Highways for LIFE
I-66 Pre-cast Concrete Pavement Demonstration Project
Virginia Concrete Conference
Richmond, VA

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FHWA Highways for LIFE Program

SAFETEA-LU Funding
$75 M from FY 2006 to FY 2009

Mission

“The purpose of Highways for LIFE is to advance Long lasting highways using Innovative technologies and practices to accomplish Fast construction of Efficient and safe pavements and bridges, with the overall goal of improving the driving experience for America”
Project Location

I-66 Old Concrete Pavement

WASHINGTON, DC

John S. Mosby Highway
Dulles Toll Road
Fairfax County Parkway
Prince William Parkway
Sully Road
Lee Highway
Little River Turnpike

I-66
234
267
7100
29
236
495
395
95
Existing Pavement Structure

- 9” JRCP built in early 1960s
- 6” plain aggregate sub-base
- 6” cement stabilized sub-grade
- Lot of joint problems and mid-slab spalling
VDOT Project Goals

Comparison of Technologies (CIP, PCP, PPCP)

- Costs
- Construction issues
- Availability of systems/qualified contractors
- Proprietary issues
- Time (design, shop drawings, casting, construction)
- MOT requirements
- Inspection requirements
- Long term performance
I-66 Highways for LIFE

Site Selection

- Based upon condition of pavement
- Available working space (barriers, drainage inlets, etc.)
- Overhead clearances
- Utilities (loop detectors, etc.)
- Curved sections
I-66 Highways for LIFE

Area A

Area B
Highways for LIFE: Area A

Ramp from I-66 WB to Rte. 50 WB

- Right lane – 3552' replaced with pre-cast panels (contractor designed); existing and proposed thickness 9".
- Left lane sporadic cast-in-place patches; thickness 9".
- Right shoulder milled and resurfaced

3,552 feet
Ramp: Pre-cast Concrete Panels (PCP) and Cast-In-Place (CIP) Patches
Ramp: Right Lane to be Replaced with Pre-cast Concrete Panels
Highways for LIFE: Area B

I-66 Mainline Westbound
- All four lanes (including right auxiliary shoulder) replaced with pre-cast, pre-stressed concrete panels.
- Existing concrete thickness ranges from 9” to 11”.
I-66 Mainline: Pre-cast, Pre-stressed Concrete Panels (PPCP)
Maintenance of Traffic

Extremely High Traffic Volumes

- $\text{ADT}_{2008} = 184,000 \text{ vpd (5\% trucks)}$
- Shoulder use 5:30 am to 11 am EB; 2 pm to 8 pm WB

Lane Closure Restrictions

- Close two lanes at 9 pm; close third lane at 10 pm; open by 5 am
Maintenance of Traffic

Hourly Traffic Volumes

Average Volume in 15 minutes at Det 392 Group at MP 59.11
(EB Friday)

Average Volume in 15 minutes at Det 411 Group at MP 61.43
(WB Friday)

Average Volume in 15 minutes at Det 392 Group at MP 59.11
(EB Saturday)

Average Volume in 15 minutes at Det 405 Group at MP 63.74
(WB Saturday)
I-66: Pre-cast, Pre-stressed Concrete Panels (PPCP)
PPCP – Sequence of Construction

1. **HOV**
2. **Rush Hour Lane**
3. **Work Zone**
4. Remove existing concrete pavement

- **Group II s**
PPCP – Sequence of Construction

Install PPCP panels and initial post-tensioning in lane 1.
PPCP – Sequence of Construction

Install PPCP panels and initial post-tensioning in lane 2

Group IIs

Rush Hour Lane

Work Zone

1. HOV

2

3

4
Complete removal of existing concrete and installation of PPCP for the entire length of project, final post-tensioning, duct and underslab grouting, fill post-tensioning block-outs and closure pour.
PPCP – Sequence of Construction

Remove existing concrete pavement

Group IIs

Rush Hour Lane

Work Zone
PPCP – Sequence of Construction

Install PPCP panels and initial post-tensioning
Remove existing concrete pavement and complete installation of PPCP panels and closure pour
Working Space Requirements
Inside Lanes – Two 12’ Panels

1. HOV
2. Rush Hour lane

Diagram showing the working space requirements with labels for HOV and Rush Hour lane.
Working Space Requirements
Outside and Shoulder Lanes – One 27’ Panel

1. HOV
2.
3.
4. Rush Hour lane
Project Challenges and Solutions

Challenges

• Differing thicknesses of ex. concrete along mainline (transverse)
• Proprietary PCP systems
• Smoothness of final pavement surface
• Estimating costs and fitting to available funding

Solutions

• Cost for #10 coarse aggregate included in PPCP bid item
• Special provisions for PPCP and PCP (based on AASHTO TIG); approved list for PCP systems; trial installation required prior to production; FWD testing for 80% joint load transfer efficiency
• Diamond grinding included for all PPCP and PCP panels (+ 50’ run-on and run-off); rideability specification (no incentives or disincentives)
• Innovative bidding
Proprietary PCP Systems: Super Slab® System

Photo source: The Fort Miller Company
Trial Installations

PCP and PPCP
• *Off-site* prior to installation under traffic
• Separate pay item
• FWD testing and cores
PPCP - Panel Fabrication
PCP - Panel Fabrication (SuperSlab®)
PPCP - Grading Leveling Aggregate
PPCP - Friction Reducing Membrane
PPCP – Initial Post-Tensioning
PPCP - Placement of Temporary Panel
PPCP – Final Post-Tensioning
PCP – Removal of Existing Pavement
PCP – “Super” Fine Grading
PCP – Panel Installation
PCP - Panel Installation
PCP – Panel Installation
PCP – Panel Installation
PCP – Underslab and Dowel Grouting
Construction Strategies (and did they work?)

Traffic
• Procurement of appropriate materials
• Practice MOT prior to beginning work

Access to Work Zone
• Self mobilizing equipment, staged locally off-site
• Kept crew size to absolute minimum
• Advance preparation (saw cutting, drilling slabs, etc.)

Existing Conditions
• Subgrade good – undercutting would have severely impacted production
• Existing concrete removed with rubber tire excavator fitted with slab bucket attachment

Preparation of Subgrade
• Accurate survey critical to success
• Hand operated grader for PCP
• Laser screed, stringline and straight edge for PPCP
Construction Strategies (and did they work?)

Material Deliveries
- PPCP panels were delivered directly to work zone
- PCP panels staged nearby and moved each night
- Misc. materials staged off-site and delivered as needed

Post-tensioning (PT)
- PT subcontractor worked directly with pre-caster at fabrication plant
- Careful and precise casting limited mis-alignment

Weather
- Careful planning and accurate forecast critical
- No choice but to complete operation if it rains....
Construction Challenges (PPCP)

Duct Grout Leaking at Joints

• Tendon grouting before underslab grout per specification
• Foam gaskets at duct openings
Construction Challenges (PPCP)

Keyway Fit

- Pre-cast tolerances have to be very tight for 27’ panels
- Some panels “shifted” under initial post-tensioning
- Fine grading of subbase very important
Construction Challenges (PPCP)

Alignment of Joints

- Pre-cast tolerances very important
- Difficult to align panels laterally and longitudinally under traffic
Construction Challenges (PPCP)

Maintaining Joint with Existing Pavement
- Difficult to maintain alignment of smaller panels
- All panels set to survey baseline
- Temporary cold patch
Construction Challenges (PPCP)

Isolated Spalling of Panels/Cracking of Keyway

- Occurred after being subjected to traffic
- Generally when top of keyway was in contact with lower panel
Construction Challenges (PPCP)

Misalignment of PT Ducts (only 1 joint !)
- Small PT duct diameter relative to tendon diameter
Construction Challenges (PCP)

Spalling of Panels

- Occurred after being subjected to traffic
- Generally when corners of panels were in contact
Construction Challenges (PCP)

Condition of Existing Concrete (tie-in)

- Difficult to predict
- Additional grout required to fill voids/spall
Construction Challenges (PCP)

Hairline Cracking of Panels
• Observed after being subjected to traffic
• Random locations
Construction Challenges

Smoothness Testing

• Difficult with single point laser (IRI 88 to 116 ins/mile)
• RoLine gave better results (IRI 80 to 96 ins/mile)
• Should improve with time as ridges in aggregate abrade
Falling Weight Deflectometer Testing

Load Transfer Efficiency,

\[ LTE = \frac{D_1}{D_3} \times 100\% \]

where \( D_{1,3} \) = deflection (mils)
Falling Weight Deflectometer Testing

<table>
<thead>
<tr>
<th>System/Measure</th>
<th>PCP</th>
<th>PPCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTE (%)</td>
<td>89.5 (range 77.3 to 99.6)</td>
<td>88.5 (range 60.1 to 109.2)</td>
</tr>
<tr>
<td>$D_1$ Defl. (mils)</td>
<td>7.5 (range 3.5 to 10.9)</td>
<td>5.8 (range 2.51 to 18.5)</td>
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<tr>
<td>Diff. Defl. (mils)</td>
<td>0.78 (range 0.01 to 2.52)</td>
<td>0.66 (range 0.0 to 3.0)</td>
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</tbody>
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Notes:
1. Not all joints were tested for each system
2. Higher $D_1$ deflections for PPCP were at expansion joints
# Costs and Production Rates

## Bid Results (April 7, 2009)

- **CIP (9”) - $225/sy - cast-in-place**
- **PCP (9”) - $350/sy - Fort Miller SuperSlab® System**
- **PPCP (8”) - $410/sy - FHWA Post-tensioned System**

### Peak Productivity*

<table>
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</thead>
<tbody>
<tr>
<td>Panels/Size</td>
<td>--</td>
<td>12 No. 16’ x 12’</td>
<td>12 No. 10’ x 12’</td>
<td>6 No. 10’ x 27’</td>
</tr>
<tr>
<td>Lane Length (LF)</td>
<td>40</td>
<td>192</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Area (SY)</td>
<td>53</td>
<td>256</td>
<td>160</td>
<td>180</td>
</tr>
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* Based on a 6-hour work window (excluding traffic control set-up and removal)
Lessons Learned (Planning/Design)

Lead Time for Shop Drawings/Submittals/Trial Installations
• Allow 2-3 months minimum

Staging Area
• Critical for deliveries, etc.

Trial Installations
• Specify off-site prior to construction
• Trial batches for grouts (hardware and underslab)
• Falling weight deflectometer testing; cores

Closure Pour
• Necessary for PPCP

Existing Conditions are Variable!
• Variability of existing pavements (cast-in-place)
• Tolerances for pre-casting
• Difficult to predict; especially at tie-ins
Lessons Learned (Construction)

Openness of System and Grout Leaks (PPCP)
• Need better seal for tendon ducts

Transverse Tie-bars (PPCP)
• Need efficient means of connecting panels in transverse direction or proof that not needed

Weak Points in Pavement Surface (PPCP)
• Potential future maintenance issues in areas of anchor pockets, tie-in slots, lifting anchor holes, or spalls during construction

Casting Accuracy Required (PCP and PPCP)
• Casting is key! Can tolerances be improved without significantly increasing cost?

Quality Contractor is Necessary to Achieve Good Product
Lessons Learned (Project Delivery)

Maintenance of Traffic
- Lane closure times comparable to CIP
- Space for delivery needs to be considered

User Impacts
- Project impacts comparable to CIP
- Long term impacts expected to be much less

Quality of Product
- Overall longevity expected to be better than CIP
Questions?

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