VIRTUAL ACI CONCRETE CONVENTION

Precast Concrete Pavements

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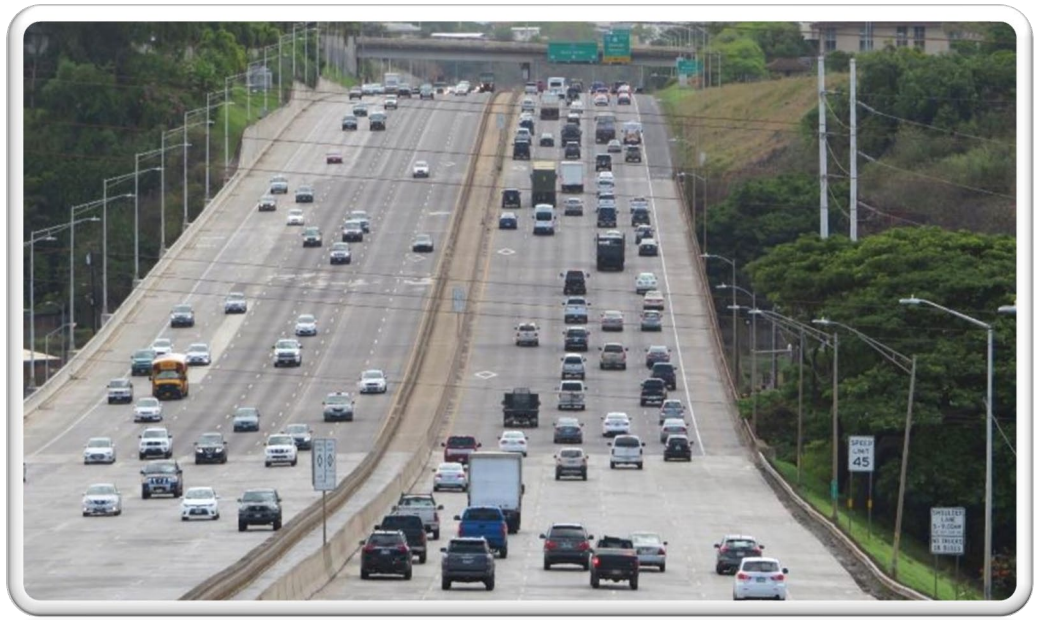
Pavement Engineering and Research Consultants (PERC), LLC



Concrete Pavement Design and Construction Special Session
Honoring Dr. Shiraz Tayabji
April 1, 2021

Presentation Outline

- A Brief History of PCP in the U.S.
- Key Developments in PCP Technology
- Current State-of-Practice for Precast Pavement Design and Construction
- Future Directions for PCP

This presentation is dedicated to Dr. Shiraz Tayabji, whose efforts and innovations have helped to usher in the modern age of precast concrete pavement.

The Primary Motivation for PCP Technology

145,000 ADT
I-287, Tarrytown, NY

200,000 ADT
I-15, Ontario, CA

180,000 ADT
I-66, Fairfax, VA

Precast Concrete Pavement is one such rapid repair alternative

There is a need for repair alternatives that :

- ✓ ***Offer rapid construction in short work windows***
- ✓ ***Cause minimum disruption***
- ✓ ***Are durable – providing long service life***

Photos: The Fort Miller Co., Inc.

Brief History of Precast Concrete Pavement in U.S.

Highways

- Some 1970s experimental use of precast concrete joint repair panels in Michigan and Virginia)

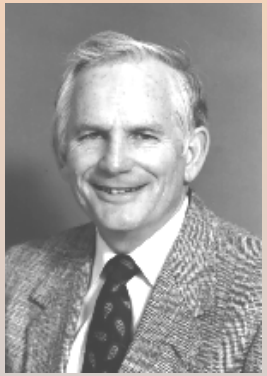
Airfields

- Numerous military airfield demo and trial applications in 1970s and 1980s
  - New York: 12 ft x 30 ft x 9 inches
  - California: 116 custom-sized panels replaced (and then overlaid with 8 inches asphalt)
  - Florida: 6ft x 6ft x 8-12 inches thick
  - Mississippi: used to predict repair times for bomb craters (up to 50 ft x 50 ft and 6-8 inches thick

Brief History of Precast Concrete Pavement in U.S.

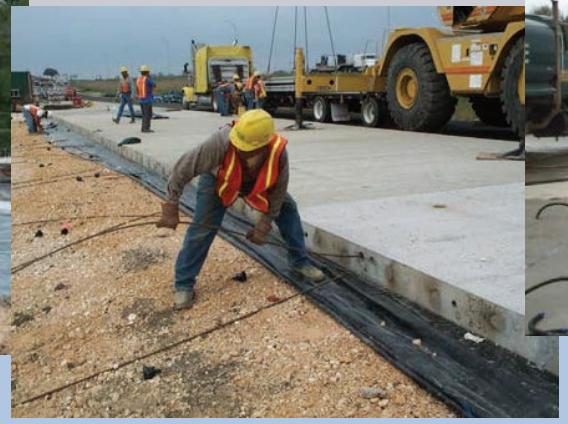
Georgetown, Texas Frontage Road Demo

(Ref. Merritt, McCullough and Burns, 2002)



B. Frank McCullough

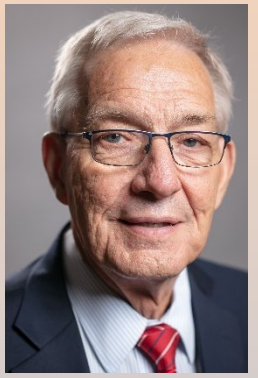
- 2001 – 2002 PPCP Demo reconstruction on I-35 Frontage Road
- ~2300 centerline-ft of 8-inch, two-lane roadway and shoulders (36 ft wide)
- 200 – 325 ft effective panel lengths (post-tensioned 2 directions)

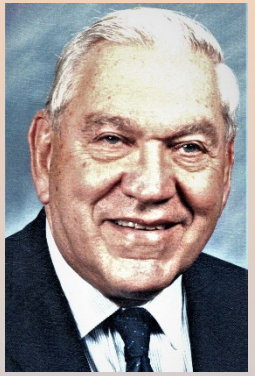


- Demonstrated advantages of precast pavement for rapid reconstruction and several specific construction techniques for PPCP.

Brief History of Precast Concrete Pavement in U.S.

Tappan Zee Bridge Toll Plaza, New York Metro Area


Peter Smith


Ernie Barenberg

- Oct 2001 – July 2002 reconstruction of Toll Plaza under traffic (off-peak)
- 1st major U.S. PCP construction project done under live traffic
- 1088 doweled and tied 10-inch thick JCP panels; 162,876 s.f.
- Production = 3,000 s.f. installed/8-hour shift, ±1/8 inch elevation – no grinding

- Proved viability of precast pavement (re)construction in high-volume urban areas
- Demonstrated advantages of specific JPrCP features

Brief History of Precast Concrete Pavement in U.S.

Taxiway Panels at Dulles Int'l (Washington, DC), 2002

- T/W Bravo
  - Removed: 4 panels, 25' x 25' x 14" thick
  - Placed: 8 precast slabs, 25' x 12.5' x 13" thick (25.3 tons each)
  - 4 panels in 2.2 hours, opened to traffic at 6am
- T/W Yankee
  - Removed: 2 panels, 25' x 25' x 14" thick
  - Placed: 4 precast slabs, 20' x 12.5' x 13" thick (20.25 tons each)

Source: The Fort Miller Co., Inc.

Brief History of Precast Concrete Pavement in U.S.

The PANY Precast Concrete System at LaGuardia Airport (2002)

- 2 Areas 100 ft x 50 ft
- 12.5 ft x 25 ft panels
- 16-in thick conventionally reinforced
- 12-in thick pretensioned
- Panels transported by barge

Source: Buch and Tayabji (SHRP R05 Study)

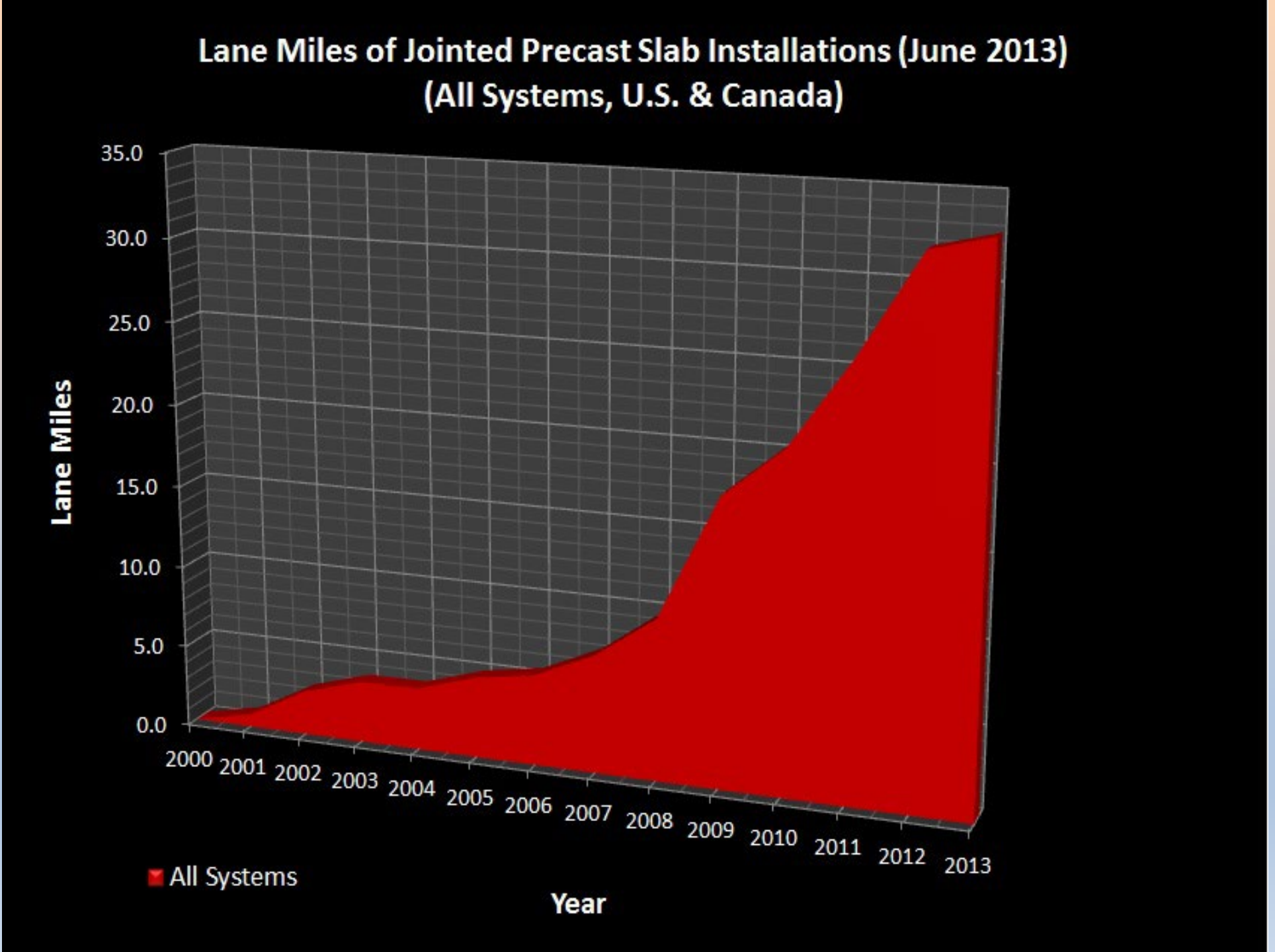
Brief History of Precast Concrete Pavement in U.S.

AASHTO TIG – Precast Concrete Paving Slabs (PCPS)

- Active 2005 - 2008
- Agencies (CA, IA, IN, NY, NYSTA, MN, MO, ONT, PANY/NJ, VA) FHWA, Academia, Industry

- Products:
  - FAQ list
  - Guide Specs for Design, Construction and System Approval
  - Specification Clearinghouse

aii.transportation.org/Pages/PrecastConcretePavingSlabs.aspx



More than 113.5 lane-miles of JPrCP as of Sept 2018, including:

- CA – 51.7 ln-mi
- NY – 28.0 ln-mi
- IL – 7.4 ln-mi
- NJ – 7.1 ln-mi
- HI – 3.6 lm-mi
- ONT – 3.2 ln-mi

Source: NPCA

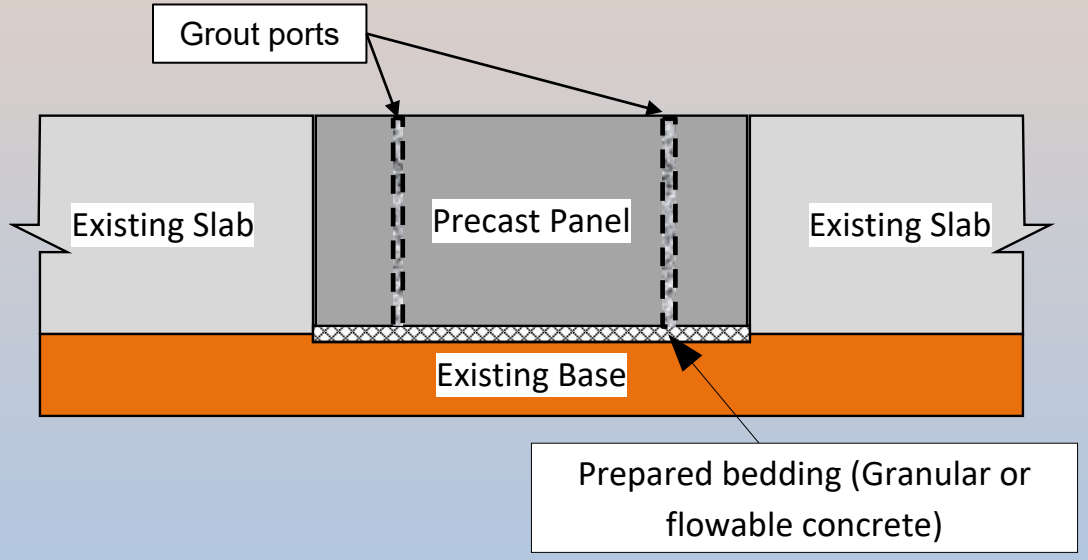
Key Developments in Precast Pavement Technology

- Slab support and leveling
- Achieving desired surface geometry
- Load transfer system design
- Other (Honorable, but unmentionable today)
  - Prestressing for increased panel length or reduced slab thickness
  - Panel designs and construction procedures for repair of CRCP

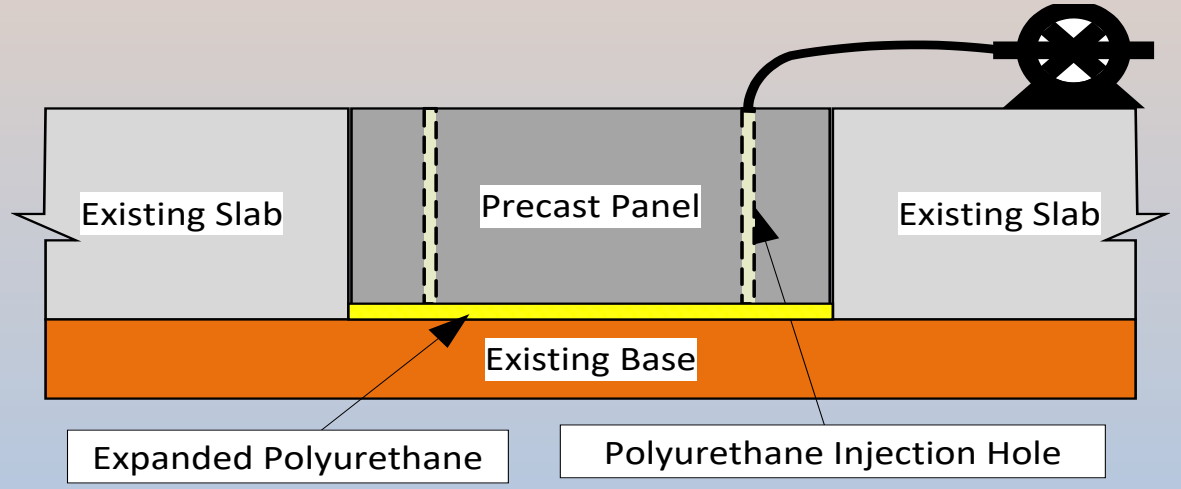
Methods of Achieving Slab Support

Uniform support is key to precast concrete pavement performance.

(The same is true for conventional concrete pavements!)



Grade-supported



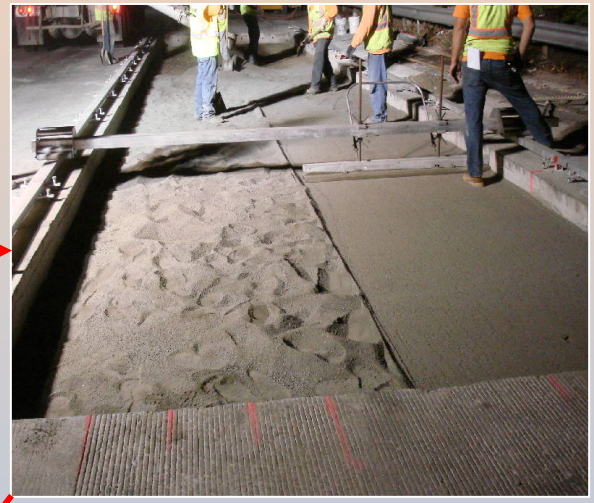
Urethane or Grout Injection

Images: Dr. Shiraz Tayabji, Advanced Concrete Pavement Consultancy, LLC

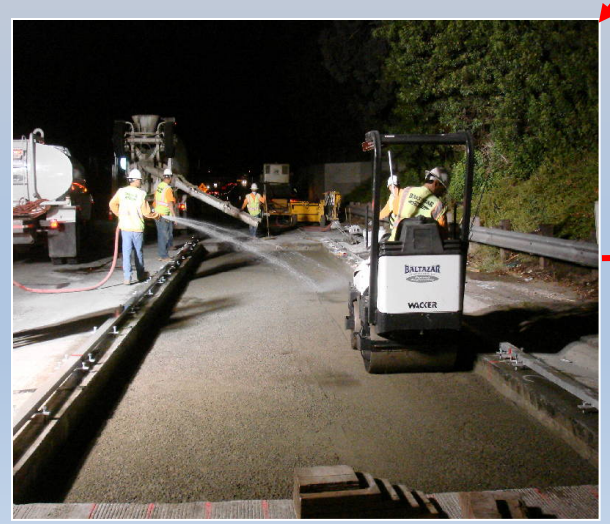
Grade-Supported Systems:

Placing, Compacting & Grading Bedding Material

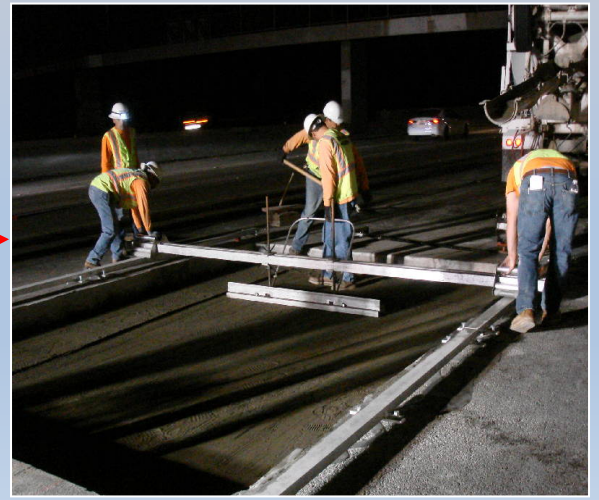
Placement of Bedding Material



First Grading Pass



Wetting & Compacting



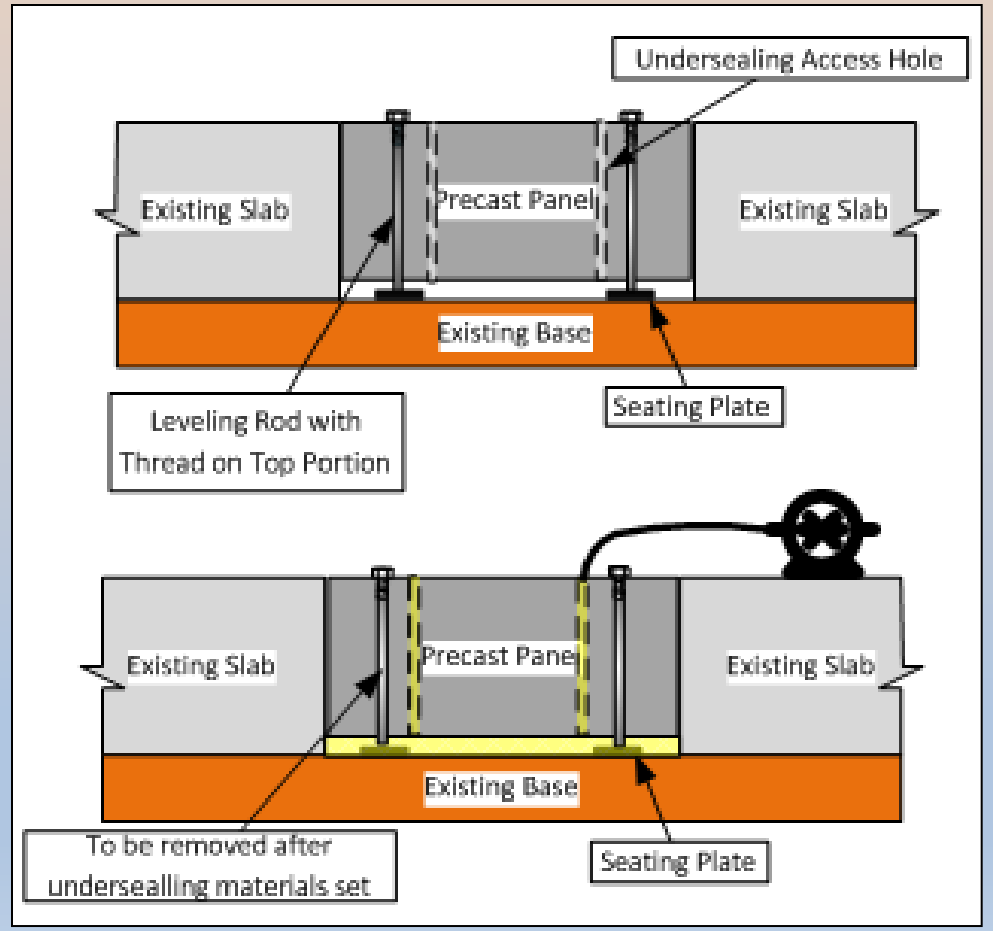
Final Grading Pass

Images: The Fort Miller Company, Inc.

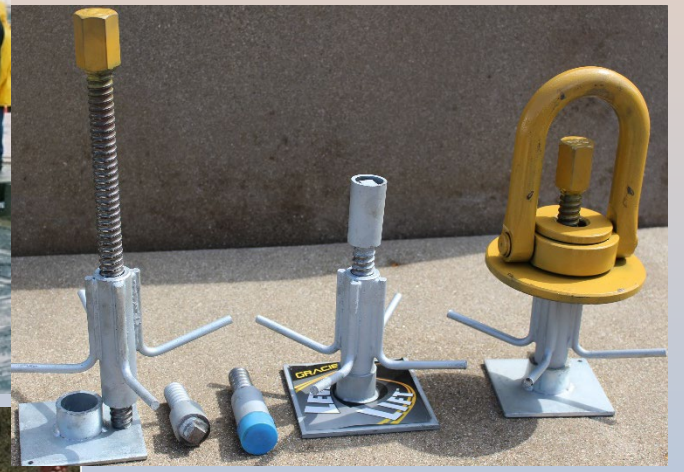
Methods of Achieving Slab Support

Uniform support is key to precast concrete pavement performance.

(The same is true for conventional concrete pavements!)



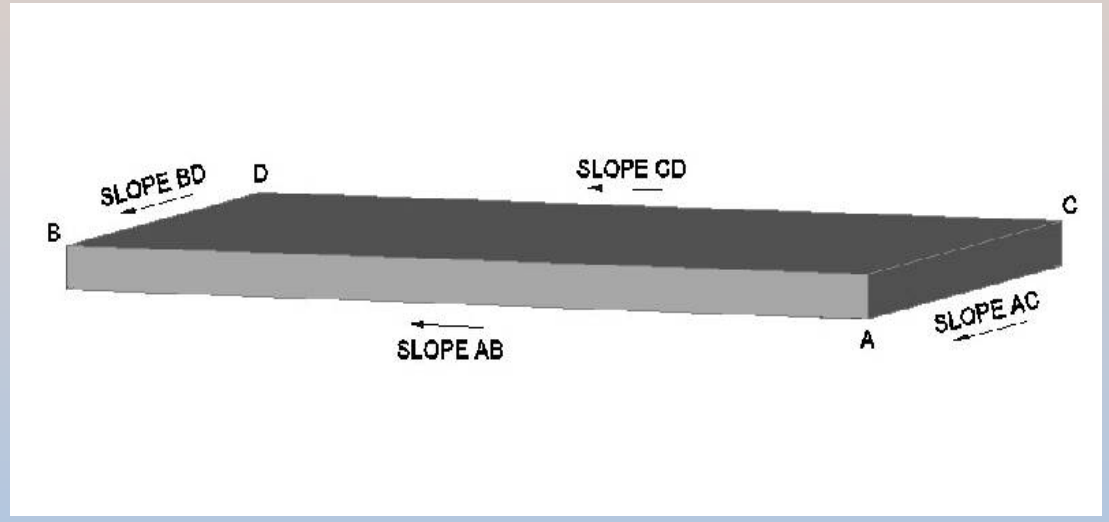
Leveling Jacks with Grout



Images: Dr. Shiraz Tayabji, Advanced Concrete Pavement Consultancy, LLC, Gracie Leveling Lift, and The Fort Miller Company, Inc.

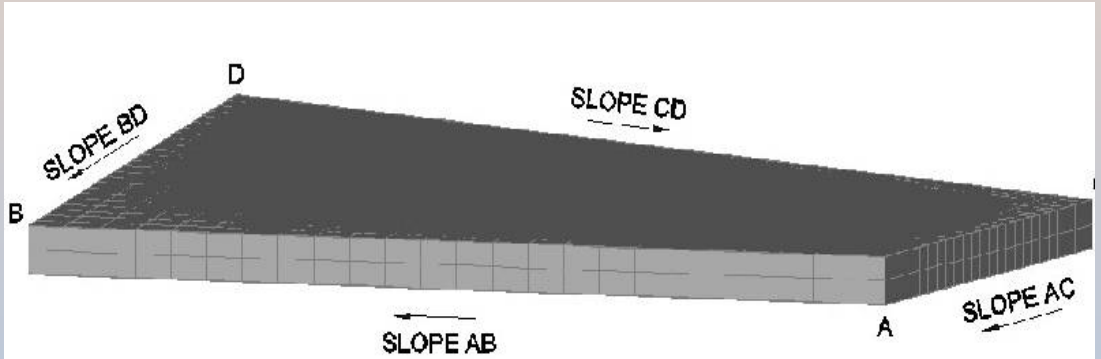
Matching Pavement Surface Geometry

Slab shape must match geometry of surrounding pavement surface



Single Plane

Slopes of opposite sides are equal



"Delta" = vertical displacement of 4th corner from plane formed by other three corners

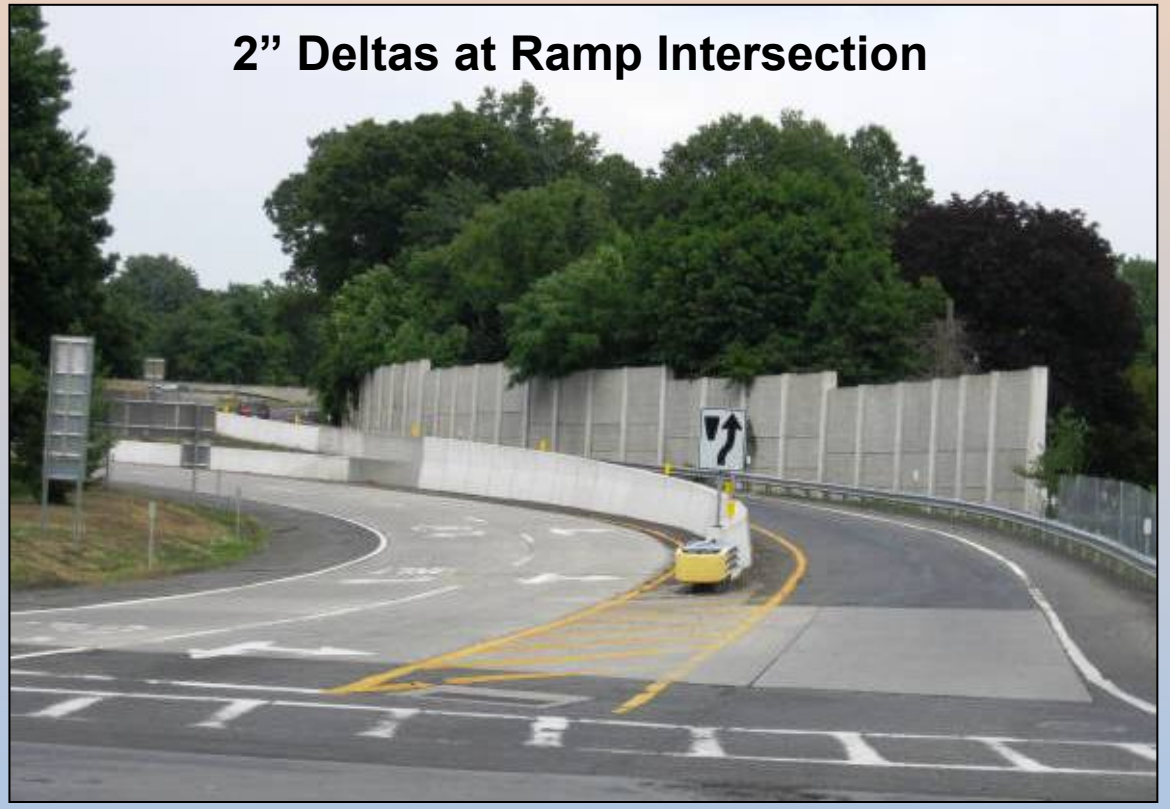
Warped Plane

Slopes of opposite sides are un-equal

Source: The Fort Miller Co., Inc.

Nonplanar Surfaces

More Common Than You Might Think!



- Often imperceptible by eye
- Perform 3-D survey to be sure

Source: The Fort Miller Co., Inc.

Creating Nonplanar Pavement Surfaces

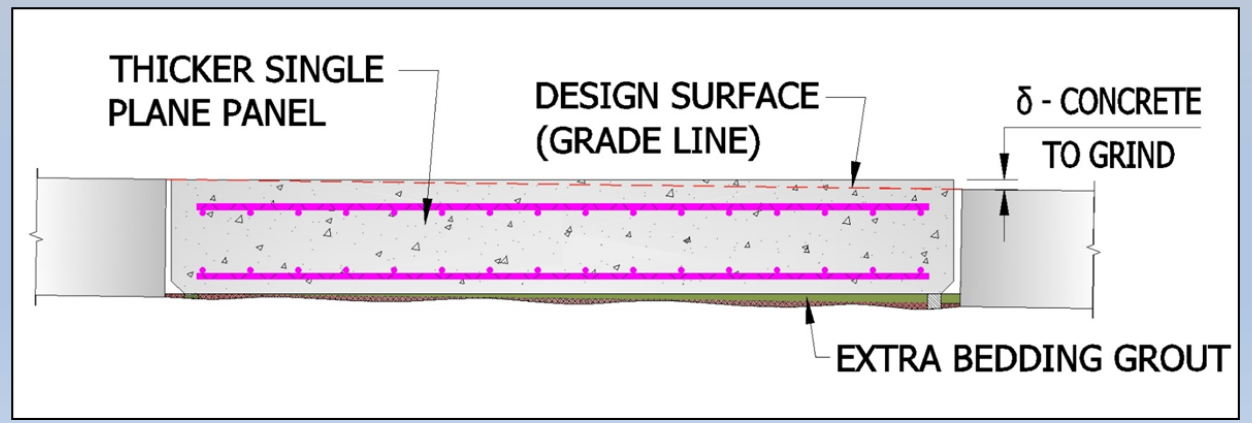
Option 1: Grind Flat Slabs to Profile

Pros:

- Flat slabs are easily fabricated and less costly

Cons:

- Added cost of grinding
- May require added slab thickness
- Voids between single-plane panel and nonplanar foundation
  - Extra extra bedding grout required
  - May prevent opening to traffic without grouting.



Images: IGGA and The Fort Miller Co., Inc.

Creating Nonplanar Pavement Surfaces

Option 2: Fabricate Nonplanar Panels

Pros:

- Minimize need for diamond grinding (less cost)
- No significant thickness reduction or need for added thickness
- Less bedding grout
- Allows opening to traffic without grout

Cons:

- Need 3D data for design, fabrication
- Needs more engineering, special forming equipment, more fabrication labor
- Can complicate prestressing

Image: The Fort Miller Co., Inc.

Load Transfer System Options

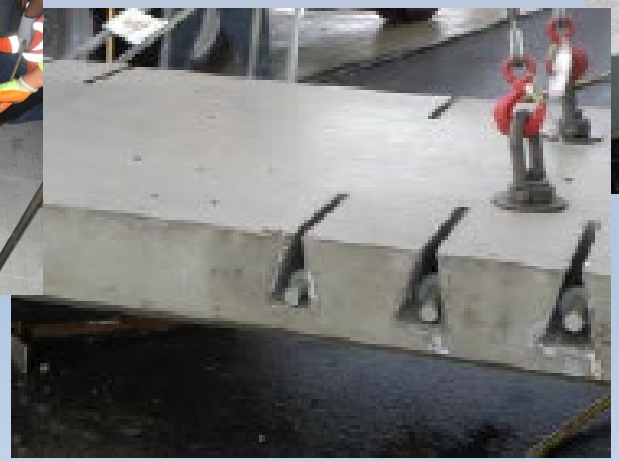
Super-Slab® Bottom Slot System

- Dowels engage slots in adjacent slab
- Pump dowel group into ports
  - Grout reaches 2500 psi in about 2 hours
- Fill slots and joint between slabs
- Dove-tail slot resists bar pop out
- “Clean” pavement surface

Source: The Fort Miller Co., Inc.

Load Transfer System Options

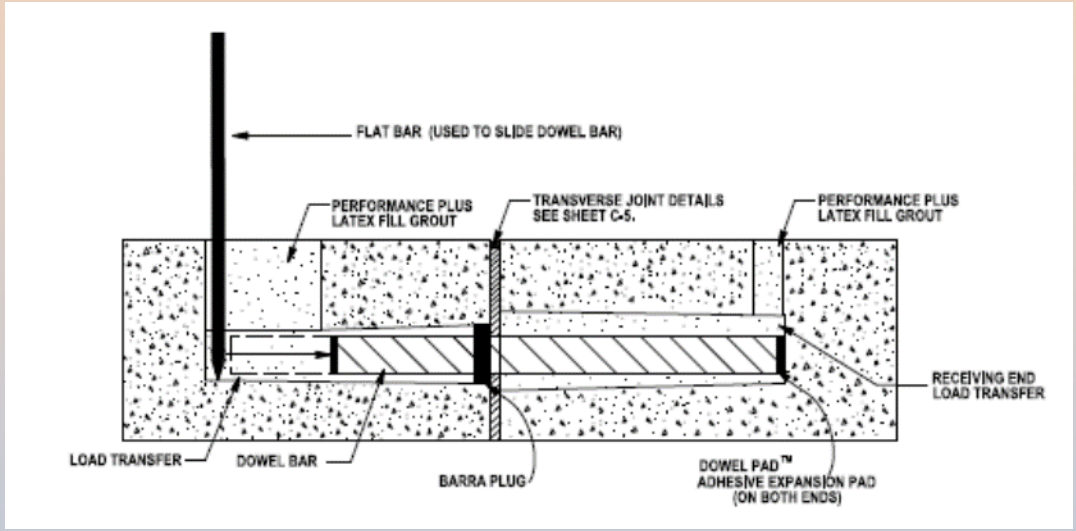
Top-Slot Systems – Early DBR-style, Teardrop, and SHRP2 Narrow-mouth

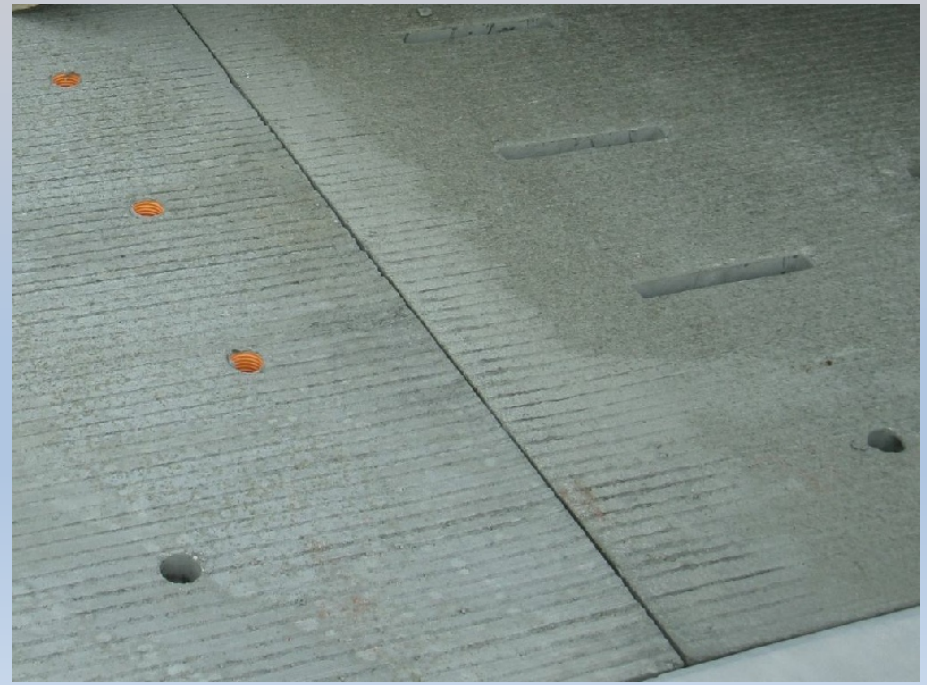


Images: Tayabji and Buch SHRP2 R05 Study, Mehdi Parvini (Caltrans), Dr. Shiraz Tayabji

Load Transfer System Options

Center-Slot Systems – Barra-Glide™





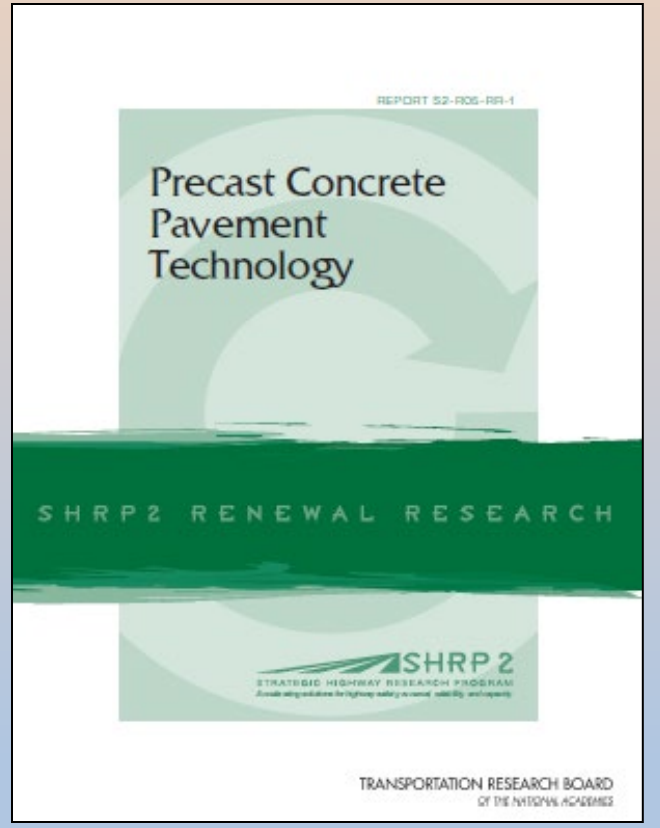
Source: Rapid Roadway Solutions (http://rapidroadwaysolutions.com)

Current State-of-Practice

SHRP2 Project R05 (2008 – 2012)

Precast Concrete Pavement Technology

- Overall findings.
- Findings based on field testing.
- Guidelines for PCP design.
- Guidelines for PCP fabrication.
- Guidelines for PCP installation.
- Guidelines for PCP project selection.
- Guidelines for PCP system acceptance.
- Model specifications.
- Implementation plan.

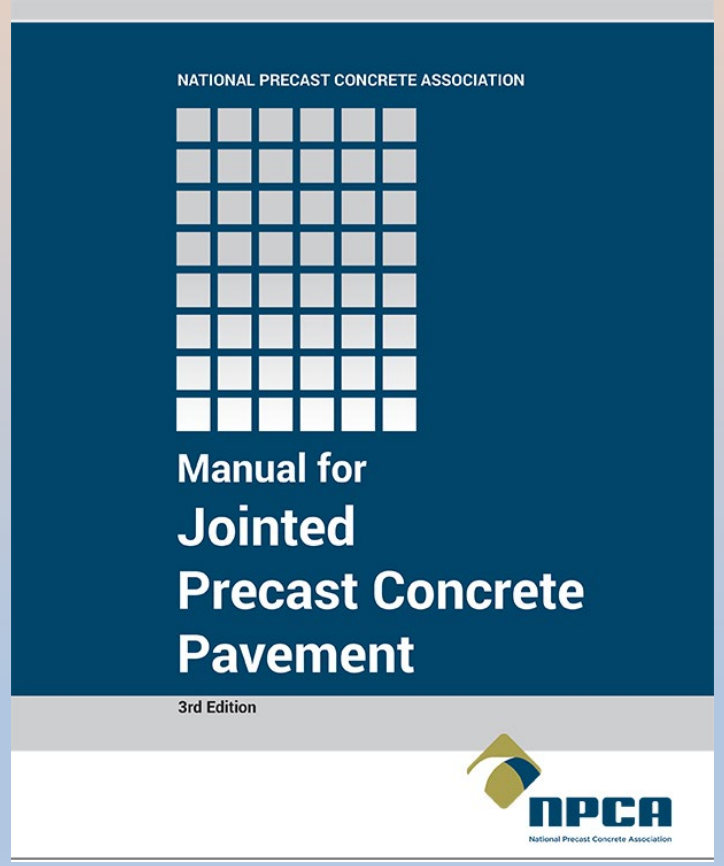


http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-R05-RR-1.pdf
http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/Pages/R05-Model-Specifications-718.aspx

Current State-of-Practice

NPCA Manual for Jointed Precast Concrete Pavement (2018)

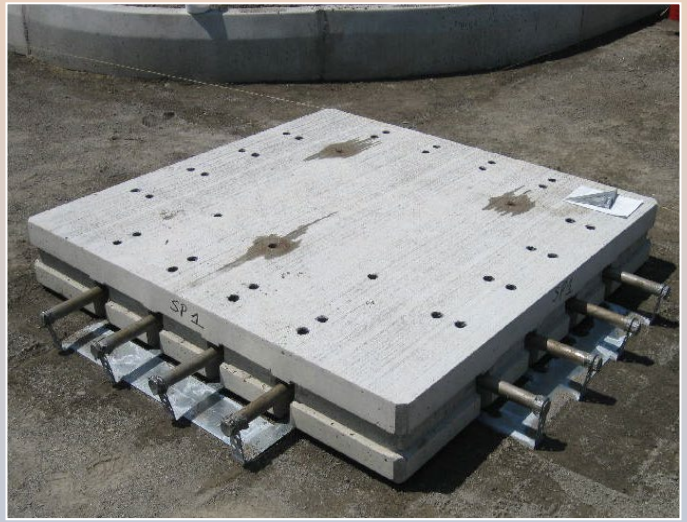
- Criteria for using PCP systems.
- Design of Jointed Precast Pavement Systems.
- Developing plans, specs and cost estimates.
- Preparing shop drawings.
- Panel fabrication.
- Pre-installation procedures.
- System-specific installation procedures.
- Project management.
- Maintenance requirements.

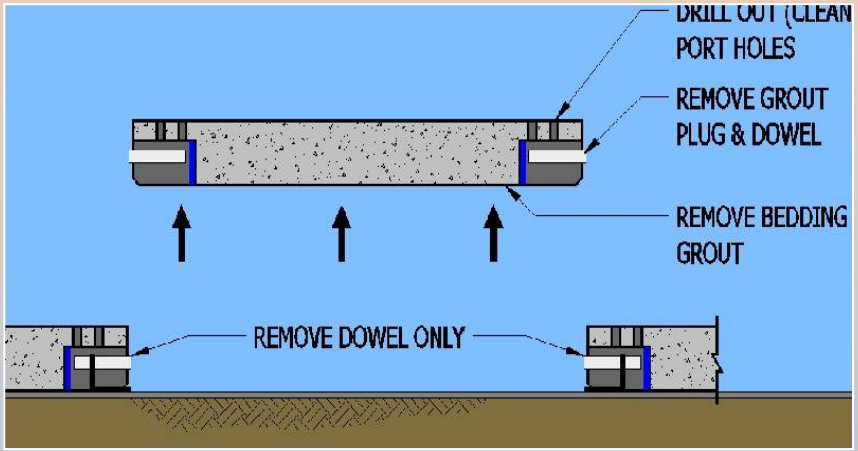


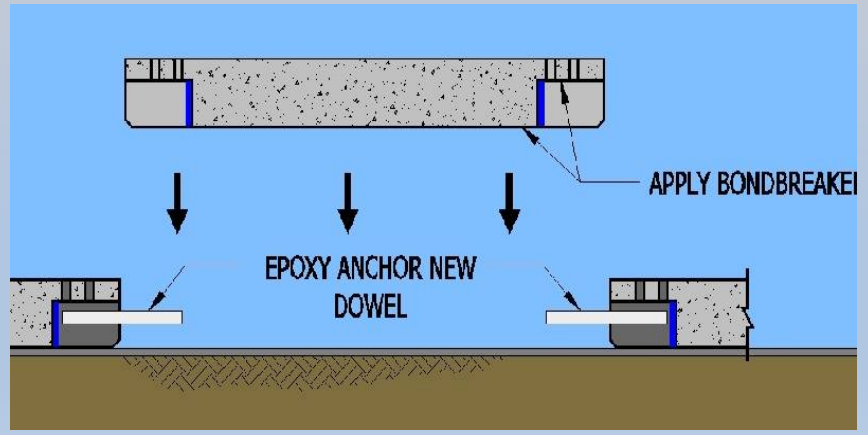
https://www.precast.org/jprcp-manual/

Future Directions for Precast Concrete Pavement Systems

Re-usable Urban Pavement (RUP) Systems





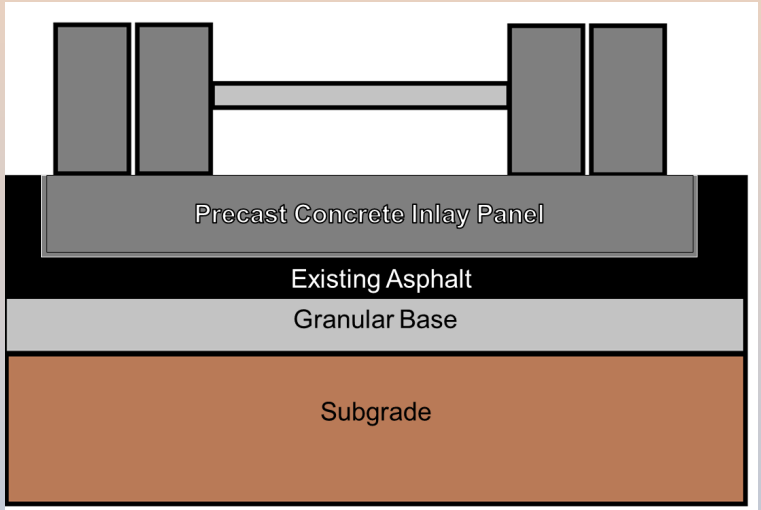


- One example: "Super-Paver"™
- Designed for utility-intensive urban areas
  - Vertically removable & replaceable
  - Warped as required to fit any surface
  - Removable and reusable
  - Relatively lightweight
    - 6' x 6' weighs 2 T
- Major installations in NYC (2015) and Richmond, IN (2019)

Source: Peter Smith – Fort Miller Company, Inc.

Future Directions for Precast Concrete Pavement Systems

Inlays of Asphalt-Surfaced Pavement



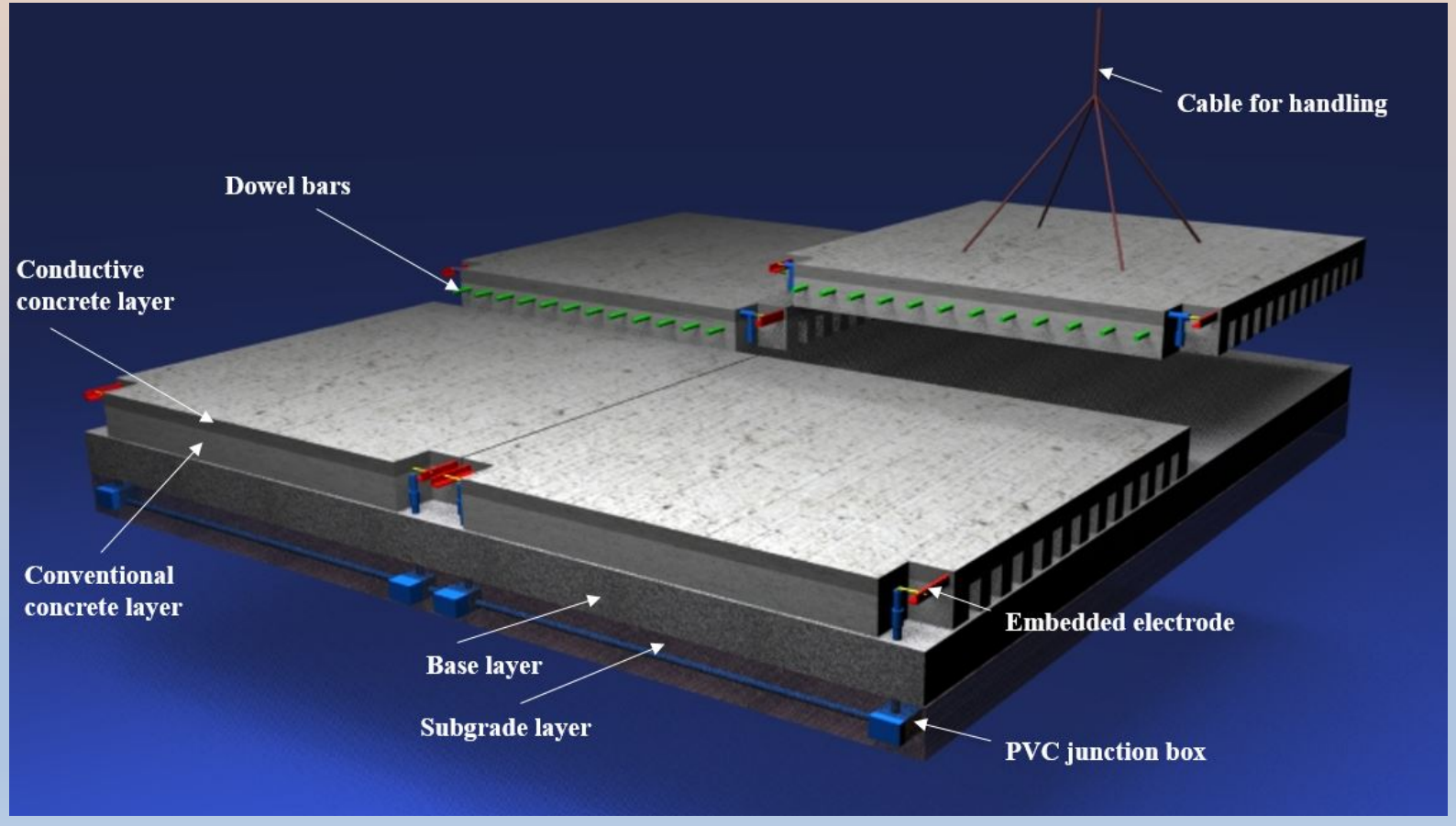
- Experiment/Demonstration project (2016)
- Kings Highway 401, near Barrie, Ontario (Toronto area)
- 400,000 vpd (35,000 truck/day)
- Deep rutting of existing asphalt, 3-4 year service life between rehab
- 12’ x 15’ x 8” panels – asphalt support, grade support, grout support
- Precision micro-milling
- Instrumented and FWD test monitoring
- Early performance is good

Source: Peter Smith – Fort Miller Company, Inc.

Future Directions for Precast Concrete Pavement Systems

Heatable Conductive Precast Panels

Carbon-fiber infused concrete between electrodes



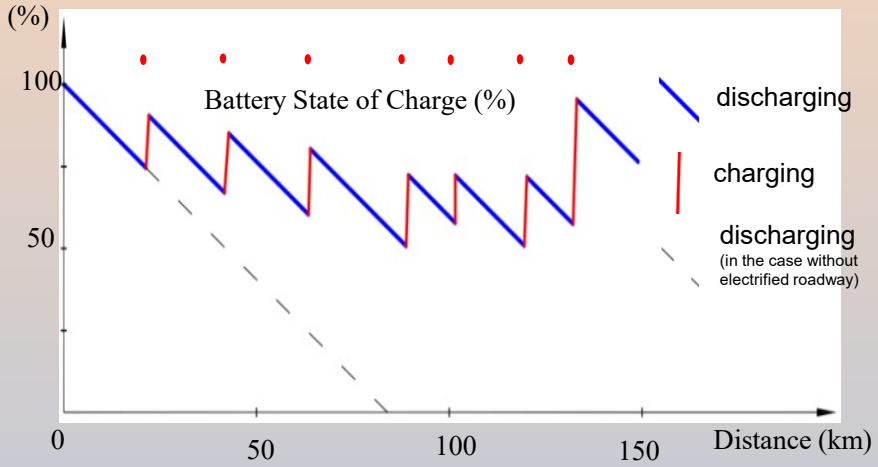
Source: Abdualla et al, Iowa State University

Future Directions for Precast Concrete Pavement Systems

Electrified Roadways – Inductive Power Transfer

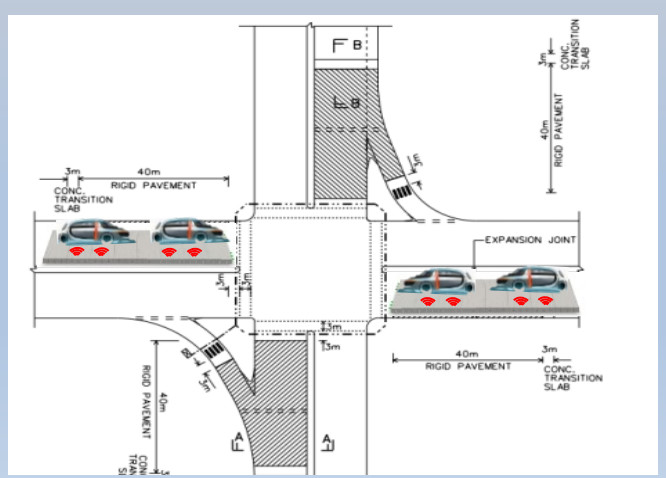
Key advantages of electrified roadways:

- No limitation of driving range
- Reduction of battery capacity



Suitable locations for precast IPT installations:

bus stops and terminals, intersections, taxi stands, etc.



Source: Bernhard Lechner, Nen Nguyen Dinh – TUM (Germany)

Future Directions for Precast Concrete Pavement Systems

Solar Power-generating Pavement Panels

SolaRoad (Kromminie, Netherlands):

- Full-scale bike path (230 ft x 11.5 ft)
- Precast structural platform
  - Houses electrical connections
  - Supports power-gen cells
  - Embedded double-key LT system
- Produces enough power for single-person household

Source: Laboratoire Central des Ponts et Chaussées

SUMMARY AND WRAP-UP

Thank you!

Questions?