

# **EVALUATION OF PRECAST CONCRETE PAVEMENT SYSTEMS, PHASE I: Identify Existing Precast Concrete Pavement Systems and State Specifications**

**Lunchtime Tech Talk! 12:00-1:15 PM**

**Presented by:**

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Center for Research and Education in Advanced  
Transportation Engineering Systems (CREATEs)  
at Rowan University



# Acknowledgments

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- State DOTs

- California
- Illinois
- Delaware
- Texas
- Utah
- Wisconsin
- Iowa
- New York



# In This Presentation...

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- Background of Precast Concrete Pavements
- Research Goal & Objectives
- Literature Review of Available Precast Systems
- SHA Experience with Precast Systems
- Proposed Precast System Approval Process
- Conclusions & Recommendations



# Background of Precast Concrete Pavements



# Background

- Precast concrete pavements (PCPs) have emerged as a PCC rehabilitation technique
  - Cast and cured offsite
  - Shipped to deteriorated pavement jobsite
  - Aligned and leveled to existing pavement
  - Grouted and secured into place



## Slide 5

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**ODI1**

**Need a picture**

Offenbacker, Daniel Irving, 5/28/2020



# Background

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- Benefits of PCP:
  - Quick installation (can be installed and open to traffic overnight)
  - Durable and Long-Lasting
  - Minimal interaction with drives
- Drawbacks of PCP:
  - Expensive
  - Challenging to install
    - Poor installation → Premature cracking
  - Contractors and systems must be capable



# Background

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- NJDOT has allowed the use of one PCP system
- This PCP system was selected because of:
  - Proven performance
  - Adequate installation practices
- Since then, however:
  1. New PCP systems have been developed and/or implemented
  2. Other state DOTs have been opened to multiple options in PCP systems





# Research Goal and Objectives



# Research Goal

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***Gain a greater understanding of the existing systems, components, and specifications pertaining to precast pavement systems.***



# Research Objectives

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- Evaluate literature pertaining to existing PCP systems in the US
- Identify components of PCP systems and their differences
- Contact state DOTs regarding their past experience, practices, and recommendations with PCP
- Synthesize existing state DOT specifications for PCP systems to develop preliminary NJDOT specifications



# Literature Review of Available Precast Systems



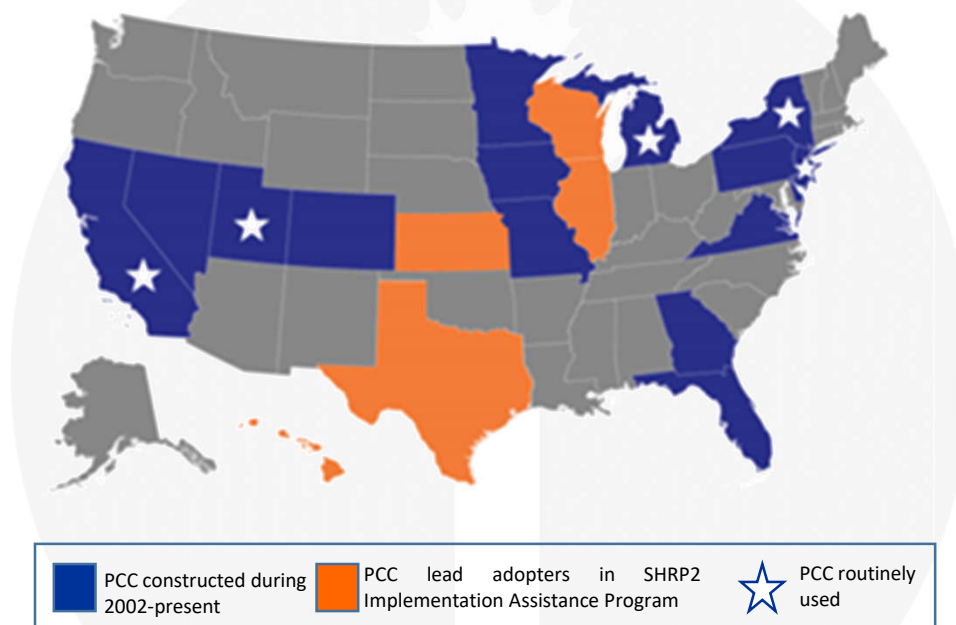
# Literature Review of PCP Systems

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- Very little literature exists pertaining to PCP systems (outside of FHWA)
- 8-10 primary research studies conducted on PCP over the past 10-15 years
  - 85-90% conducted by FHWA
  - 5-10% conducted by Academia/Industry
  - 5% conducted by DoD



# Distributions of Precast Systems



System	CA	CO	HI	IA	IL	MI	MN	NJ	NV	NY	ON	PA	QC	UT	VA	VT	Total
Fort Miller	19				1		1	14	1	24	2	1	1	2	1	1	68
Roman Stone										7							7
Unknown System					3					1	3			9	2		18
Michigan						1											1
Kwik Slab			2														2
Stitch-in-Time		1															1
Custom	3																4
Grand Total	22	1	2	1	4	1	1	14	1	32	5	1	1	11	3	1	101

<sup>1</sup>Tayabji, S., Ye, D., and Buch, N., 2013. *SHRP 2 Report S2-R05-RR-1: Precast Concrete Pavement Technology*.



# Overview of Precast Systems

State	Proprietary	Nonproprietary	Notes
CA	Bottom-Slot Jointed System		-
CO	Stitch		Marketed
HI	Interlo		System no longer used
IL			
IA			
MI			no longer used
NJ			-
NY	Bottom Slot System		-
TX	-	Interlocking PCP	-
UT	Bottom-Slot Jointed System	Utah DOT	Utah DOT System no longer used

**Approximately 11  
 different PCP systems  
 were identified from  
 literature search**

<sup>1</sup>Tayabji, S., Ye, D., and Buch, N., 2013. *SHRP 2 Report S2-R05-RR-1: Precast Concrete Pavement Technology*.

<sup>2</sup>NPCA, 2018a. Jointed Precast Concrete Pavement Web Explorer [online]. [Accessed 21 Mar 2018].

<sup>3</sup>Buch, N., 2007. Precast Concrete Panel Systems for Full-Depth Pavement Repairs. Field Trials.

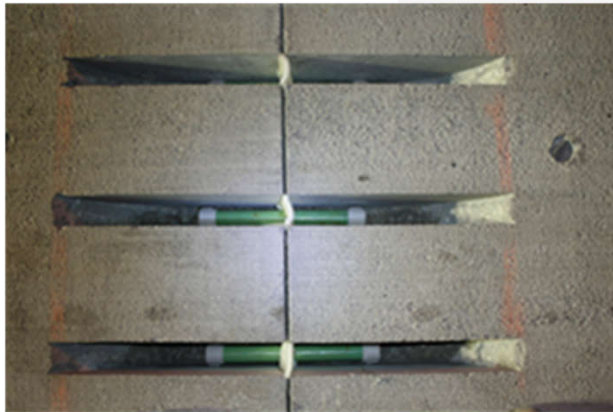
# Common Precast System Components



# Literature Review of PCP Systems

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- Overview for PCP systems were also documented
- Critical differences among PCP systems:
  - Bedding and Support Options
  - Load Transfer System

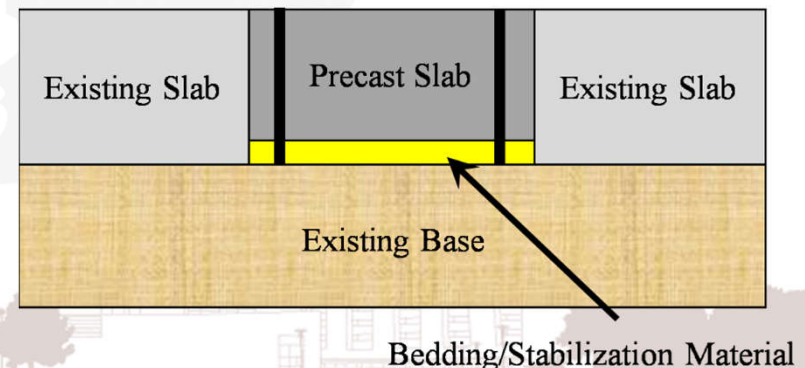
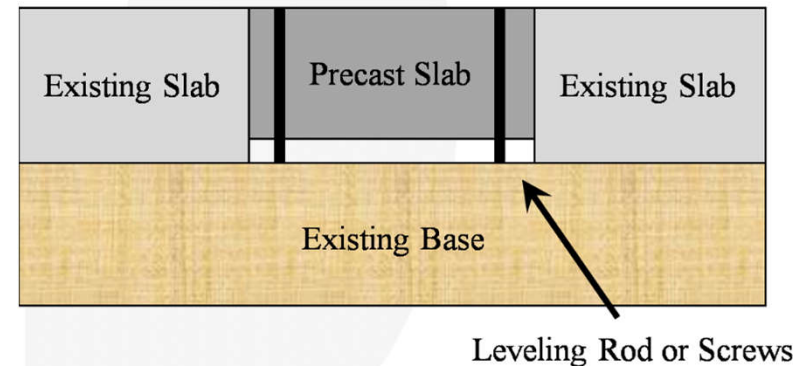
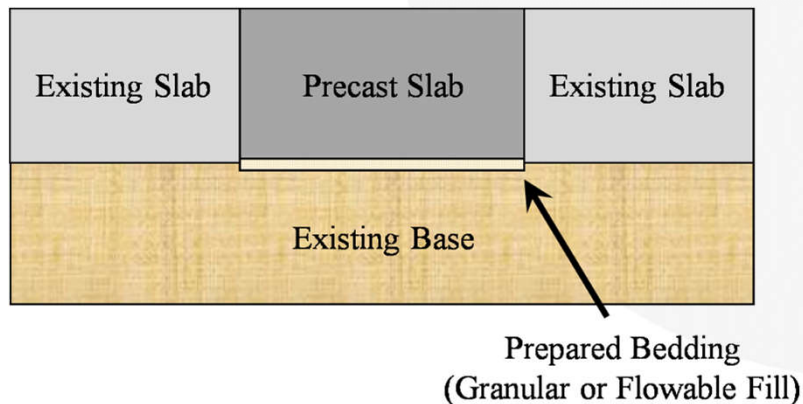


<sup>4</sup>Tayabji, S. and Brink, W., 2015. Load Transfer Systems for Jointed Precast Concrete Pavements.

<sup>5</sup>Tayabji, S., 2016. Precast Concrete Pavement Practices—Generic System Use In Michigan, Texas & California.

# Bedding System

- Two primary bedding/leveling systems:
  - Grade-Controlled
  - Lifted and Grouted

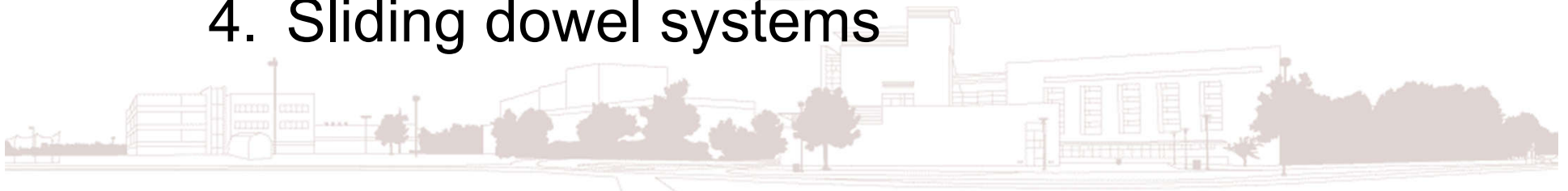


<sup>6</sup>Tayabji, S., 2016. Precast Concrete Pavement Practices Overview.

# Load Transfer System

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- Different systems exist to transfer traffic load and minimize damage
- Four major load transfer systems:
  1. Bottom-slot dowel (*Proprietary*)
  2. Partial retrofit with narrow-mouth dowel
  3. Full retrofit dowels
  4. Sliding dowel systems

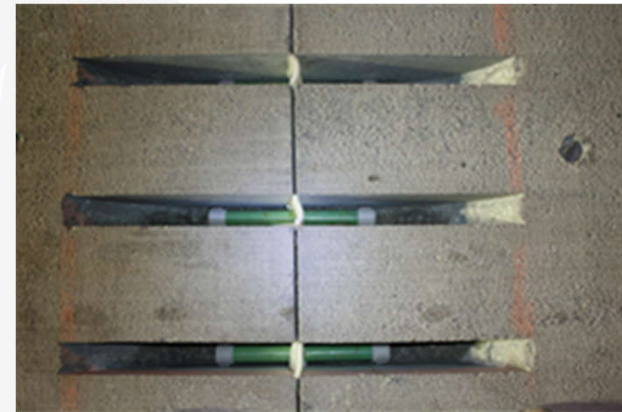




# Load Transfer System



**Bottom-Slot Dowel<sup>7</sup>**



**Full Dowel Bar Retrofit<sup>4</sup>**



**Partial Dowel Bar Retrofit<sup>1</sup>**



**Sliding Dowel<sup>4</sup>**



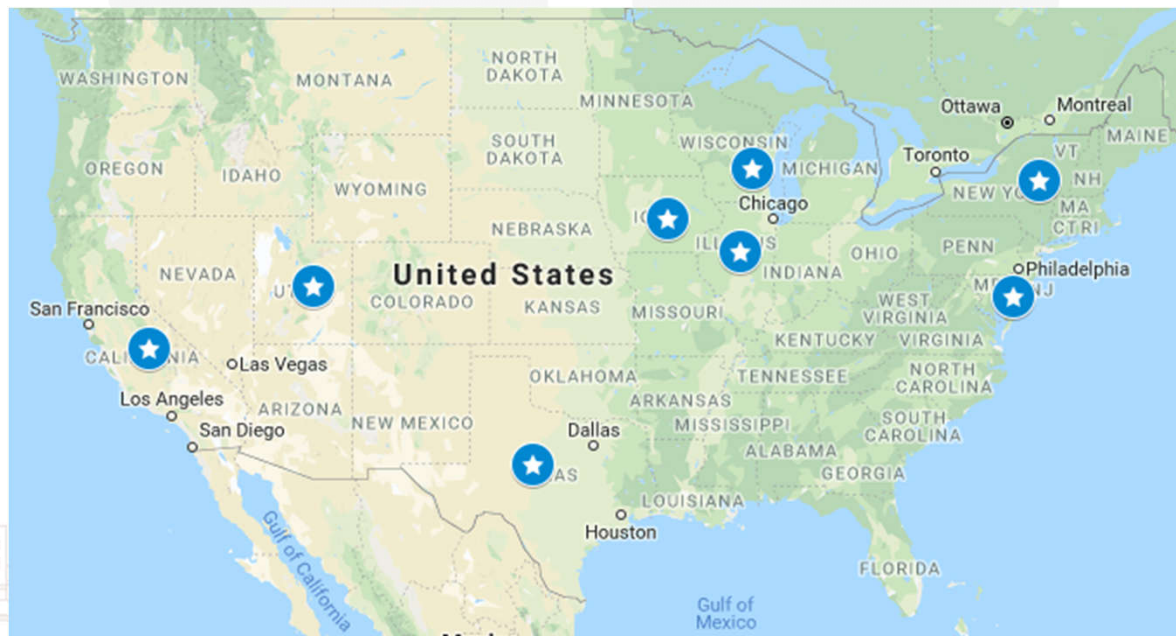
# SHA Experience with Precast Systems



# SHA Experience of Precast Systems

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- Several states were contacted regarding their use of precast pavement systems (~17 states)
- 8 DOTs had follow-up phone interviews to discuss PCP experiences:



# SHA Experience of Precast Systems

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The following topics were discussed in the survey:

1. Current PCP systems and components commonly being used in their respective state
2. State standards on the manufacture and installation of precast pavement
3. Procedures for permitting new PCP systems
4. Experiences and challenges observed with PCP installation and performance



# SHA Survey Results

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## 1. Current PCP systems and components commonly being used in their respective state:

- Not all precast systems are still in use/available for PCC roadways
- Based on contact with SHAs, the current precast systems available are:

Proprietary systems: **Jersey Precast** and **Fort Miller Super Slab**®

Non-proprietary systems: **Roman Road**, **Illinois Tollway**, and **California Rapid Roadway**



# SHA Survey Results

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## 2. State standards on the manufacture and installation of precast pavement:

- Several specifications existed (based on FHWA)
  - 8 different state specifications were identified
- Four major parts of PCP systems and installation were controlled by specification
  1. Precast Panel Fabrication
  2. Bedding/Grout Stabilization
  3. Installation Tolerances
  4. Encasement Grout



# SHA Survey Results

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## 3. Procedures for permitting new PCP systems:

- Most states follow a performance-based approval process
  - Provide evidence of adequate historical performance
- If unavailable, field demonstration is warranted
- Field demonstration consists of three step
  - Optional fourth step depending on agency preference



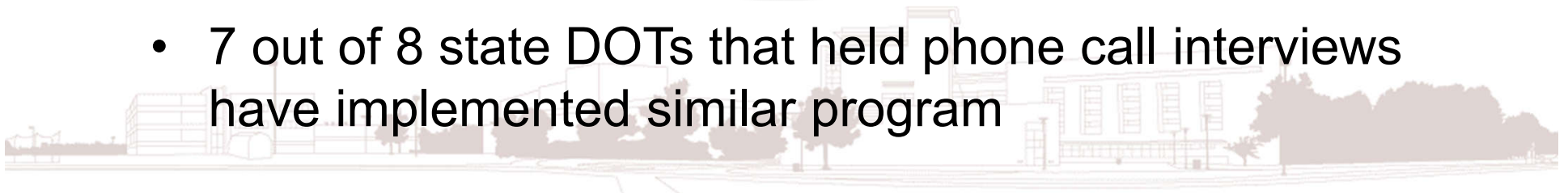


# SHA Survey Results

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## 3. Procedures for permitting new PCP systems:

1. Show ability to install PCP without damaging PCP system or surrounding pavement
  2. Must be able to install PCP within a given amount of time
  3. Performance test:  $LTE > 70\%$  and deflection  $< 2$  mils
  4. Exposure to traffic for given amount of time
- 7 out of 8 state DOTs that held phone call interviews have implemented similar program



# SHA Experience of Precast Systems

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## 4. Experiences and challenges observed with PCP installation and performance:

- Survey highlighted experiences with PCP that are not well documented
- **Installation is critical to the performance of PCP**
  - Poor leveling or misalignment → Premature failure
  - Shims are not recommended
  - Leveling bolts have shown to improve efficiency



# SHA Experience of Precast Systems

## 4. Experiences and challenges observed with PCP installation and performance:

- **Precast systems are usually replaced due to surrounding PCC pavement failure**

At time of  
rehabilitation  
(precast):

		<b>Failed Section</b>	
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After 5 to 10  
years:

	<b>Failed Section</b>	<b>Precast Section</b>	<b>Failed Section</b>
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# SHA Experience of Precast Systems

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## 4. Experiences and challenges observed with PCP installation and performance:

- **Leveling Bolts and Sliding Dowels provide the greatest installation efficiency**
  - One State DOT Case:
    - Before: ~20 slabs installed in an overnight work window (~8 hours, mixed cont. and non-cont.)
    - After: ~32 slabs installed in an overnight work window (~8 hours, mixed cont. and non-cont.)
  - Efficiency increased by 65%
  - Costs decreased by ~60%



# SHA Experience of Precast Systems

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## 4. Experiences and challenges observed with PCP installation and performance:

- **One state recommended flexible specifications to allow for Contractors to select their preferred PCP system**
  - Minimize installation error and premature failure
  - Improve installation efficiency
  - Requires thorough understanding of the different PCP system components and their performance



# Proposed System Approval for Precast Pavement in NJ





# Proposed System Approval Process

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- Draft specifications for approval of precast pavement systems in NJ
- Specifications needed to be applicable for (i) currently existing and (ii) newly developed systems
- The approval system contained 3 major parts:
  1. Materials and slab fabrication approval
  2. Demonstration of system installation
  3. Proof of performance



# Proposed System Approval Process

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## **5-Step PCP Approval Process**

**Step 1**

Obtain Materials and Plant Approvals from NJDOT's Bureau of Materials

**Step 2**

Select Intended Applications (Planar or Warped Repairs) of the Rapid Precast Repair System

**Step 3**

Submit System Design Details and Other Information to NJDOT

**Step 4**

Performance Evaluation of the Precast System (Low-Risk, Medium-Risk, and High-Risk Tracks)

**Step 5**

Approval Decision and, if Approved, Addition of System to NJDOT's Qualified Products List (QPL)

# Proposed System Approval Process

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## Step 1. Materials and Slab Fabrication Approval

- All precast pavement slabs must use approved NJDOT materials and precast plants
  - Currently specified in NJDOT specifications
  - Remain similar to current NJDOT precast items
- Fabrication tolerances determined by the state DOT review and NJDOT preference



# Proposed System Approval Process

Dimensional Tolerances	State							
	DE	CA	NY	WI	UT	IL	SHRP	TX
Length and Width	±1/4"	L: ±1/4" W: ±1/8"		±3/8"	+/- 1/4"	+/- 1/8"	±1/4"	±1/4"
Nominal Thickness	±1/8"	±1/8"			-1/8", +3/16"		±1/16"	±1/4"
Squareness	±3/16"				+/- 1/4"	+/- 1/8"	±1/4"	±1/8"
Horizontal Alignment	±1/4"							±1/8"
Deviation from straightness of mating edge of panels Vertical Alignment:	±1/8"	1/8"	±1/8"	±1/8"				±1/8"
Position of lifting anchors (horizontal location)	±6.0"				+/- 1"		±1/2	±3"
Position of non-prestressed reinforcement (horizontal and vertical)	±1/2"						±1/2"	±1/4"
Position of pre-tensioned strands	±1/4"	1/8"					±1/4"	±1/4"
Position of dowel bar inserts	±1/4"				+/- 1/4"			
Dimensions of block outs and grout pockets	±1/4"							±1/4"
<b>Panel Strength Requirements</b>								
Stripping Strength (psi)				3000			2500	
Shipping Strength (psi)							4000	
28 day compressive strength (psi)			4500	5000		4500	4500	
28 day Flexural Strength (psi)					650		650	

# Proposed System Approval Process

## Step 1. Materials and Slab Fabrication Approval

### Precast Panel Dimensional Tolerances

Panel Feature	Tolerance
Length and width	$\pm 1/4$ in.
Thickness	$\pm 1/16$ in.
Squareness of corner in plan view	$\pm 1/4$ in. over 12 in.
Squareness of sides in section view	$\pm 1/4$ in. over the thickness
Local smoothness of any surface	$\pm 1/4$ in. over 10 ft in any direction
Vertical location of reinforcement	$\pm 1/2$ in.
Vertical location of pretensioning strand	$\pm 1/4$ in.
Blockout dimensions (if applicable)	$\pm 1/4$ in.
Location of lifting inserts	$\pm 1/2$ in.

### RE Visual Inspection

- Dimensional tolerances;
- Surface defects;
- Improper surface texture;
- Damage to the concrete;
- Embedded dowel bar and tie bar alignment, if applicable; and
- Pretensioning based on strand elongation

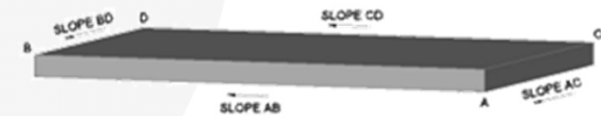


# Proposed System Approval Process

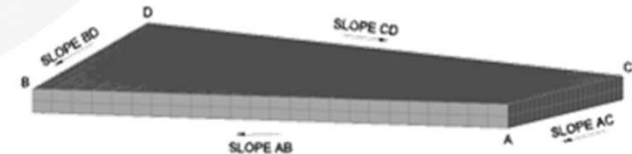
## Step 2 & 3. Select Intended Use of PCP and Submit System Details

- All PCP systems can be used in different conditions and this needs to be identified
  - Continuous vs. Non-Continuous
  - Planar vs . Non-Planar
- Submit details regarding:
  1. Load transfer system
  2. Bedding stabilization
  3. Overall installation process

**Planar**



**Non-planar, Warped**



<sup>7</sup>The Fort Miller Company Inc., 2015. *Super-Slab Precast Pavement Brochure*.



# Proposed System Approval Process

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## Step 4. Demonstration of PCP installation and performance

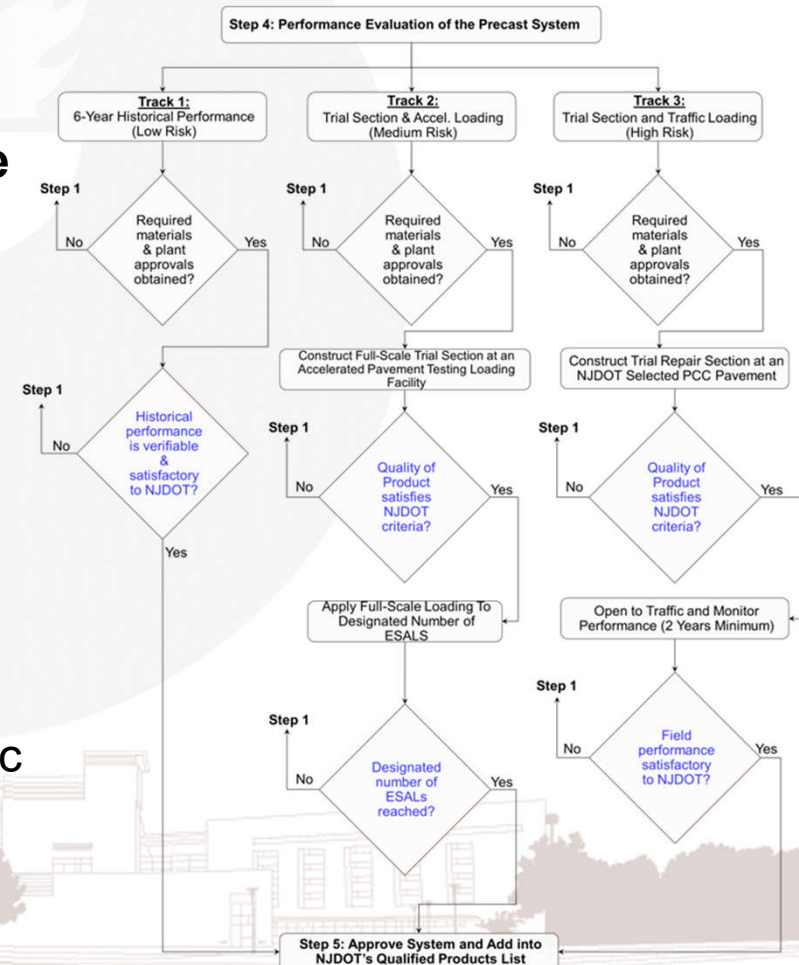
- Ensures two important aspects of PCP
  1. Can be installed efficiently and properly
  2. Will withstand adequate traffic loading and durability
- Three different evaluation paths were developed based on risk level to NJDOT (low, medium, and high)



# Proposed System Approval Process

## Step 4. Demonstration of PCP installation and performance

- **Track 1: 6-Year Historical Performance**
  - **Low-risk**; Proven performance under live traffic
- **Track 2: Trial Section & APT Study**
  - **Medium-Risk**; Proves durability under traffic loads, but not exposed to live traffic or harsh environments
- **Track 3: Trial Section & Field Study**
  - **High-Risk**; Proves durability under live traffic loads, but exposes general public to an unproven system



# Proposed System Approval Process

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## Step 4. Demonstration of PCP installation and performance

- Track 2 or 3 selected: Evaluated based on:
  - Successful installation to tolerances (determined from SHA review)
  - LTE must be greater than 70% and deflections less than 2 mils
  - Adequate durability (no visual distresses) over given time
- Any failure would deem the system unapproved



# Proposed System Approval Process

Dimensional Tolerances	State							
	DE	CA	NY	WI	UT	IL	SHRP	TX
<b>Transverse Joints</b>								
Horizontal Alignment	±1/2"	±1/8"	±3/8"	±3/4"	±3/8"	±1/2"	±1/8"	±1/8"
Vertical Alignment	±1/4"	±1/4"	±1/4"	±3/8"	±3/8"	±1/4"	±1/4"	±1/4"
<b>Longitudinal Joints</b>								
Horizontal Alignment	±1/2"	±1/4"	±3/8"	±3/4"	±3/8"	±1/2"	±1/4"	±1/4"
Vertical Alignment	±1/2"	±1/4"	±1/4"	±3/8"	±3/8"	±1/4"	±1/4"	±1/4"

Alignment	Tolerance (inches)	
Transverse Joints	Horizontal	±1/8"
	Vertical	±1/4"
Longitudinal Joints	Horizontal	±1/4"
	Vertical	±1/4"



# Proposed System Approval Process

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## Step 5. Submission of performance data and approval decision by NJDOT

- All documentation is provided to the NJDOT including (i) materials, (ii) PCP system components, and (iii) performance data
- NJDOT provides final approval of the PCP system and components
  - Add the PCP system to an approved QPL



# Conclusions and Recommendations





# Conclusions

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- Several precast systems exist in NJ
  - Both proprietary and non-proprietary
- PCP systems differ in two major areas:
  - Bedding Stabilization
  - Load Transfer System
- Slab installation is the most critical factor in precast concrete pavement performance



# Conclusions

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- Most SHAs require:
  - Quality control measures on 4 different PCP areas
    - Precast slab fabrication process
    - Bedding/Stabilization material
    - Installation
    - Encasement Grout
  - Performance-based approval process
    - Adequacy in precast installation
    - Achieve an acceptable Load Transfer Efficiency (LTE)



# State Agency Recommendations

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- Use the documented experiences and state practices as guidelines for future specifications
  - Leveling bolts are recommended for leveling precast systems
  - LTE of at least 70% and deflection less than 2 mils
- Explore the development of a generic PCP system that suits state needs



# Future Work

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- Investigate long-term performance of precast systems
- Identify economic benefits of using precast pavements (user costs, longer durability, etc.)
- Assess the usefulness of intermittent precast systems
- Adequate training and experience for contractors are critical to ensure proper installation



# References

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1. Tayabji, S., Ye, D., and Buch, N., 2013. SHRP 2 Report S2-R05-RR-1: Precast Concrete Pavement Technology. Transportation Research Board.
2. NPCA, 2018. Jointed Precast Concrete Pavement Web Explorer [online]. Available from: <https://precast.org/precast-products/pavement-explorer/> [Accessed 21 Mar 2018].
3. Buch, N., 2007. Precast Concrete Panel Systems for Full-Depth Pavement Repairs. Field Trials.
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6. Tayabji, S., 2016. Precast Concrete Pavement Practices Overview
7. The Fort Miller Company Inc., 2015. *Super-Slab Precast Pavement Brochure*.

# Thank You!

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