Concrete Pavement Innovation and Technology Transfer Workshop

*Rapid Repair of Concrete Pavement with Precast Slabs*

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Motivation

The need is to explore repair alternatives that:

✓ Are rapid (construction) in nature
✓ Cause minimum disruption
✓ Offer long lives

Precast Concrete Pavements is one such rapid repair alternative.

145,000 ADT, I-287, Tarrytown, NY
200,000 ADT, I-15, Ontario, CA
180,000 ADT, I-66, Fairfax, VA

Source: The Fort Miller Co., Inc.
What is Needed At These Locations

**Very Rapid Repairs**
- Work windows are limited
- Minimize construction-related congestion

**Very Durable Repairs**
- Needed most in high traffic areas
- Think in terms of 40- to 50-year pavement life

**Premium Pavement – Overnight!**
Definition of Precast Concrete Pavements

✓ Modular pavement slabs are fabricated 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 used for rapid renewal and reconstruction of asphalt and concrete pavements.
Precast Pavement Systems

✓ Intermittent Repairs
  ▪ Nominally reinforced
  ▪ Pre-stressed panels

✓ Continuous Repairs
  ▪ Jointed Precast Systems
    • Nominally reinforced
    • Prestressed panels
  ▪ Post-Tensioned Precast Systems
    • Fewer active joints
    • Longer sections

Generic & Proprietary Systems
(Components) Available
What is out there
What is out there (Jointed Precast Pavements)

✓ 33+ lane miles have been installed in 16 states and two provinces of Canada.
  ▪ >17,000 slabs

✓ 97+ projects
  ▪ Intermittent
  ▪ Continuous
  ▪ Bridge approaches

✓ Special installations
Typical Distresses
State of Practice (Jointed Systems)

Roman Stone System

Illinois Tollway Generic System

Fort Miller System

Bottom Slots
California Slab Repair System

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

www.rapidroadway.com

/Installation
<table>
<thead>
<tr>
<th>TECHNIQUE</th>
<th>PROS</th>
<th>CONS</th>
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<tbody>
<tr>
<td>WIDE TOP SLOT (GENERIC)</td>
<td>• SAME AS DOWEL BAR RETROFIT</td>
<td>• SAND BLASTING OF SLOT SIDES REQUIRED – BOND IS CRITICAL</td>
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<tr>
<td></td>
<td>• CONTRACTORS FAMILIAR WITH EQUIPMENT AND METHOD</td>
<td>• SLOTS MUST BE FILLED BEFORE SLABS MAY BE USED</td>
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<td>• DOWEL GROUT EXPOSED TO ROAD SALTS</td>
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<tr>
<td>NARROW TOP SLOTS (IL TOLLWAY METHOD)</td>
<td>• SLOTS NEED NOT BE FILLED TO OPEN SLABS TO TRAFFIC</td>
<td>• MAY BE DIFFICULT TO ENSURE PROPER EPOXY ANCHORING OF DOWELS IN ADJACENT SLABS</td>
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<td>• DOVETAIL SHAPE OF SLOT PROVIDES MECHANICAL AS WELL AS BOND RESISTANCE TO DOWEL POP-OUT</td>
<td>• DOWELS MUST BE FIELD INSTALLED – CAN NOT BE CAST IN SLABS</td>
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<td>• GENERIC – NON-PROPRIETARY</td>
<td>• LONGER DOWEL SLOTS REQUIRED</td>
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<tr>
<td>BOTTOM SLOT (FORT MILLER)</td>
<td>• VERY EFFECTIVE LOAD TRANSFER – NO SAND BLASTING REQUIRED</td>
<td>• PROPRIETARY</td>
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<td>• FULLY TESTED</td>
<td>• ACCURATE CASTING IN SHOP REQUIRED – CAN NOT BE CHANGED IN FIELD</td>
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<td>• DOWEL GROUT PROTECTED FROM ROAD SLOTS</td>
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<td>• CLEAN TOP SURFACE</td>
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<td>BARRA GLIDE™ (RAPID ROADWAY)</td>
<td>• CLEAN TOP SURFACE</td>
<td>• MAY BE DIFFICULT TO ENSURE PROPER EPOXY ANCHORING OF DOWELS IN ADJACENT SLABS</td>
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<td>• QUICK OPENING (LATEX GROUT)</td>
<td>• DOWELS MUST BE FIELD INSTALLED – CAN NOT BE CAST IN SLABS</td>
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<td>• LESS “WEAKENING” OF SLAB THAN DEEP SLOTS</td>
<td>• LONGER DOWEL SLOTS REQUIRED</td>
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<td>• FEWER CONFLICTS WITH SLAB REINFORCING</td>
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Keys to Success!-Material and Structural

✓ Concrete strength and thermal/volumetric expansion characteristics.
✓ JPCPS panel reinforcement (design for temperature and shrinkage, design for transport and handling, design for service loads, use of structural fibers).
✓ Load transfer system design (e.g., various systems of dowel and tie embedment with either top-down or bottom-up slots and grouting).
✓ Load transfer system materials (e.g., epoxy-coated carbon steel, solid or clad stainless steel products, zinc-clad products and others) and designs (e.g., traditional cylindrical dowels vs. plate dowels).
Keys to Success!-Material and Structural

✓ Panel thickness (including consideration of non-uniform/warped vs. uniform/planar panels).

✓ Panel surface texture and materials (e.g., monolithic construction with a selected surface finish vs. multi-layer systems with porous concrete surface for noise reduction and surface drainage).

✓ JPCPS support (e.g., grade-supported, grout-supported and use of piles with precast cross-beams).

✓ Development of specifications that allow the use (but not the requirement) of proprietary systems.
Keys to Success! - Feasibility

✓ Length of the allowable construction work window (this is the single most important factor in determining whether precast pavement is the most desirable construction option).

✓ Construction of tangent sections versus curved (and possibly superelevated) alignments.

✓ Distance to a suitable precasting plant (a key factor in the economy of precast paving and minimizing potential for transport-related supply disruptions).
Keys to Success!-Feasibility

✓ Sizing of panels for economical shipping and placement.
✓ Panel transport considerations (e.g., the size of panels as they relate to what time of day or night or what days they are permitted to be transported in busy city areas).
✓ Work area required to remove existing pavement and install new panels as it relates to maintenance of traffic.
Keys to Success

☑ Independent of installation technique or Precast Pavement System the following issues should be considered:

- What problem(s) is(are) being addressed?
  - drainage
  - Base/subbase
  - Type of distress may indicate underlying issues
  - Condition of surrounding pavement
Keys to Success

- Slab Removal
Keys to Success

- Base considerations
  - Uniform support is key to minimize stresses and deflections
  - Compaction

- Base Materials
  - Granular
  - ATB
  - LCB
  - CTB
  - *Pervious concrete*
  - *RSLCB*

- Bedding Material
  - Granular
  - Cement grout
  - HDP
Keys to Success

Independent of installation technique or Precast Pavement System the following issues should be considered:

- Slab dimensions
  - Manage aspect ratios
  - Bases type and bedding material
  - Manage slab weights
  - Ease of transportation, handling and installation
  - Reducing handling stresses
  - Establish a menu of slab lengths (repetition sizes minimizes fabrication costs)
  - Tolerances to minimize on-site adjustments/modifications
Keys to Success

- Joint considerations
  - Minimize deflections/maximize load transfer efficiency
  - Dowel installation techniques/Dowel alignment considerations
  - Joint width considerations
“Systems Approach” should be adopted when designing jointed precast concrete pavement systems, i.e. avoid a “cafeteria approach”---interdependency of features must be considered.
References

- Precast/Prestressed Concrete Institute Guidelines (5 part series)
- Northeast Pavement Preservation Partnership, presentation made by Dr. Shiraz Tayabji
- Dr. Mark Snyder, Engineering Consultant
- The Fort Miller Company
Innovative Technologies and Applications for Jointed Precast Concrete Pavement Systems
Why Precast Pavement Systems?

- Rapid installation in short work windows
  - Reduce construction-related traffic congestion
  - Higher production rates than CIP are possible
  - “All-season” installation

- Reduces field inspection time and cost
  - Precast slabs – plant inspected
  - Durable, pre-engineered, pre-inspected systems

- Long-lasting construction – 40+ years
  - Reduced (long-term) repair costs
  - “Get in, get out and stay out”
Newer Concepts for Precast Pavement Applications

- Precast Pavement Features
  - Reduced Dowel/Tie Slot Lengths and Vertical Placement
  - Panel Leveling Techniques
  - Re-usable Precast Concrete Paving Panels

- Innovative Installations and Applications
  - Incremental Reconstruction (Precast Pavement Add-ons)
  - Airfield Installations
  - Unbonded Concrete Overlay of Asphalt Pavement
  - Embedded Sensors (Tolling, WIM)
  - Electrified Roadways (Vehicle Charging)
Reduced Slot Length: Why Worry?

- Reduced potential for development of cracking along slots
- Better placement of slab reinforcement
- Increased slab shipping width (from reductions in exposed bar length)
- Reductions in fabrication costs and time
- Material savings
Dowel-Concrete Bearing Stress

FEM: 1-in dowel, 5-inch embedment

Peak Bearing Stress = 2751 psi
(~10% increase over 9-inch embedment)
For round, metallic dowels, provide a minimum of 4 inches of embedment on each side of joint.

- Select dowel length to include embedment requirements and tolerances for placement and joint sawing variability.
  - Shorter dowels are possible for retrofit and full-depth repairs where dowel placement and joint location are known more precisely (e.g., precast pavement applications).

Source: NCC 2011
LONGITUDINAL JOINT CONNECTION

#6 DAYTON SUPERIOR EPOXY COATED D-108 HEADED DOWEL-IN @ 2'-0" O.C. & 6\(\frac{3}{4}\)" LONG.

#6 DAYTON SUPERIOR EPOXY COATED DB-SAE @ 2'-0" O.C. & 1'-6" LONG.

1"x1" FOAM GASKET

1"x1" CHAMFER ALONG ALL BOTTOM EDGES

APPROVED HIGH STRENGTH STRUCTURAL GROUT

Source: Peter Smith, The Fort Miller Company, Inc.
Potential Savings

- ~60% reduction in hardware grout
- Comparable steel savings
- Reduced fabrication costs
TIE BAR SLOTS, TYP

1'-8"

8"

1'-7"

7"

SLAB REINFORCEMENT, TYP

PLAN VIEW

Source: Peter Smith, The Fort Miller Company, Inc.
Dowel/Tie Bar Vertical Position in Slab

- Typically required to be placed at mid-depth in U.S.
  - Maximize concrete cover (top and bottom)
- Dowel load and moment do not change significantly with vertical placement
- Recommended 3-inch minimum cover

Photo Source: The Fort Miller Company, Inc.
Improvements and Future Directions for Positioning Panels

- **Grade positioning**
  - Improvements in setting grading rails
  - Hand-operated grading equipment
  - Laser-controlled grading equipment
  - Use of cement-treated bedding material (in wet areas)

- **Leveling screw positioning**
  - Leveling and lifting combined in one insert

- **Positioning with pre-set shims**
Repair Panel Installation Options
(Leveling Bolt Systems)

Gracie Lift System (California)

Generic

Paterson Bolt
Adjusting Panels to Grade with Leveling Screws

• Panels set on stabilized base and subsequently raised to grade
• Air wrench to minimize labor
• Raise/lower panels to achieve best fit
• No traffic allowed on ungrouted elevated panels until bedding grout has reached strength
• A surveyor and grades may be necessary on multiple-panel and multiple lane installations

Sources: John Collins, Rapid Roadway Solutions; Peter Smith, The Fort Miller Company, Inc.
The PANY System (shims and grout)  
- LaGuardia Airport, NY

Source: Shiraz Tayabji, ARA

- Access to underground utilities with rapid return to service
- Durable, long-lasting repairs
- Sustainable practices
RUP Developed in France
(at the Pont et Chaussees Laboratoire [LCPC])

Interlocking

Placing with Vacuum Lifter

Source: Shiraz Tayabji, ARA; and Jean-Pierre Christory, LCPC

- Light-weight – place with light equipment
- Translate horizontally to interlock
- Translate horizontally to disassemble
Super-Paver™ — A Re-usable Urban Pavement (RUP) System

- Relatively lightweight
  - 6’ x 6’ weighs 2 T
- Vertically removable & replaceable
- Warped as required to fit any surface
- Removable and reusable
- 2015 Installation in NYC (underway)

(Designed specifically for utility-intensive urban highways and intersections)

Source: Peter Smith — Fort Miller Company, Inc.
Super-Dowel™

Facilitates:

- Removable & Re-usable Precast Pavement
- Precast Pavement Add-ons
Replacing Cleaned-up Slab Over New Dowels

Source: Peter Smith – Fort Miller Company, Inc.
Advantages of RUPs

- Relatively lightweight
- Remove only what’s needed
- Precast slabs “bridge” poorly-compacted backfill better than flexible paving materials
- Small size minimizes disturbed foot print
- Initial street appearance and functionalities fully restored
- Provides a “green” sustainable solution for pavement maintenance
- New standard slabs can be kept in stock
Precast Pavement Add-ons
(Using Super-Dowels or Similar)

- Incremental reconstruction makes the most of our existing pavement asset
- Maintenance dollars can be spread out over a number of years as available
- First major project on New England Thruway in New Rochelle, NY 2014
Airfield Application Examples:
Dulles Int’l Airport Taxiway Panels

Replaced Overnight, Opened at 5:50 AM On Un-Grouted Slabs
(Slabs Grouted Subsequent Nights)

Source: Peter Smith – Fort Miller Company, Inc.
Unbonded Concrete Overlay/Inlay

- Demonstration project under development for Hwy 100, Ontario, Canada
- Tentatively 12’ x 12’ x 8” precast panels on milled asphalt surface (~9” milling depth)
- Instrumenting for pressure, moisture at slab–asphalt interface
- 2015 construction planned
High-Speed EZ Pass Instrumented Panels

Installed on I-87 North Bound
Spring Valley, NY, 2006

• “Plug-and-Play” installation: cables attached to embedded treadles

• Panels installed during two overnight closures – no impact on traffic flow

Source: Peter Smith – Fort Miller Company, Inc.
Weigh-in-Motion Panels: I-95, Manhattan, NY

• Equipment in Form Ready to Pour
  • Embedded equipment precisely placed
  • Every detail carefully addressed prior to overnight installation
  • Notice accessing conduits
  • Sensitive equipment protected from elements during installation

Field Placement, December 2013

Source: Peter Smith – Fort Miller Company, Inc.
PreCast Concrete for Electrified Roadways
(Inductive Power Transfer – IPT)

Key advantages of electrified roadways:
• No limitation of driving range
• Reduction of battery capacity

Suitable locations for precast IPT installations: bus stops, bus terminals, intersections, taxi stands, etc.

Source: Bernhard Lechner, Nen Nguyen Dinh – TUM (Germany)
Challenges for the incorporation

Incorporation of windings => prefabricated modules

Anchorage of the modules in the concrete pavement with polymer rebars

Extra adherence between module and top layer of 50 mm

Source: Dr. Anne Beeldens, BRRC
Thank You!

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