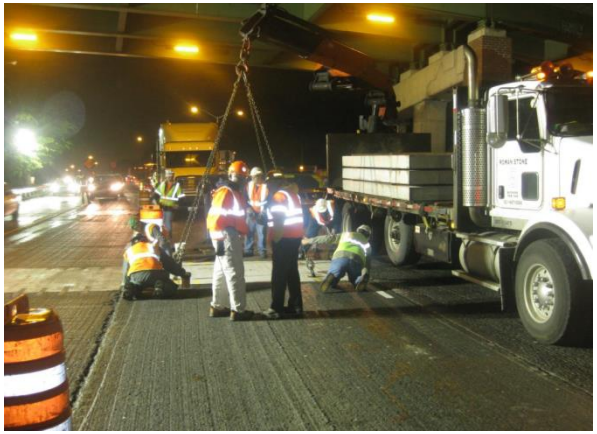
- For intermittent repairs
  - Nominally reinforced panels
  - Prestressed panels
- For continuous Applications
  - Jointed PCP systems (JPrCP)
    - Nominally reinforced panels
    - Prestressed panels
  - Post-tensioned systems (PPCP) - fewer active joints; longer sections
  - Incrementally connected PCP (ICPCP)
    - Simulates JRCP: intermediate joints locked-up
    - Fewer active joints; < 100 ft long sections



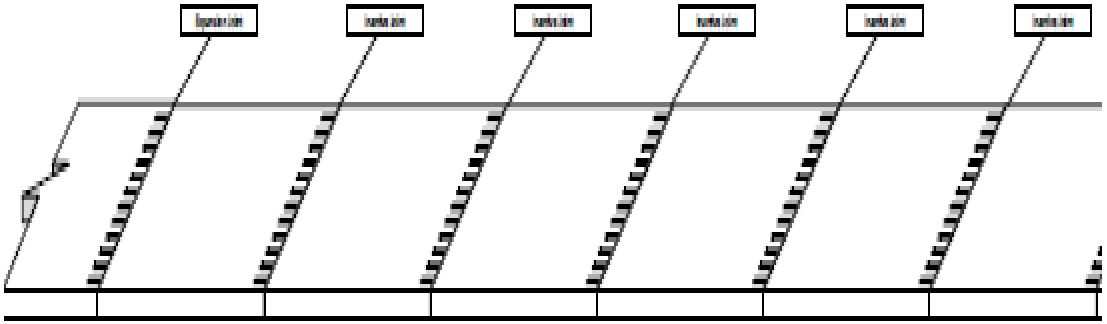
Generic & Proprietary Systems (Components) Available

PCP Systems





Repair Panels



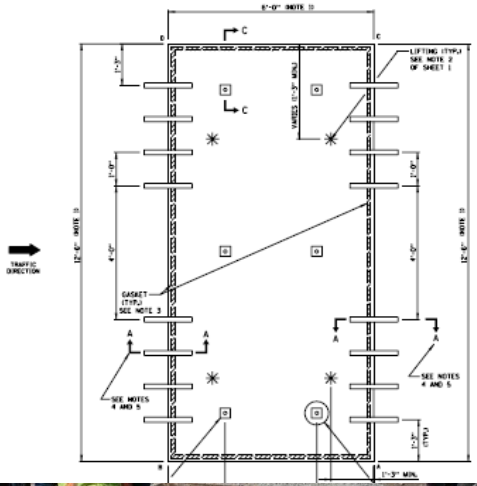
Conventional Jointed PCP System

State of Practice (Jointed Systems)

Roman Stone System

Polyurathane Foam Bedding

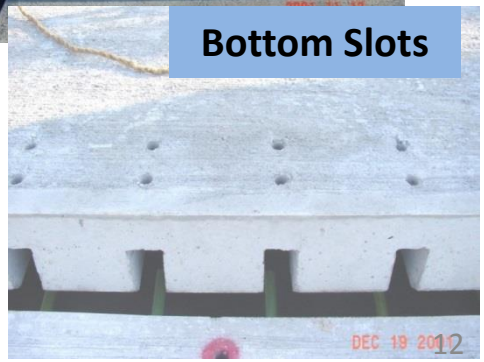
Illinois Tollway Generic System



<<Narrow Mouth Surface Slots

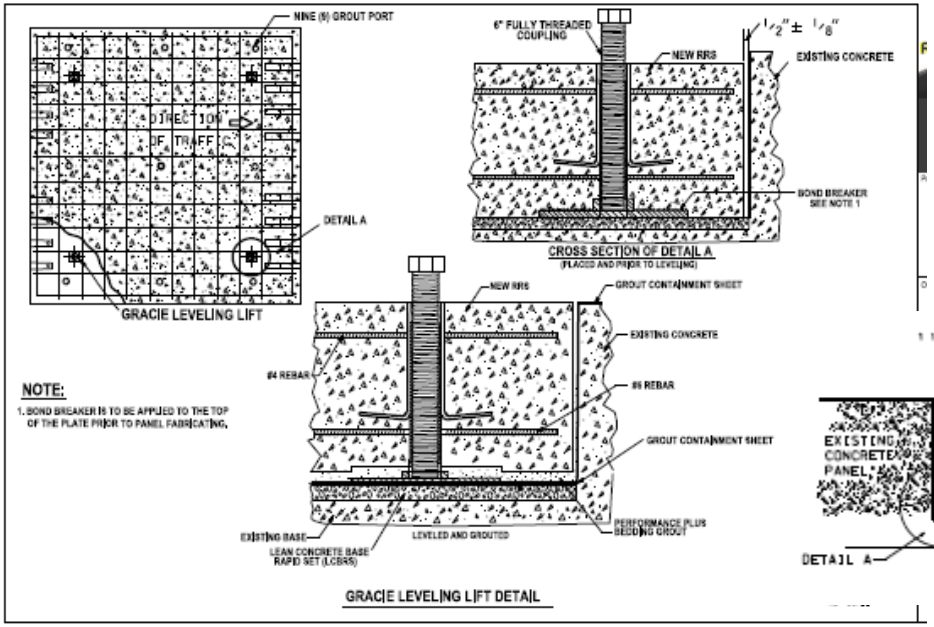
Fort Miller System

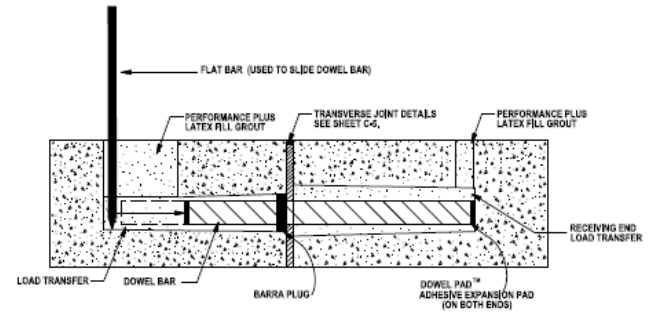
Bottom Slots

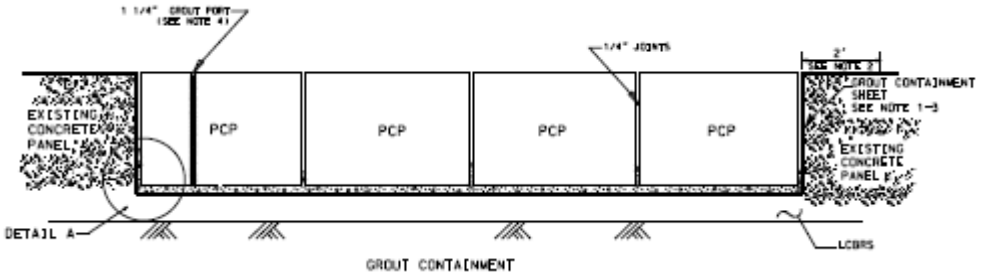


California Slab Repair System

Barra Glide Load Transfer System & Gracie Lift Device
Developed in 2013; used by Caltrans

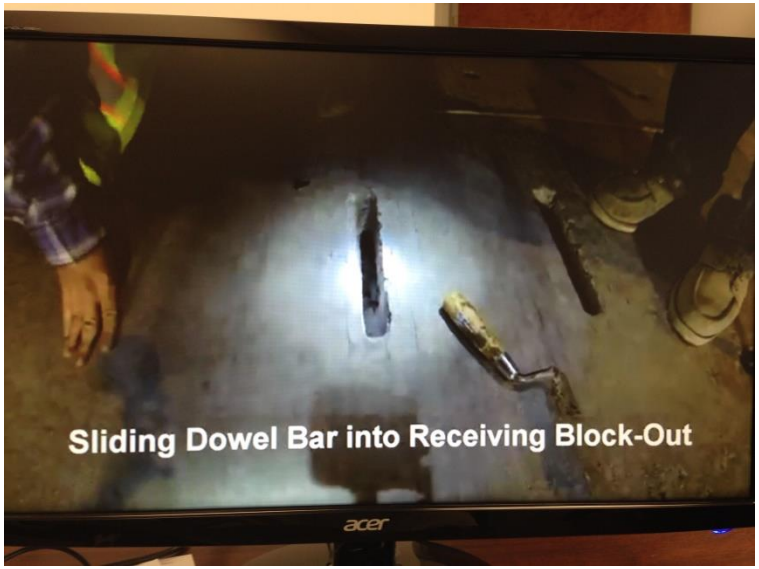


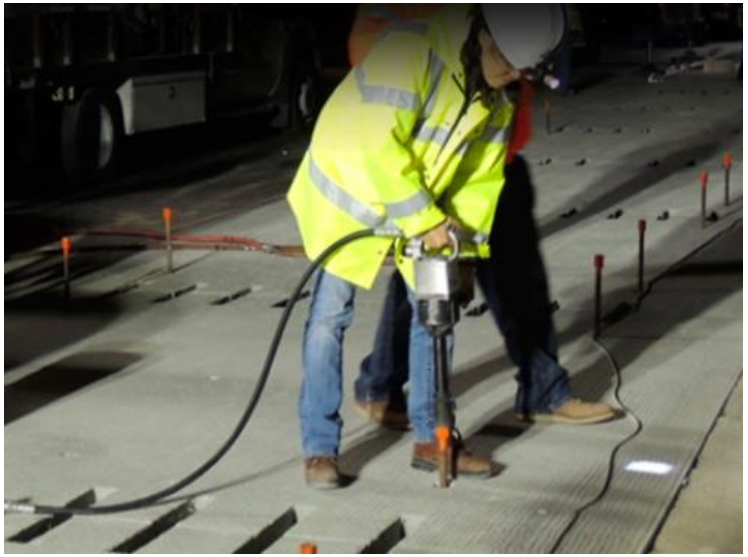




California Slab Repair System

Barra Glide Load Transfer System & Gracie Lift Device
Developed in 2013; used by Caltrans District 7

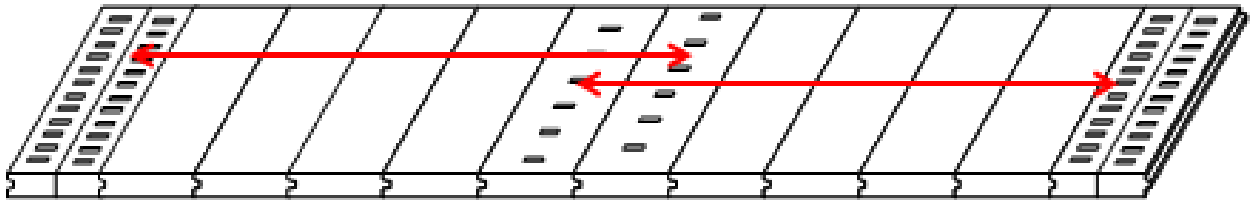




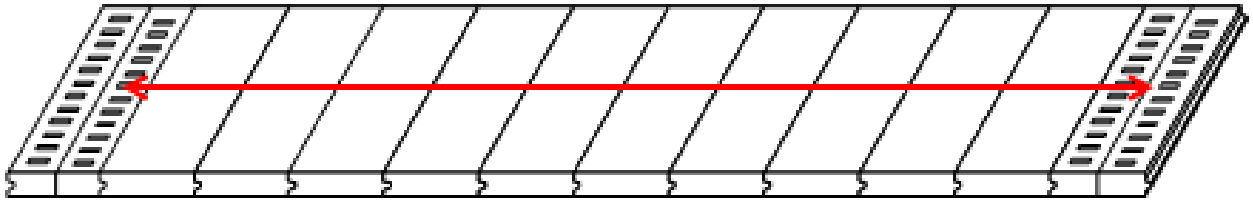
PPCP Systems

(Concept Developed at University of Texas – 2001)

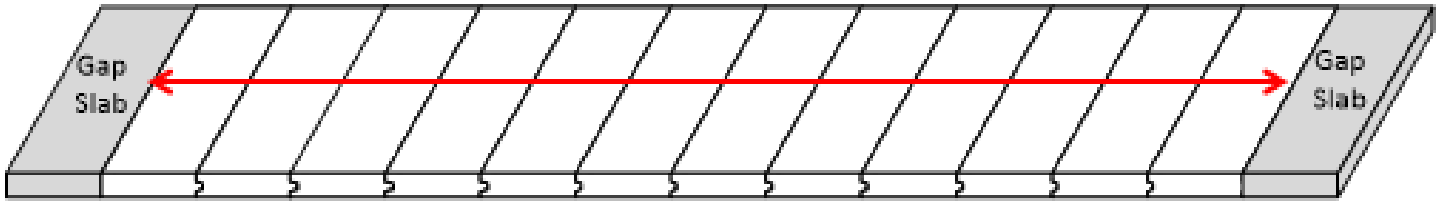
- A number of panels are posttensioned together to result in a posttensioned section length of 200 to 250 ft & induced prestress of 150 to 200 psi
- Tendons are bonded to the concrete thru grouted tendon ducts



Original - Central panel surface pocket posttensioning



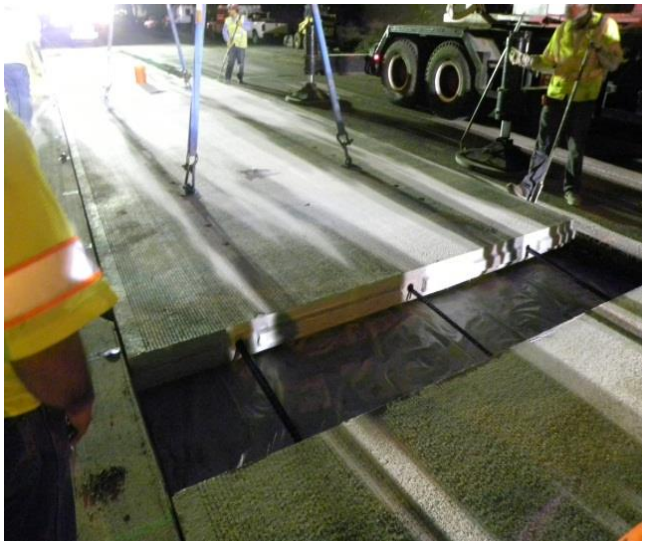
Refined - End panel surface pocket posttensioning

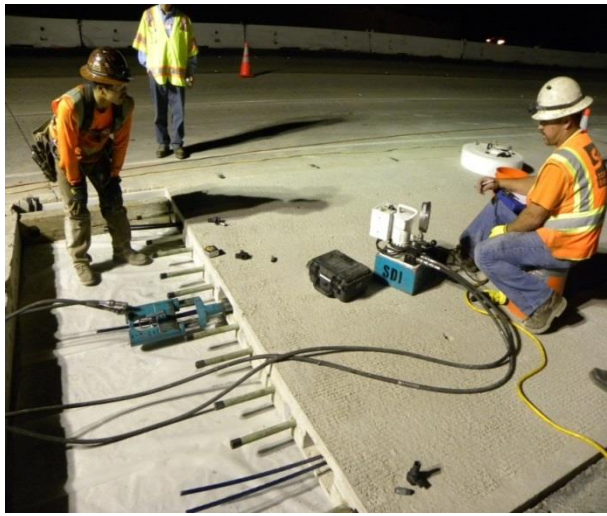


Current - End panel joint face posttensioning and gap panel use

PPCP Systems

(Concept Developed at the U of Texas)



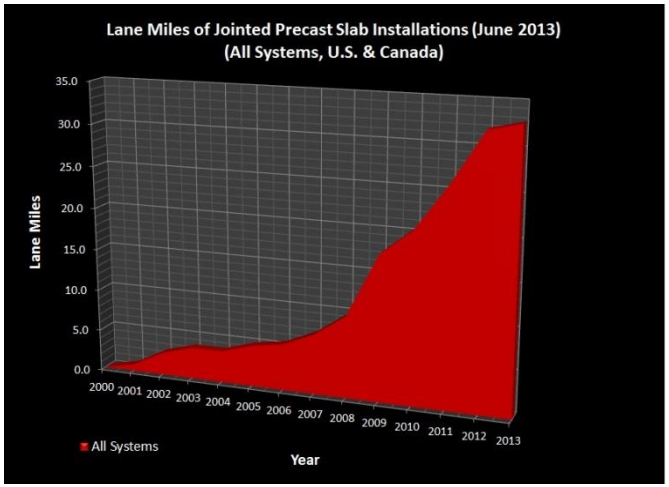


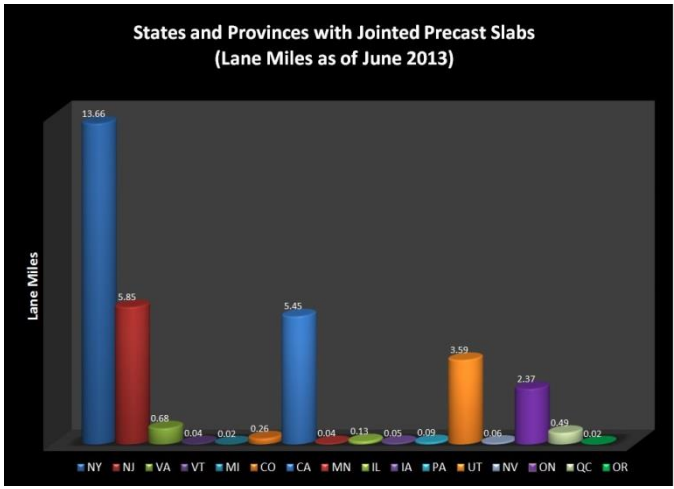
Precast Concrete Pavements
Jointed versus Prestressed: Highlights

	Precast Jointed	Precast Prestressed
Thickness	Conventional – 10 to 14 in.	Thinner - 8 to 10 in.
Active Joint Spacing	15 ft, typical	150 to 250 ft
Joint Width, typical	0.25 to 0.35 in.	0.5 to 2.0 in.
Joint Load Transfer	Dowel Bars	Dowel Bars
Support Needs	Good support	Very Good Support
Base/Panel Interface	Panels placed over finished base & bedding layer, if needed	Smooth base needed. Typically, use of a polyethylene sheet over well graded (stabilized) base

Precast Pavement Systems - Users

- US/Canada
  - Production use
    - CA, IL Tollway, IA, MI, NJ, NY, UT,
    - Ontario, Quebec
  - Demos
    - CO, DE, FL, GA, HI, MN, MO, NV, PA, TX, VA, WI, PANY/NJ, Dulles Airport, US Air Force
- Overseas
  - Russia, Japan, France, the Netherlands, Indonesia





Graphs courtesy of FMC

Panel Production vs. Installation Rates

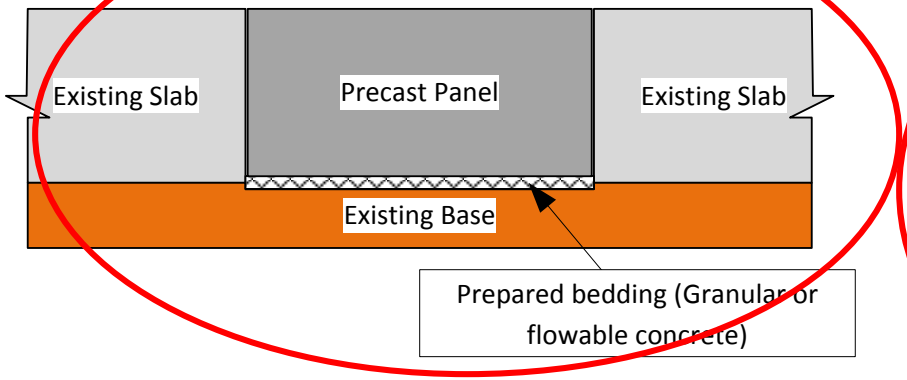
- Panel fabrication rate
  - 8 to 10 panels per day (inside/outside plant – jointed)
  - Similar rate for PPCP panels – inside plant or outdoor beds
- Panel installation rate
  - Repair – 15 to 20 repairs/night
  - Jointed continuous – 30 to 40 panels/night (500 to 600 ft)
  - PPCP – two posttensioned sections or up to about 500 ft
- So, several weeks (months) of back-log of panels is necessary before installation can begin

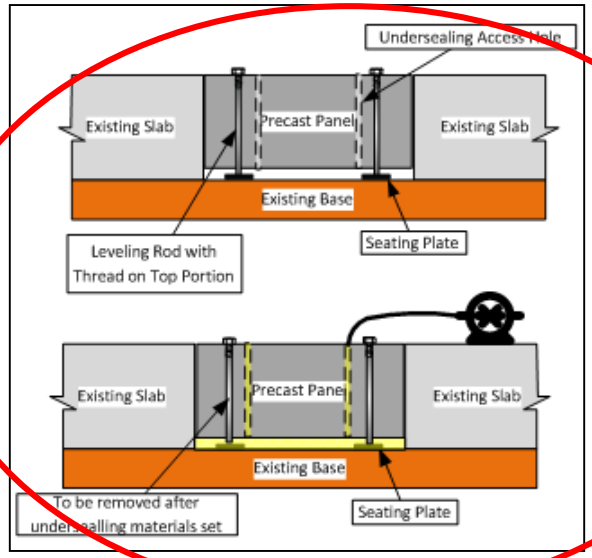
NEAR FUTURE EXPECTATIONS

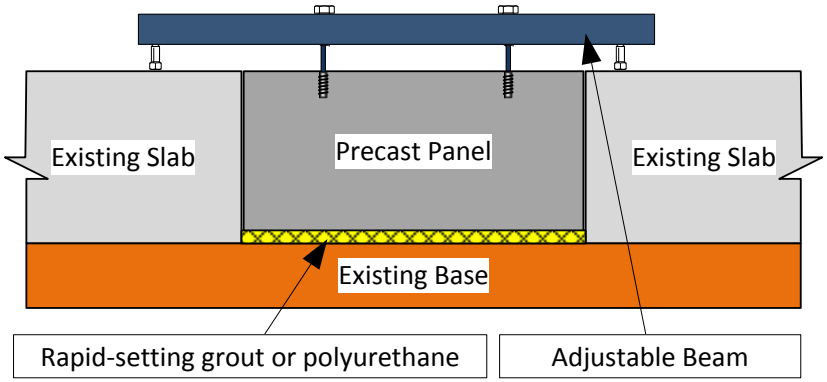
REPAIR APPLICATION – 30 TO 40 REPAIRS PER NIGHT

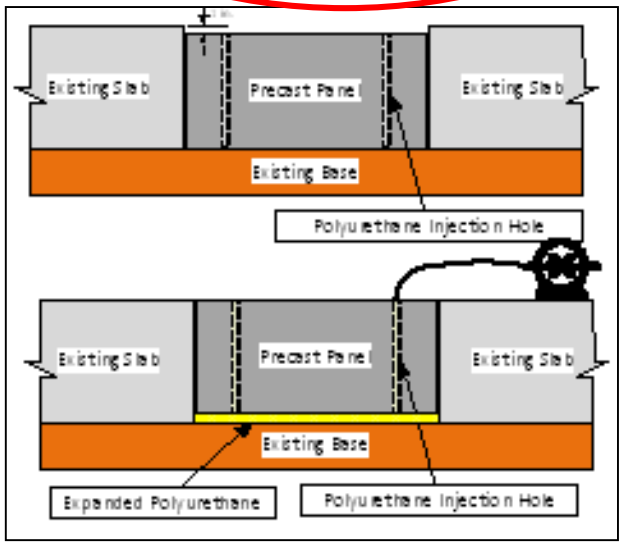
CONTINUOUS (JOINTED OR PPCP) – 1,000 + FT/NIGHT

Repair Panel Installation Options









PCP Key Technical Considerations

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

DIFFERENT SYSTEMS SHARE MANY COMMON FEATURES AND REQUIREMENTS

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

Concrete Requirements

- Both slump concrete & self-consolidating concrete have been used.

Spud vibrator used for consolidation.

Consolidation effort not needed.

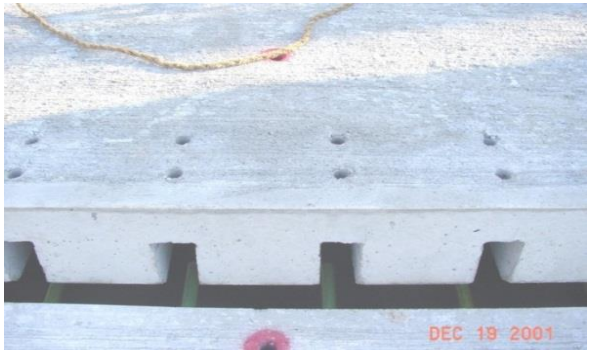
Panel Lifting Requirements
(Reinforcement and/or pretensioning necessary)

- PCI four-point lifting stresses

Panel Length (ft)	Panel Width (ft)	Panel Thickness (in.)	Maximum Concrete Lifting Stress (lbf/in^2)
10	12	9	39
10	24	9	154
10	36	9	347
10	12	10	35
10	12	11	32
10	12	12	29
12	12	9	39
12	24	9	154
12	36	9	347
12	12	10	35
12	12	11	32
12	12	12	29
15	12	9	60
15	24	9	154
15	36	9	347
15	12	10	54
15	12	11	49
15	12	12	45

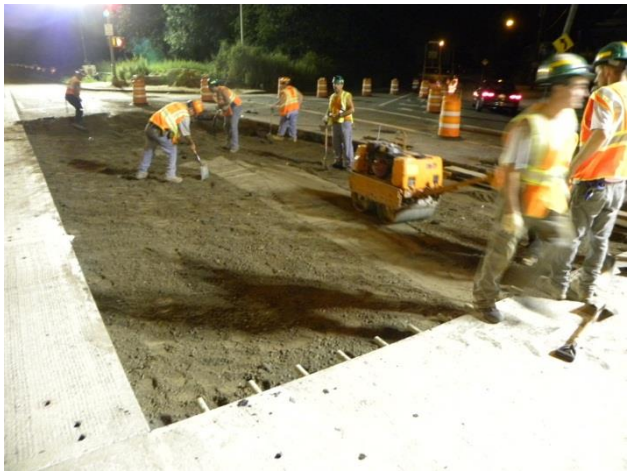
Joint Load Transfer Considerations

- For repairs
  - Method 1: Dowels are drilled and epoxy-grouted along existing pavement sides of joint & dowel slots in panel (top or bottom)
  - Method 2: Dowels embedded in the panel & dowel slots provided in existing pavement
  - Method 3: Dowel slots cut in panel & existing pavement
- For continuous applications:
  - Dowels embedded along one side of the panels & dowel slots at other side of the panel (top or bottom)
  - Surface dowel slots along both sides of the panels (Full DBR approach)



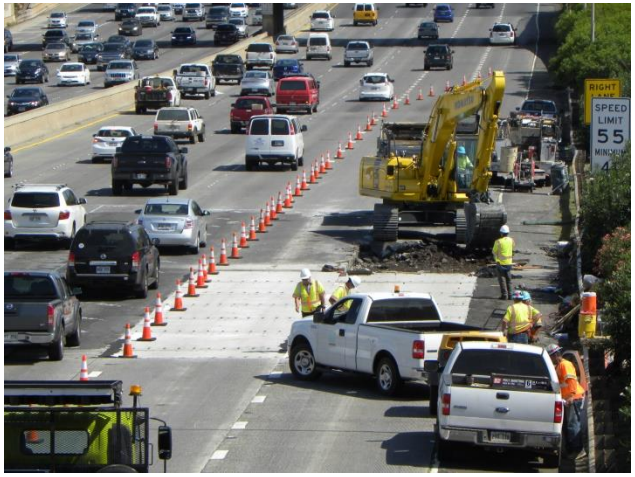
Panel Support Condition Considerations

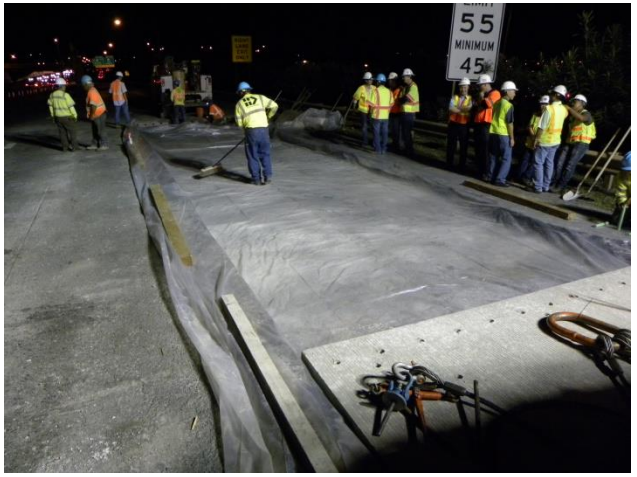
- Use of existing base
  - Granular
    - Reworked, compacted & regraded
    - Reworked, compacted, regraded material applied
  - Stabilized
    - Used as is or trimmed; bedding material applied
  - Bedding material
    - < ¼ in. fine-grained granular material
    - **Thicker layer of rapid-setting flowable grout using elevated panel placement techniques**
    - High density polyurethane grout
- New base – granular or rapid-setting LCB

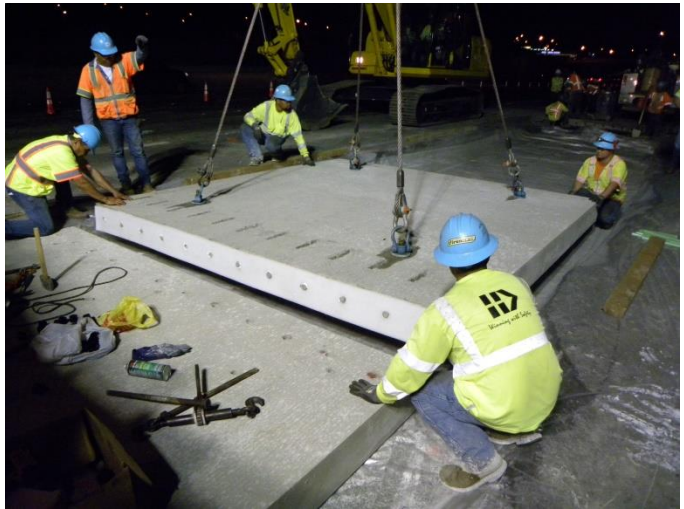


Example: Honolulu H1 Highway

- Use of system with levelling lift; rapid-setting bedding grout under panels

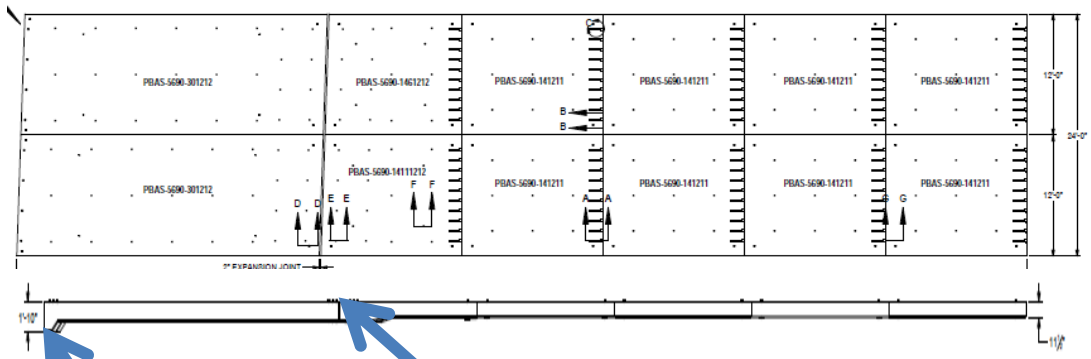






Example: Bridge Approach Slab (BAS)
Illinois Tollway Project (2014)
(Demo of rapid & long lasting rehab of existing settled BAS at sleeper slab & future new BAS)
Location: Midlothian Turnpike Bridge on I-294

- Current IDOT approach – precast base panels with CIP surface concrete
- Tollway proposed approach – eliminate CIP concrete step



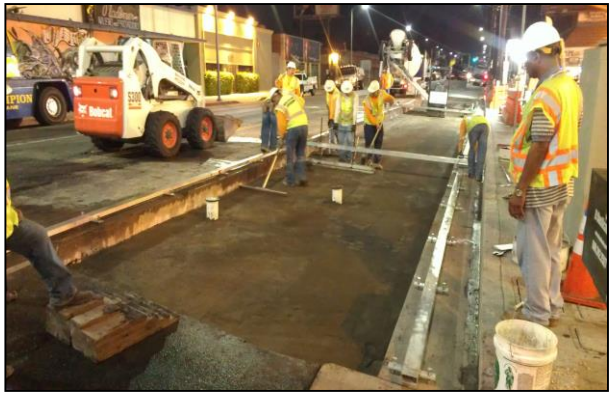
Proposed Tollway approach

- 30ft long BAS, lane wide
  - Levelling system at abutment end
  - Levelling system at opposite end over sleeper slab
  - Higher strength bedding grout for gap
- 70 ft length of transition panels, each 14 ft long

Example: Bus Pad Rehab - Overnight

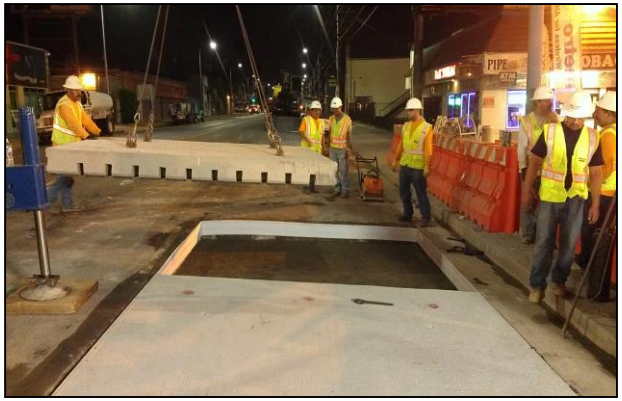
Hollywood & Santa Monica Blvd.

North Hollywood, CA, 2012



Grading Bedding Material

Placing



Placing Last panel

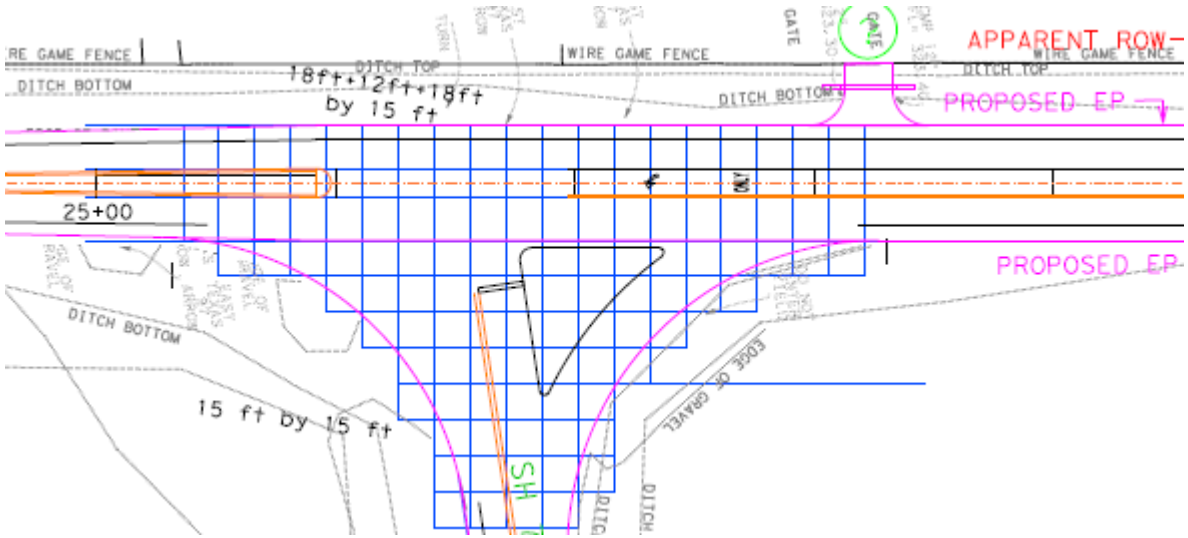
Opened Next Morning

Source: The Fort Miller Co., Inc.

Example: Damaged AC Intersection

Texas DOT Project (2015) (San Antonio District)

(Rehab of intersections damaged by energy trucks)



Summary

- Although experience with PCP systems is limited, less than 12 years, performance to-date indicate that well-designed and well-constructed PCP systems can be installed rapidly and can be expected to provide long-term service
- Precast concrete pavement technology is an implementable technology and continues to evolve.
- The need for the technology is obvious – rapid construction and longer-lasting solutions.


Thank You!
stayabji@gmail.com