ACI Spring 2016 Convention
Milwaukee, Wisconsin - April 2016

OVERVIEW OF PRECAST CONCRETE PAVEMENT PRACTICES & RECENT INNOVATIONS

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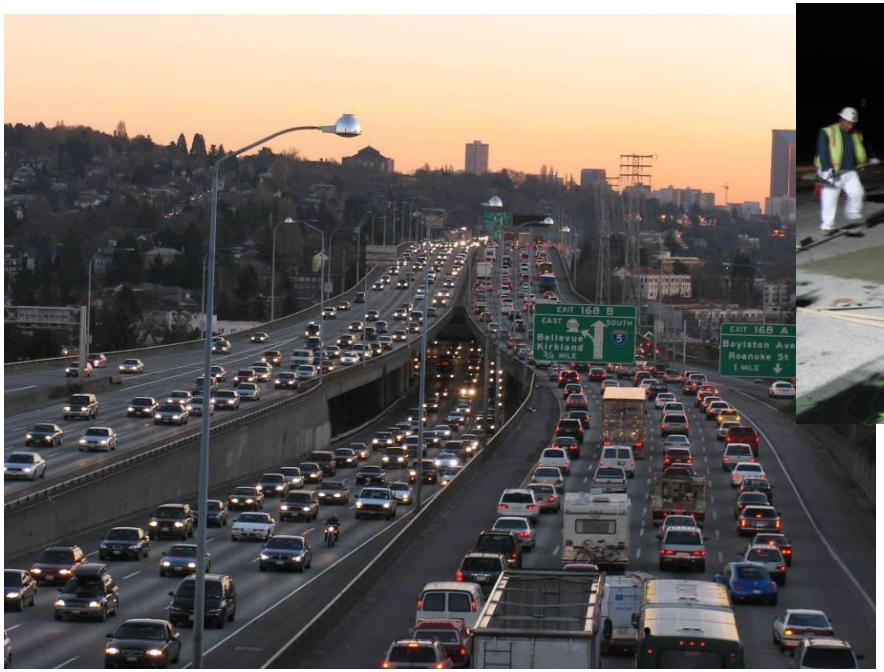
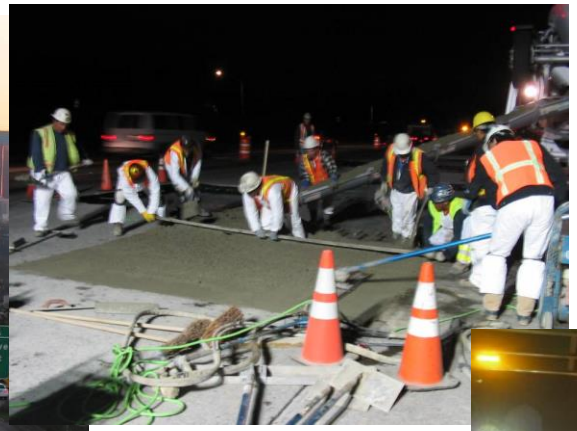
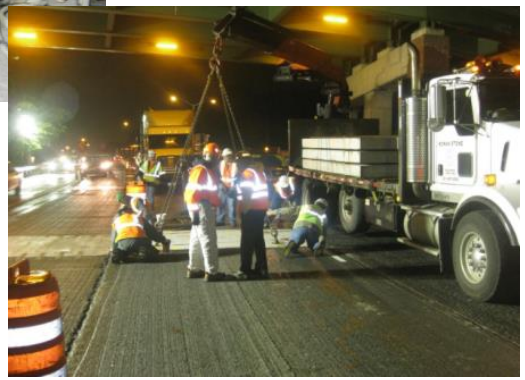
The Need – Pavement Rehab Under Heavy Urban Traffic

A very serious issue throughout urban US







- **Shorter closure, but possibly shorter service life (rapid setting concrete)**
- **Longer service life, but longer closure (conventional concrete paving)**
- **Shorter closure & longer service life (PRECAST PAVEMENT)**

Preamble

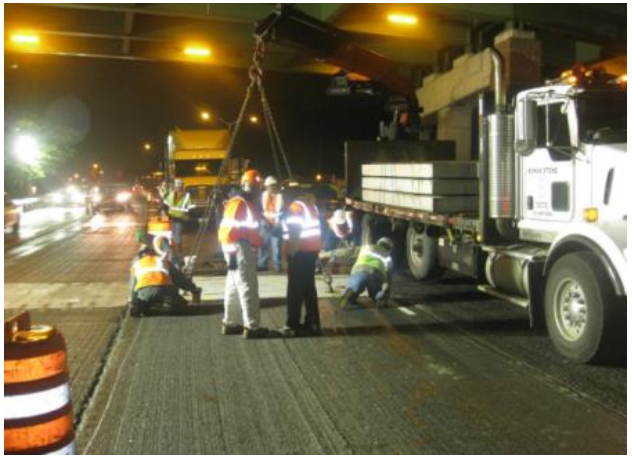
- **PCP technology is not a passing fad. It is here to stay**
- **PCP technology is used routinely by several agencies for rapid repair and rehabilitation of concrete as well as asphalt pavements**
- **PCP projects have been successfully constructed in numerous States by contractors with no prior experience with PCP & precast panels can be fabricated by most precaster**
- **Good availability of precast plants throughout the US**

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**

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



Traffic Considerations

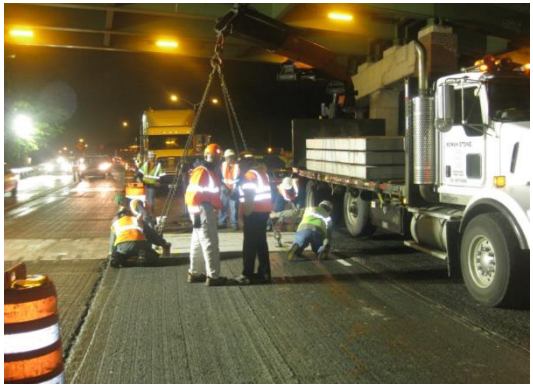
- Traffic volume – is it heavy enough to preclude other pavement alternatives?
  - If fast-track fixed-form or slipform paving techniques are possible, use of precast pavement may not be the best option!

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

But, if there is only 8 hours or less of lane closures to perform the repair/rehab work, precast pavement should be strongly considered

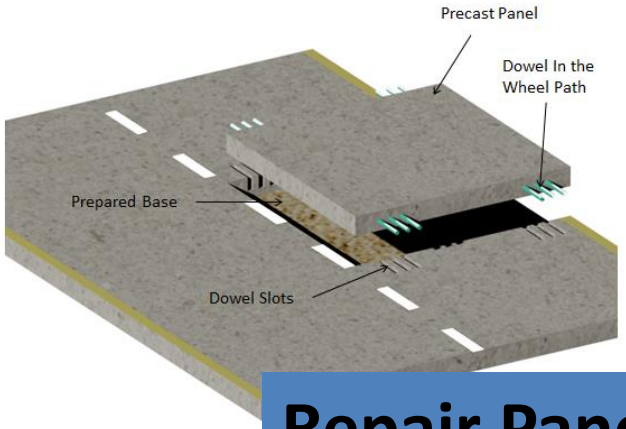
PCP Systems

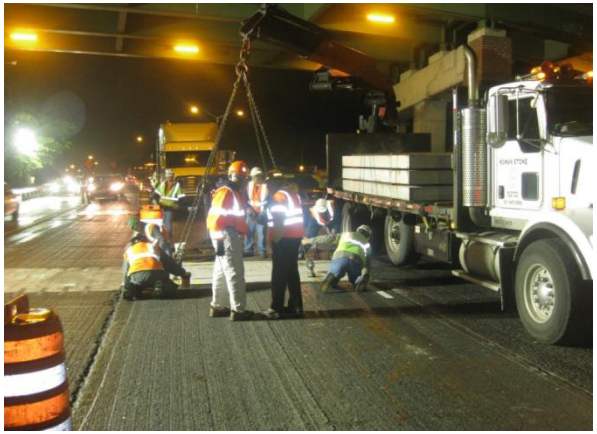
- For intermittent repairs
  - Nominally reinforced panels
  - Prestressed panels
- For continuous applications
  - Jointed PCP systems (JPrCP)
    - Nominally reinforced panels
    - Prestressed panels
  - Post-tensioned systems (PPCP) - fewer active joints; longer sections



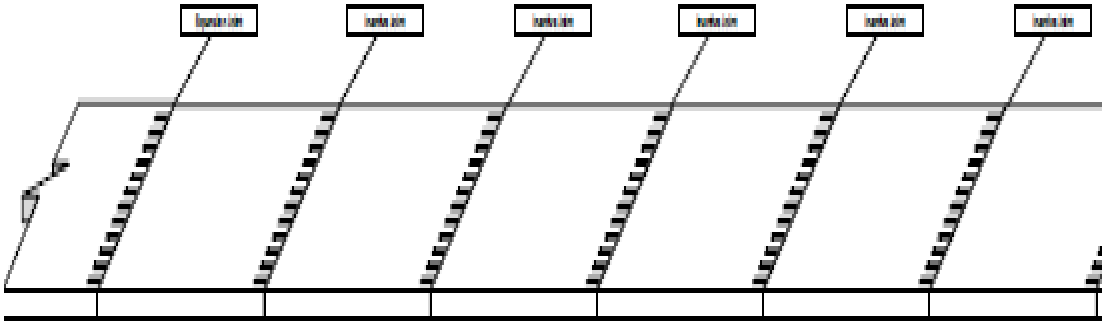
Generic & Proprietary Systems (Components) Available

PCP Systems





Repair Panels



Conventional Jointed PCP System

State of Practice - Jointed Systems

Overall Approaches

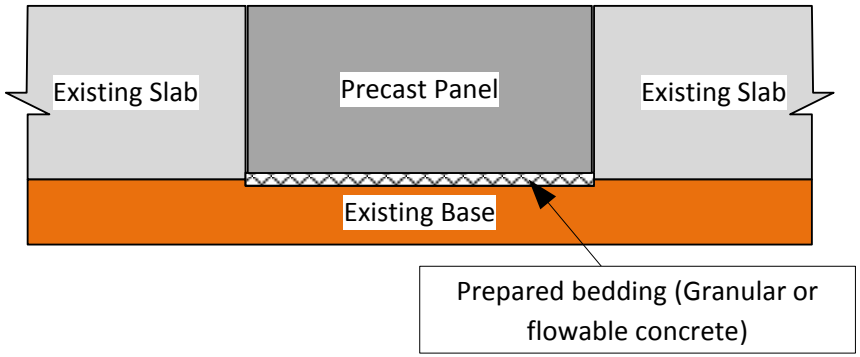
Support Condition

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

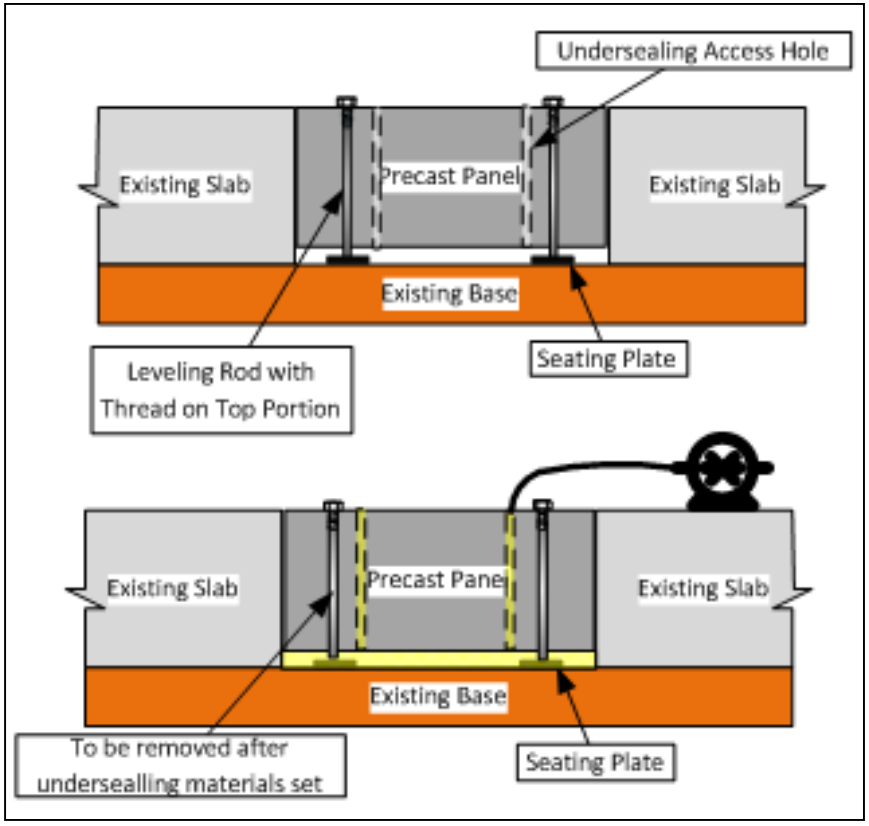
Load Transfer System

1. Using slots at the panel surface (several variations)
2. Using slots at the panel bottom (one patented system)

Panel Installation Options
(Grade placed – Repair & Continuous)

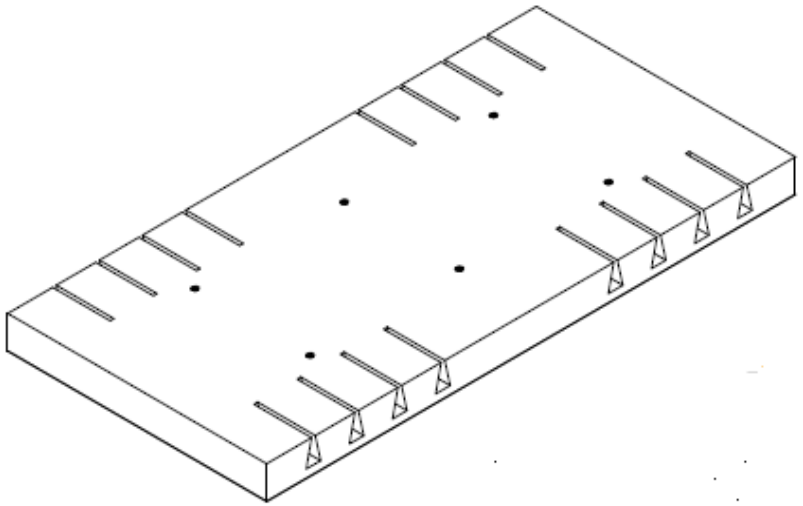


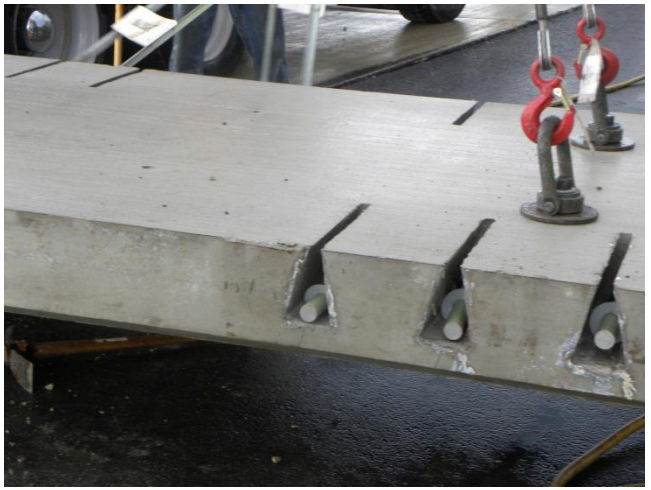
Panel Installation Options
(Levelling bolts & thicker bedding - Repair & continuous)



PCP Load Transfer Refinement (USA)

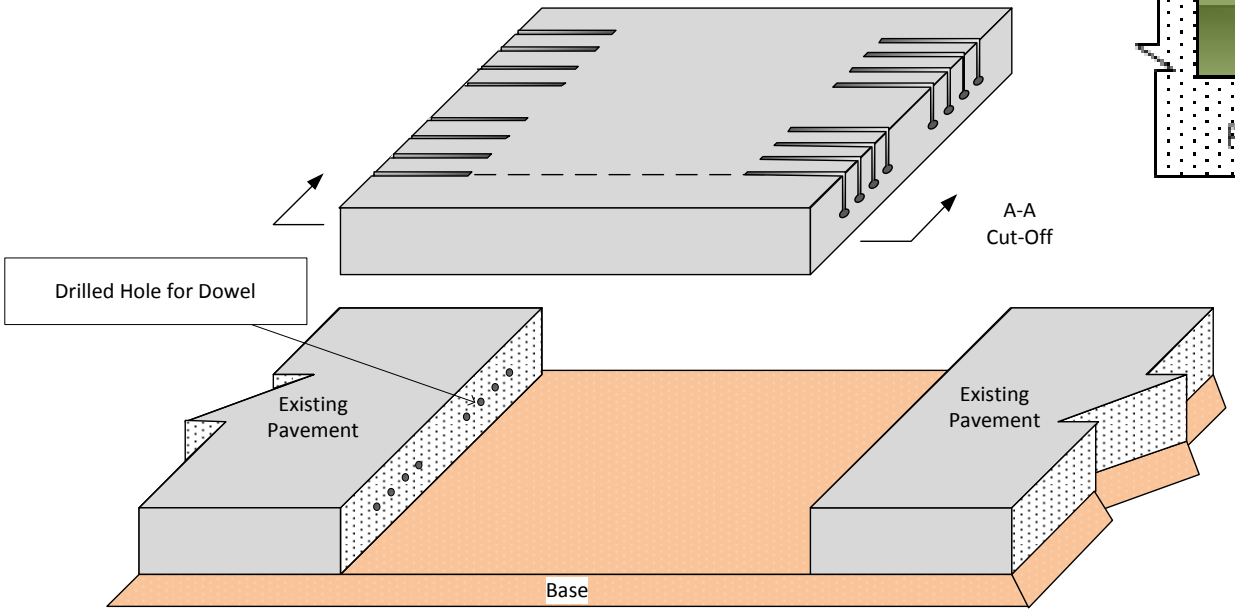
- Alternate method for installing dowel bars at transverse joints
  - Use of a narrow dowel bar slots at the surface for transverse joint load transfer – allows opening to traffic before the dowel bar slots are patched

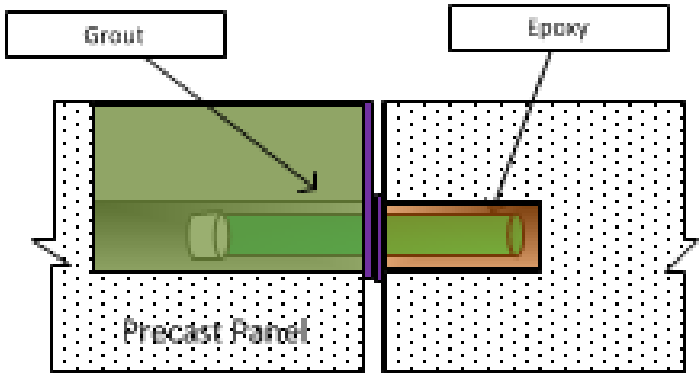


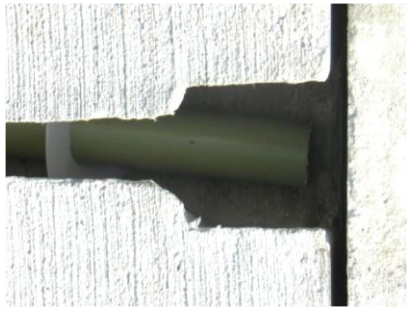


PCP Load Transfer Refinement (USA)

- Adopted by the Illinois Tollway
  - Use of a narrow-mouth dowel bar slots at the surface



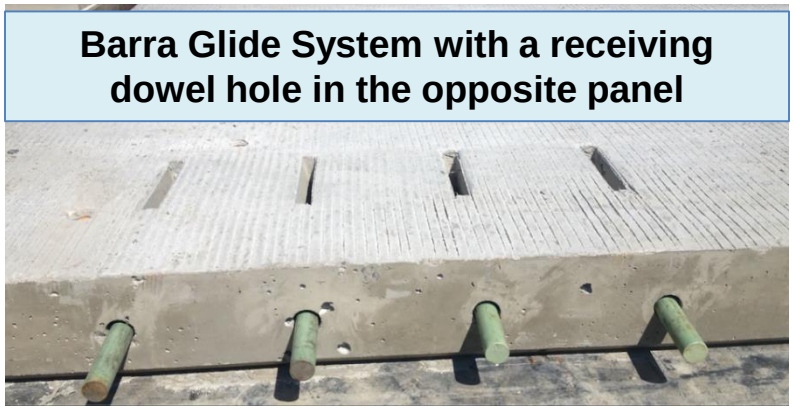


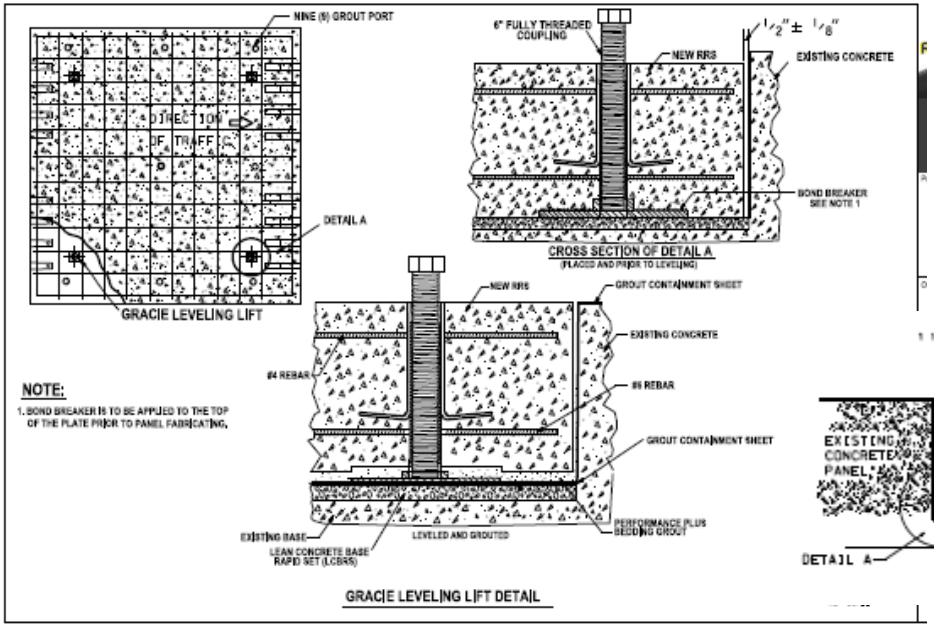


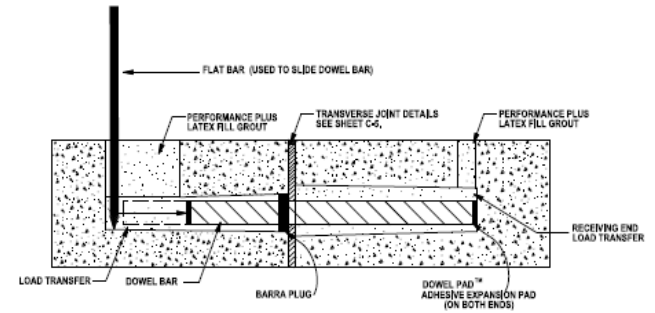
California Rapid Roadway Pavement System

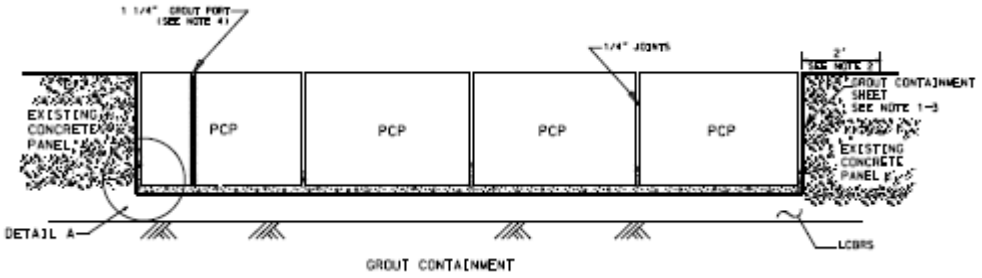
Barra Glide Load Transfer System & Gracie Lift Device Developed in 2013

Barra Glide System with a receiving dowel hole in the opposite panel



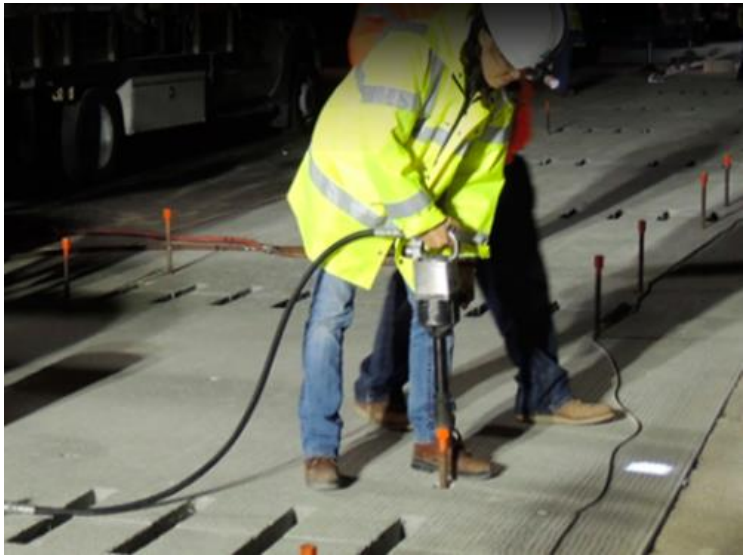


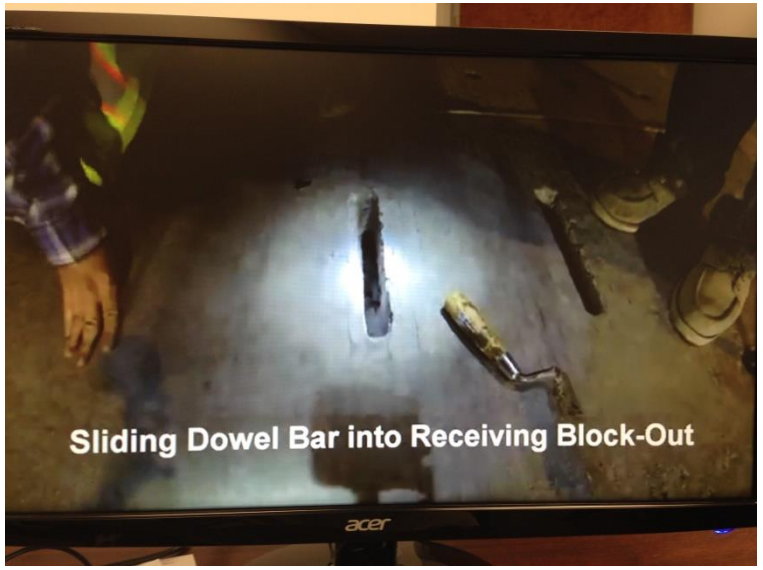




California Rapid Roadway Pavement System

Barra Glide Load Transfer System & Gracie Lift Device





Caltrans Load Transfer Refinement

Generic Caltrans Tear Drop Slot System used with Gracie Levelling Lift System (or Shims)

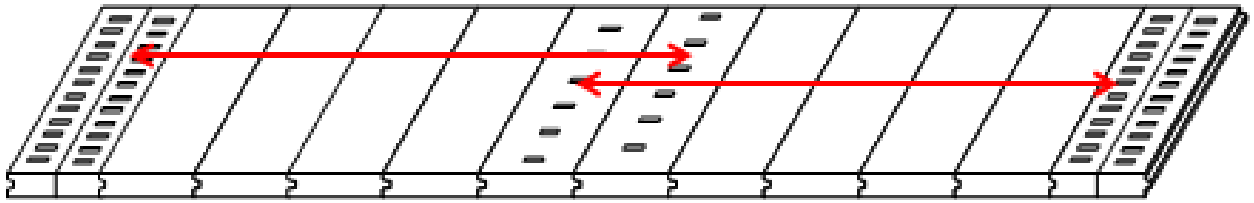
SH 101 design (2015)

I-210 design (2016)

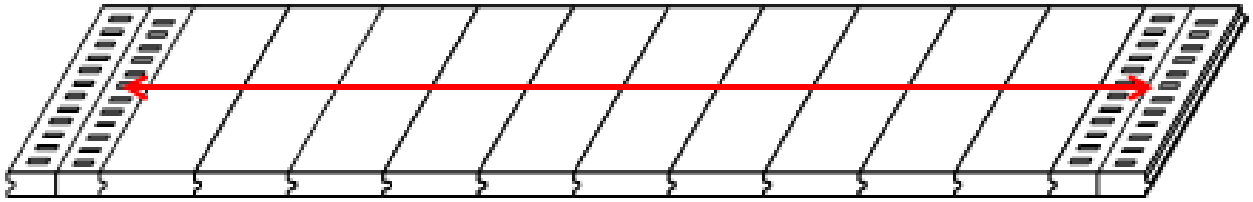
PPCP Systems

(Concept Developed at University of Texas – 2001)

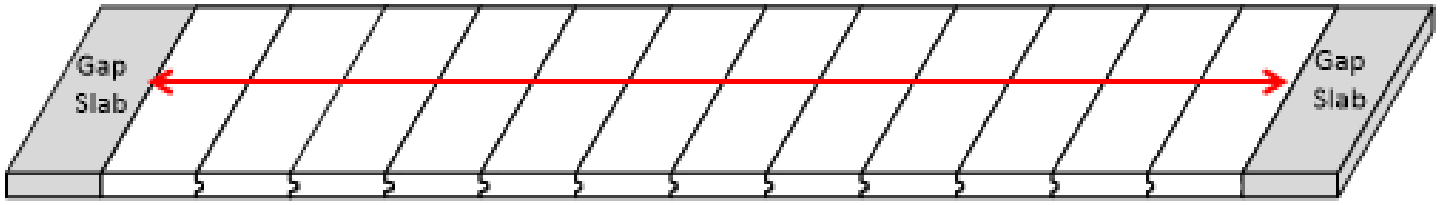
- A number of panels are posttensioned together to result in a posttensioned section length of 200 to 250 ft & induced prestress of 150 to 200 psi
- Tendons are bonded to the concrete thru grouted tendon ducts



Original - Central panel surface pocket posttensioning



Refined - End panel surface pocket posttensioning



Current - End panel joint face posttensioning and gap panel use

Panel Production vs. Installation Rates

- Panel fabrication rate
  - 8 to 10 panels per day (inside 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

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
- 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
  - Underpasses - Where height restrictions may limit rehab options
  - Bus pads - Where alternative bus stop locations are not acceptable, bus pads can be replaced overnight
  - Airfield Applications - A developing market
  - Utility "bridges" - Over failed drainage pipes & culverts

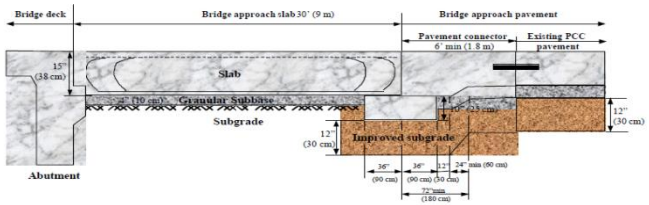
Intersections

(Rehab of distressed AC Intersections)

- A very effective option to rehab distressed/rutted AC intersections that carry high volume of traffic, including heavy truck traffic

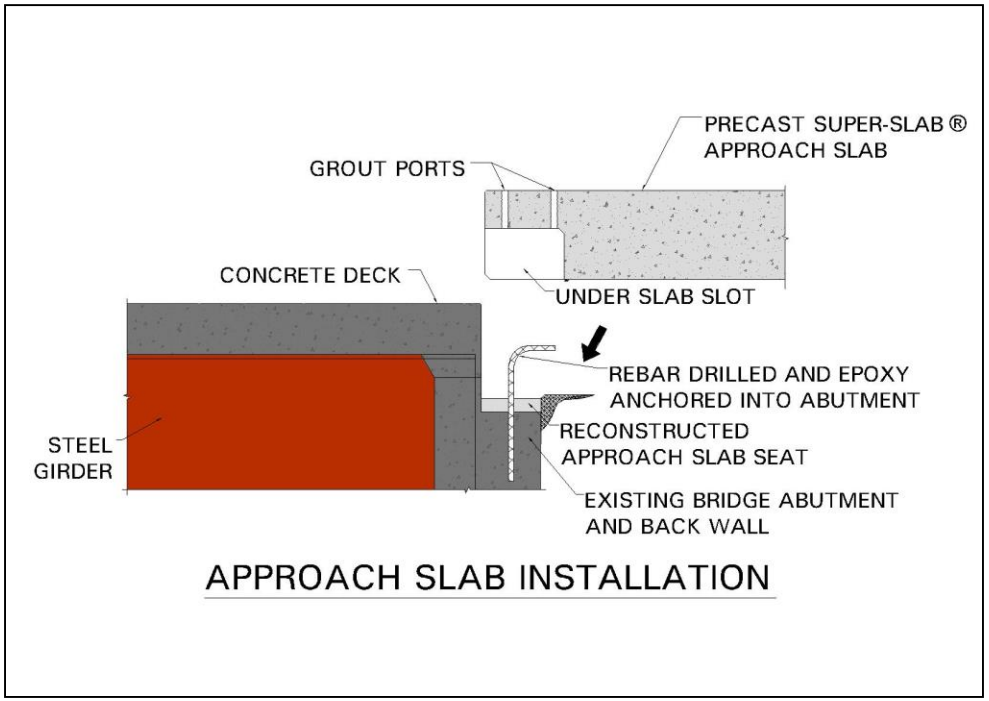
Bridge Approach Slabs (BAS)

- Thousands of distressed approach slabs exist
  - Exhibited by classic “bump” at bridge end/approach
- Causes of failure
  - Settlement of underlying soils
  - Erosion of embankment materials
- Difficult to rehab/replace
  - Often repaired with “band-aid” materials
- Precast panels - a good fast and permanent repair
  - Full-depth replacement allows opportunity to repair underlying embankment
  - Can be installed in over night or over-the-weekend work windows



Active program underway at the Illinois Tollway to study implementation of precast panels to rehab existing BAS & for new BAS at new integral abutment bridges

Example: Approach Slab on Existing Bridge Abutments



Cross Section at End of Existing Bridge

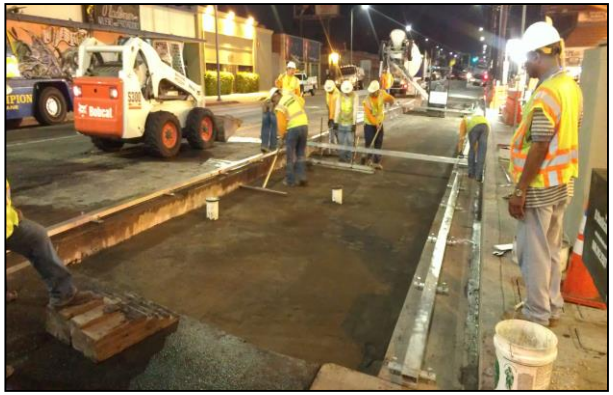
Placing panel Over Anchor Rods

Placing panels In One Lane

Source: The Fort Miller Co., Inc.

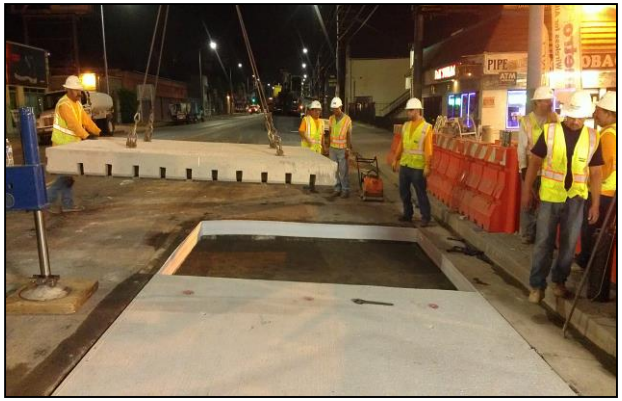
Bus Pad Rehabilitation

Hollywood & Santa Monica Blvd.
North Hollywood, CA, 2012



Grading Bedding Material

Placing



Placing Last panel

Opened Next Morning

Source: The Fort Miller Co., Inc.

Long-Life Expectations for PCP

- Repair applications – 15 to 20 years or to reconstruction of existing pavement
- Continuous applications
  - Original PCC surface service life – 40+ years
  - Pavement will not exhibit premature failures and materials related distress
  - **Pavement failure=> Result of traffic loading**
  - Pavement will have reduced potential for cracking, faulting & spalling, and
  - Pavement will maintain desirable ride and surface texture characteristics with minimal intervention activities to correct for ride & texture, for joint resealing, and minor repairs

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

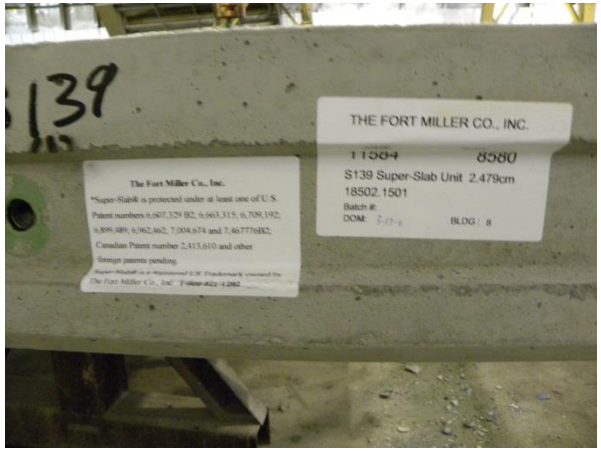
Panel Static Lifting Flexural Stresses

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

As a panel dimension gets longer, pretensioning becomes necessary

PCI guidelines (PCI 2004)

Panel Fabrication (Current Jointed) – Reasonably Standard & Routine



The Panel Fabrication Process (Current) - Prestressed Panels for Jointed PCP

Panel Support Condition Considerations

- Use of existing base
  - Granular
    - Reworked, compacted & regraded
    - Reworked, compacted, regraded , bedding 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 fill (RSFF) or grout using elevated panel placement techniques (levelling bolts/shims)**
    - High density polyurethane grout
- New base – granular or rapid-setting LCB, with or without bedding material

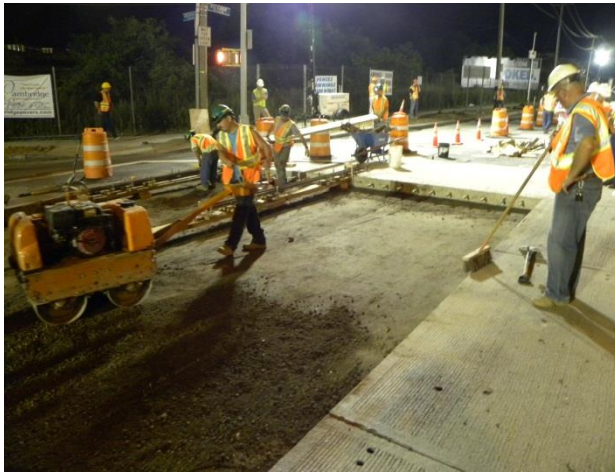
Virginia I-66 (Sept. 2009)

Continuous Placement – Fort Miller System (Ramp Lane)

Note: If an extra 6 in. width had been trimmed off, most of the longitudinal spalling would have been taken care of.

New York City - Continuous Jointed PCP

Fort Miller System – Rehab of AC Intersections, 2010
Rockaway Boulevard near JFK Airport



Summary

- Although experience with PCP systems is limited, less than 15 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
- The need for the technology is obvious – rapid construction and longer-lasting solutions.