



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

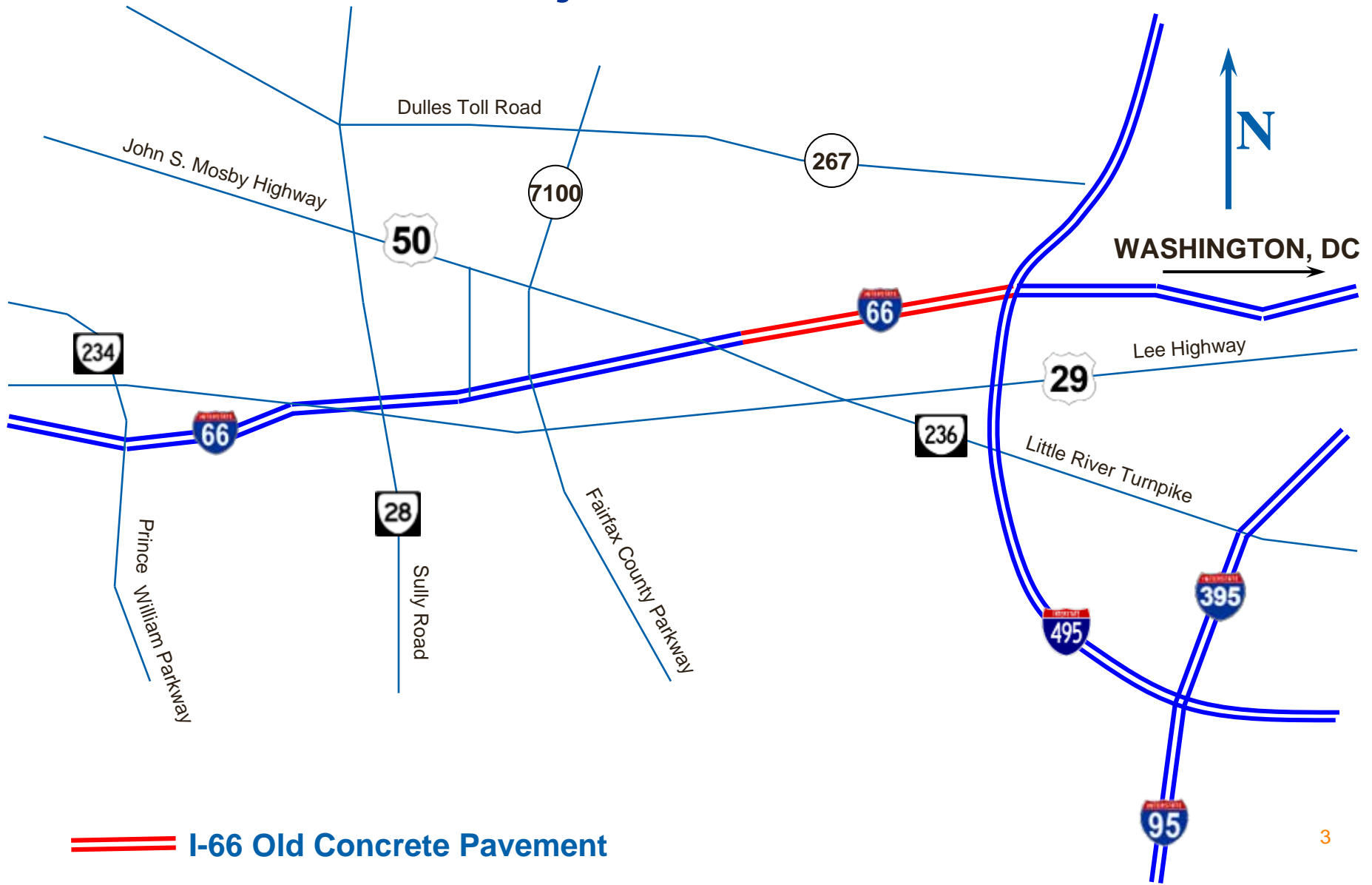
SAFETEA-LU Funding

\$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

I-66 Highways for LIFE

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

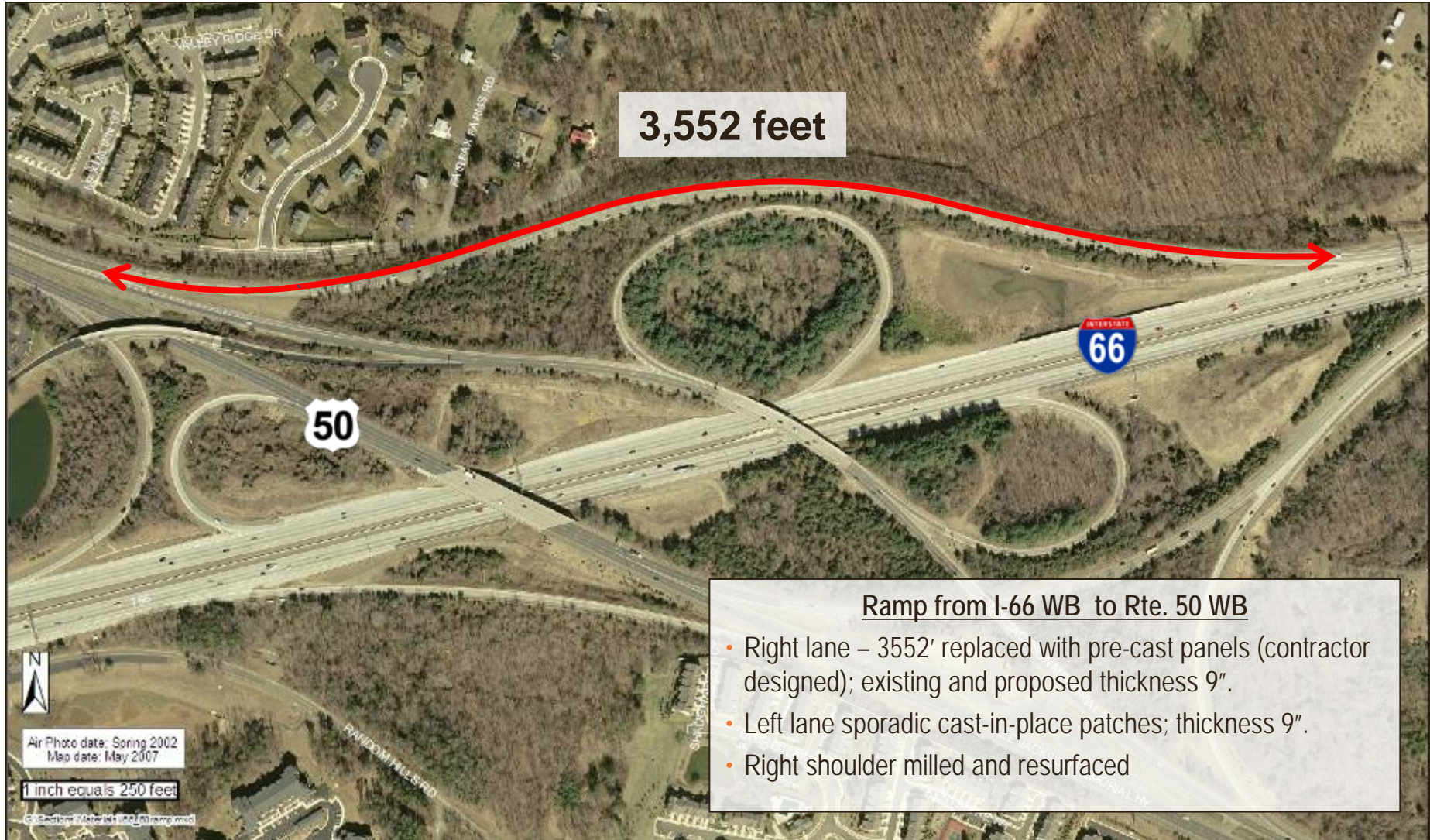
- Based upon condition of pavement
- Available working space (barriers, drainage inlets, etc.)
- Overhead clearances
- Utilities (loop detectors, etc.)
- Curved sections



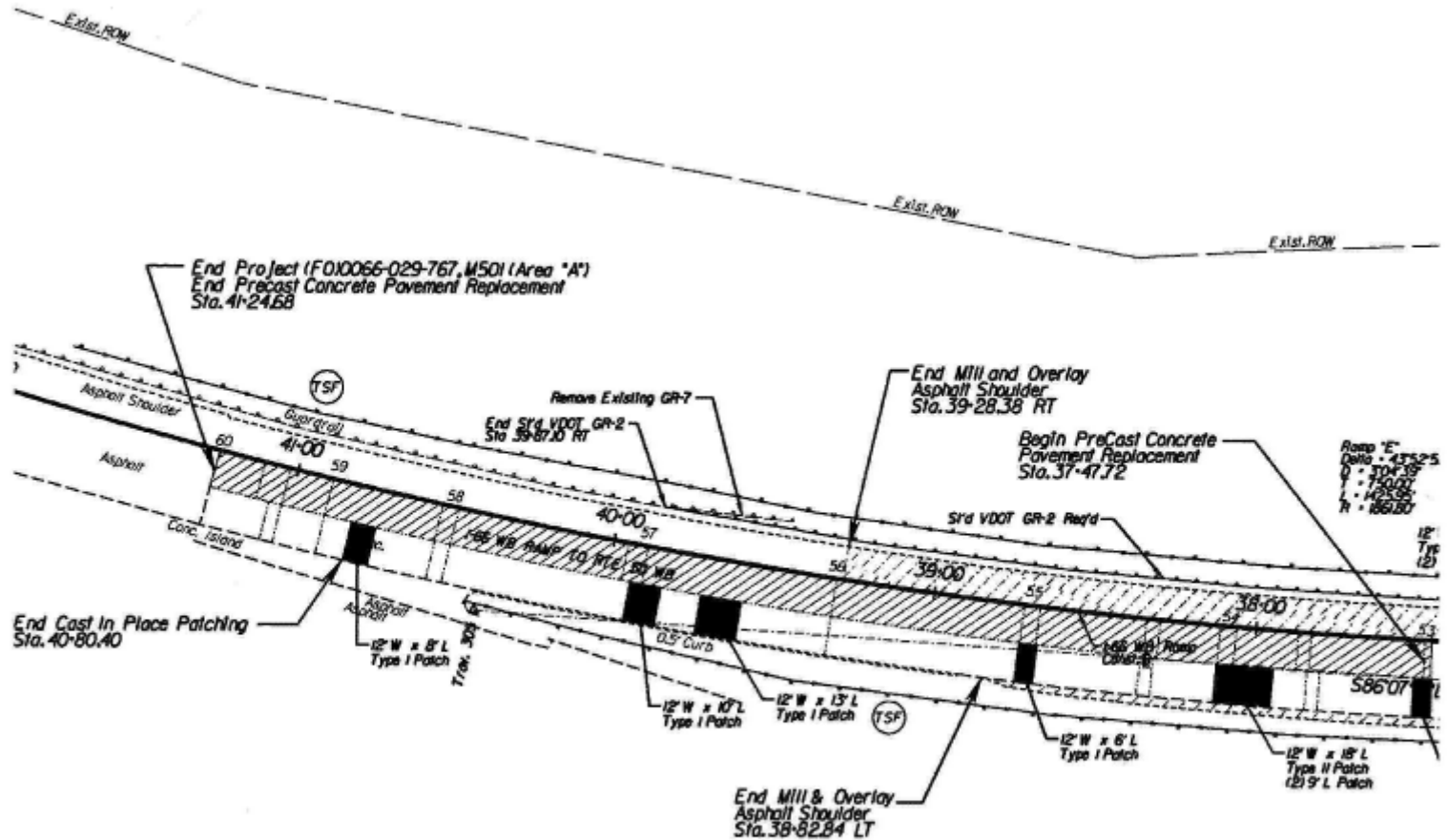
I-66 Highways for LIFE



Highways for LIFE: Area A



Ramp: Pre-cast Concrete Panels (PCP) and Cast-In-Place (CIP) Patches



Ramp: Right Lane to be Replaced with Pre-cast Concrete Panels



I-66 Mainline: Pre-cast, Pre-stressed Concrete Panels (PPCP)



Maintenance of Traffic

Extremely High Traffic Volumes

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

Lane Closure Restrictions

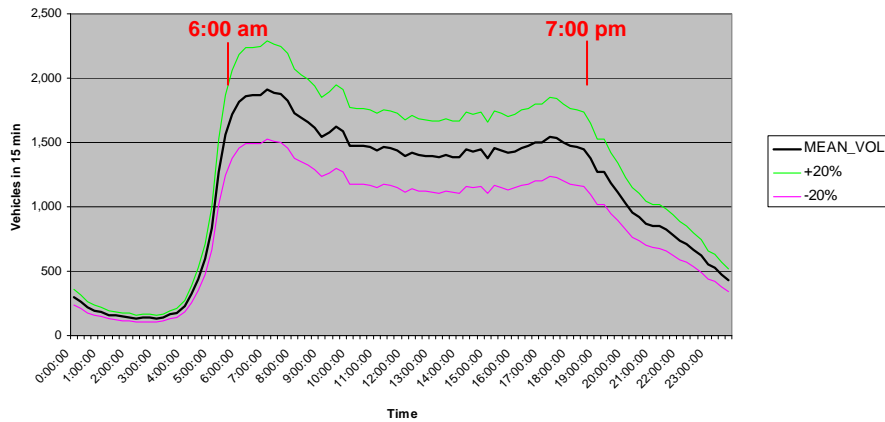
- Close two lanes at 9 pm; close third lane at 10 pm; open by 5 am



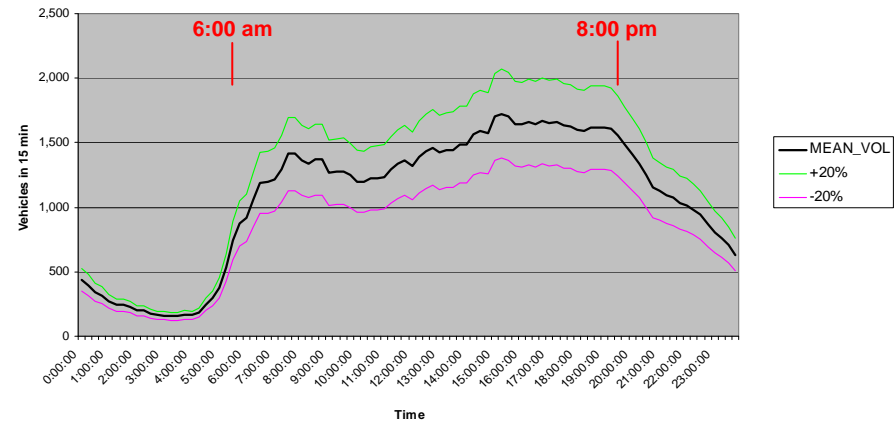
Maintenance of Traffic

Hourly Traffic Volumes

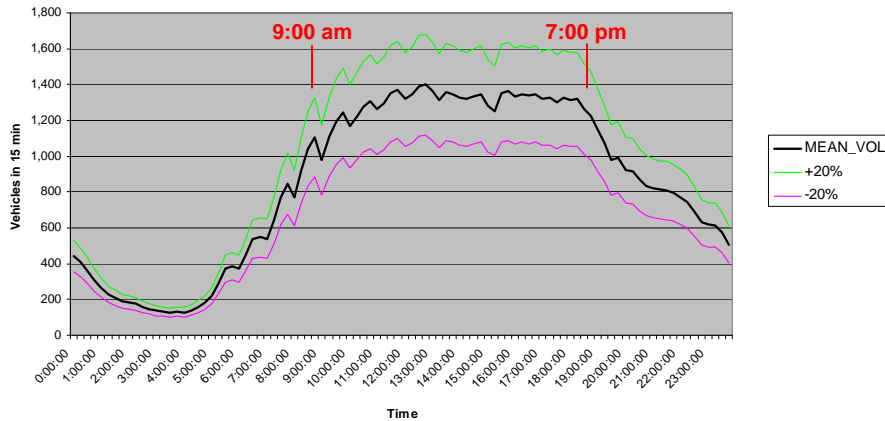
Average Volume in 15 minutes at Det 392 Group at MP 59.11
(EB Friday)



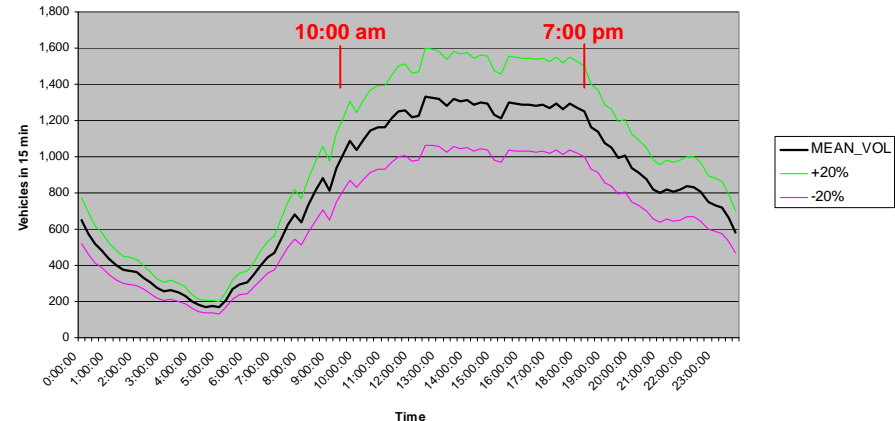
Average Volume in 15 minutes at Det 411 Group at MP 61.43
(WB Friday)



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



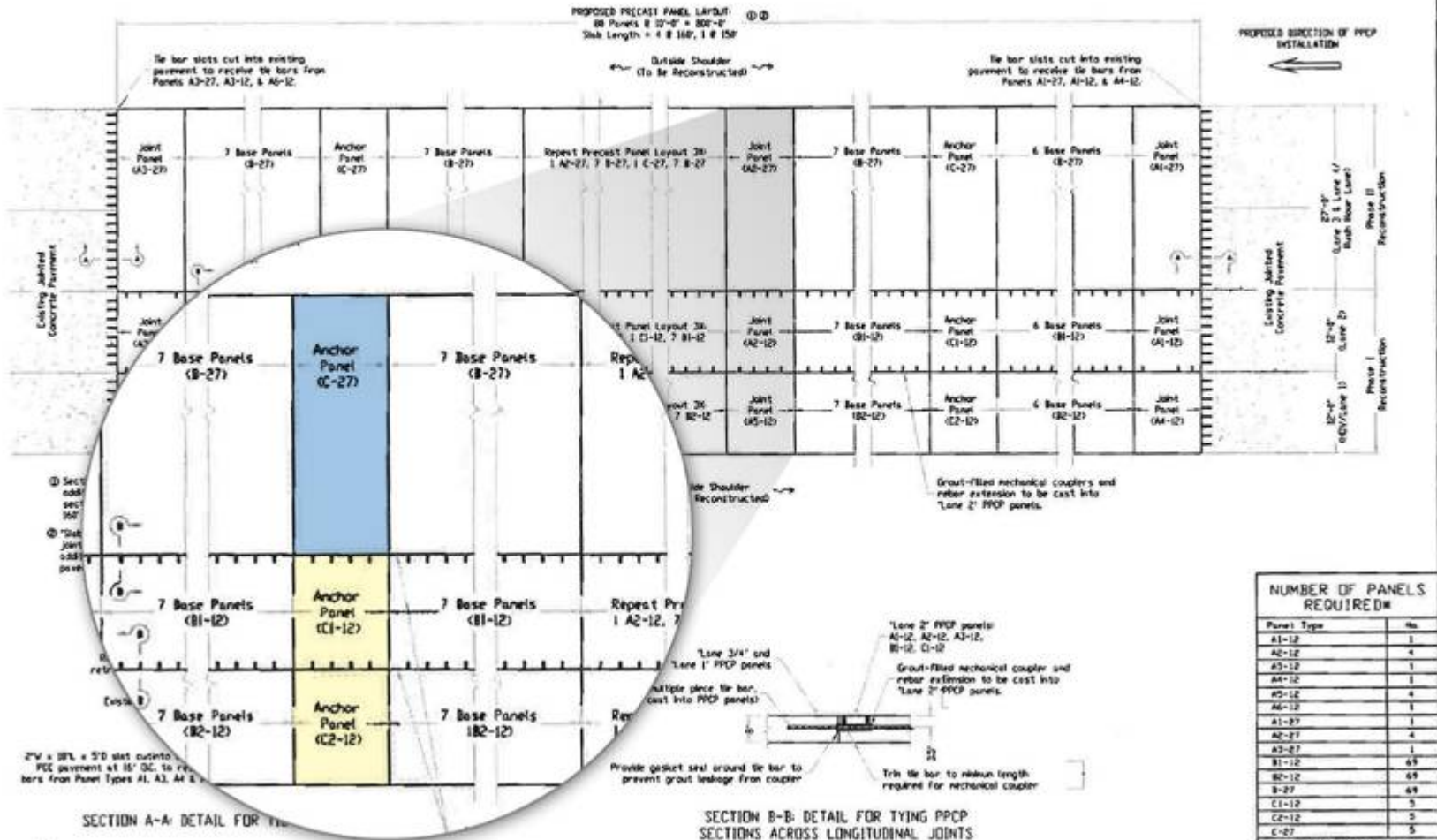
Average Volume in 15 minutes at Det 405 Group at MP 63.74
(WB Saturday)



I-66: Pre-cast, Pre-stressed Concrete Panels (PPCP)

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT	REVISED	DATE	ISSUE NO. PROJECT	DATE PROJECT	NO. OF SHEETS
ORIGINAL, DIMS AND SEALS PLAN HEIGHT IS ON FILE AT THE NORTHERN VIRGINIA LOCATION AND DESIGN ENGINEER'S OFFICE.	VA	01-06-11(322)	I-66	0066-029-787 M501	2

PPCP PANEL LAYOUT & TIE-IN DETAILS



Panel Type	No.
A1-12	1
A2-12	4
A3-12	1
A4-12	1
A5-12	4
A6-12	1
A1-27	1
A2-27	4
A3-27	1
B1-12	69
B2-12	69
B-27	69
C1-12	3
C2-12	3
C-27	3

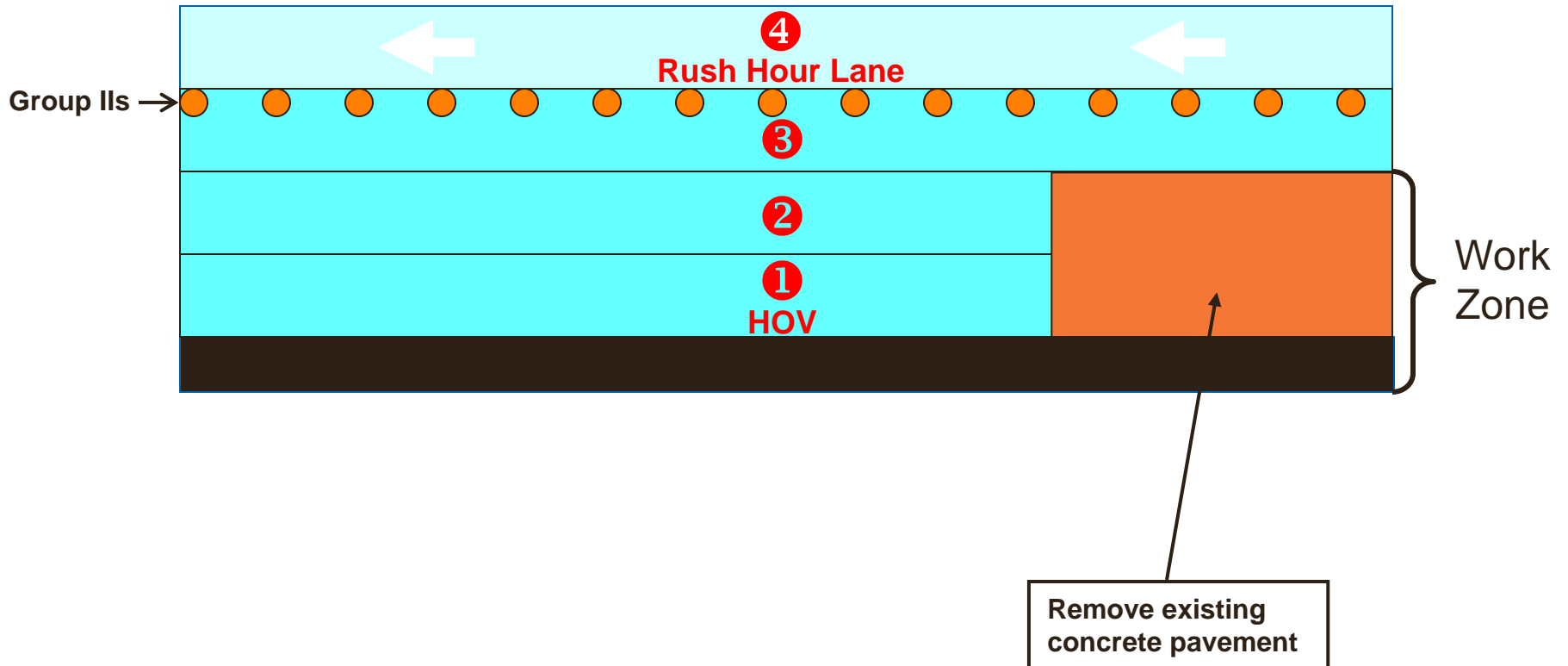
*Estimate for 800' Section Length

SECTION A-A: DETAIL FOR TYPING PPCP SECTIONS ACROSS LONGITUDINAL JOINTS

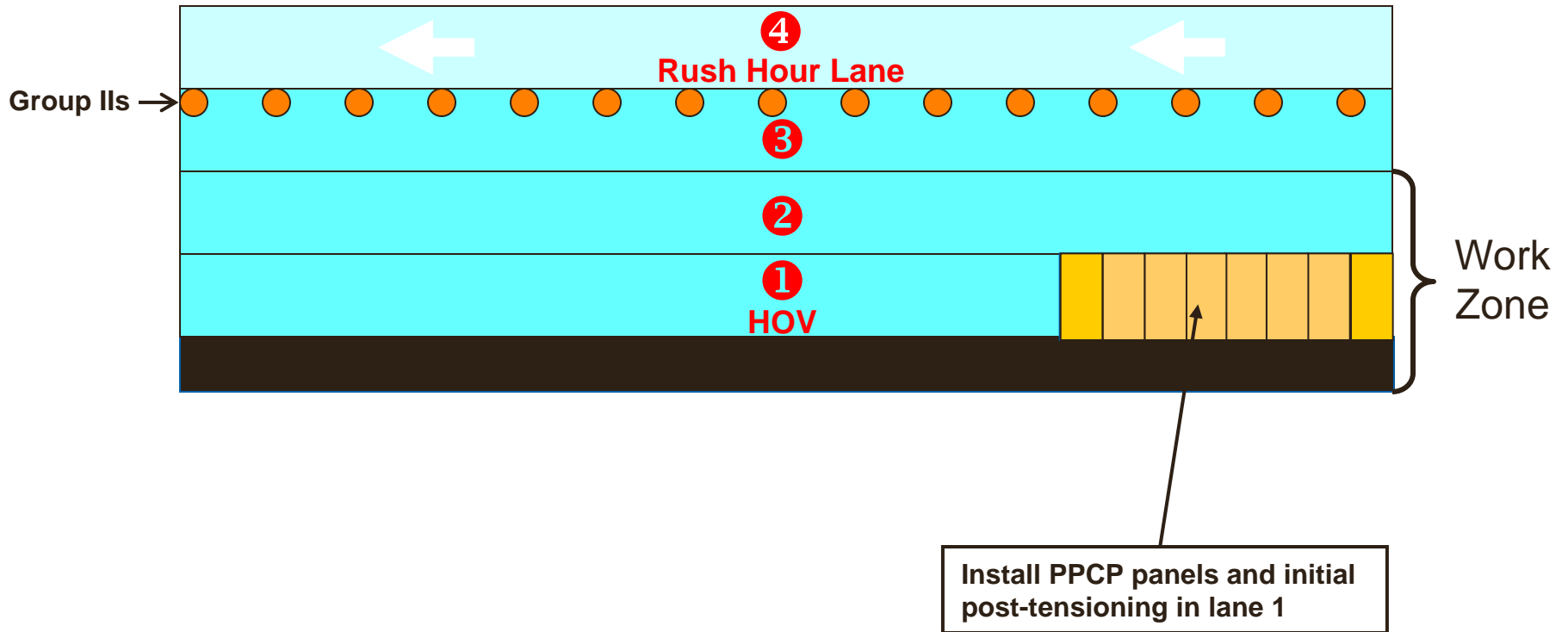
SECTION B-B: DETAIL FOR TYPING PPCP SECTIONS ACROSS LONGITUDINAL JOINTS

PLAN NO.	PROJECT	FILE NO.	SHEET NO.
0066-029-787	I-66		2

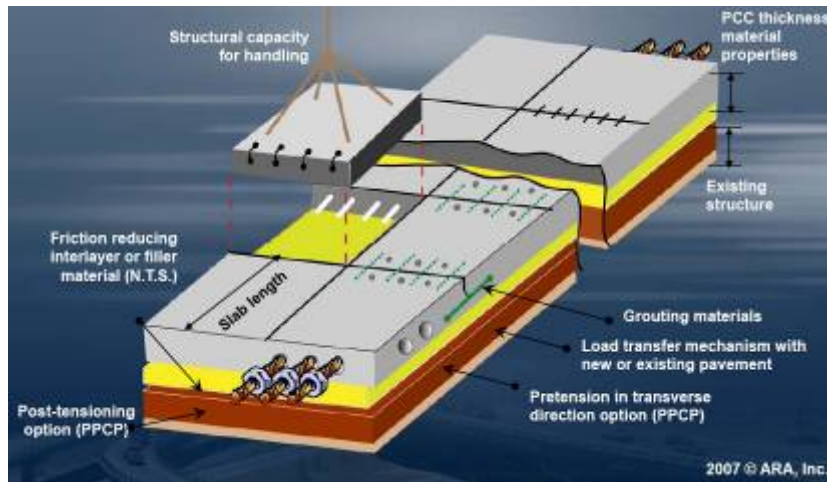
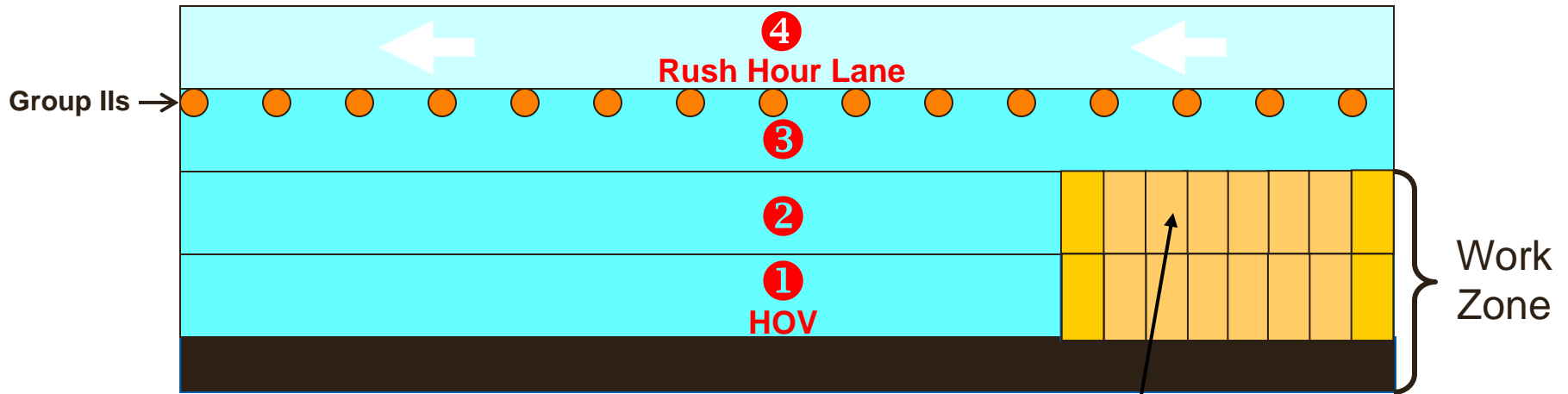
PPCP – Sequence of Construction



PPCP – Sequence of Construction

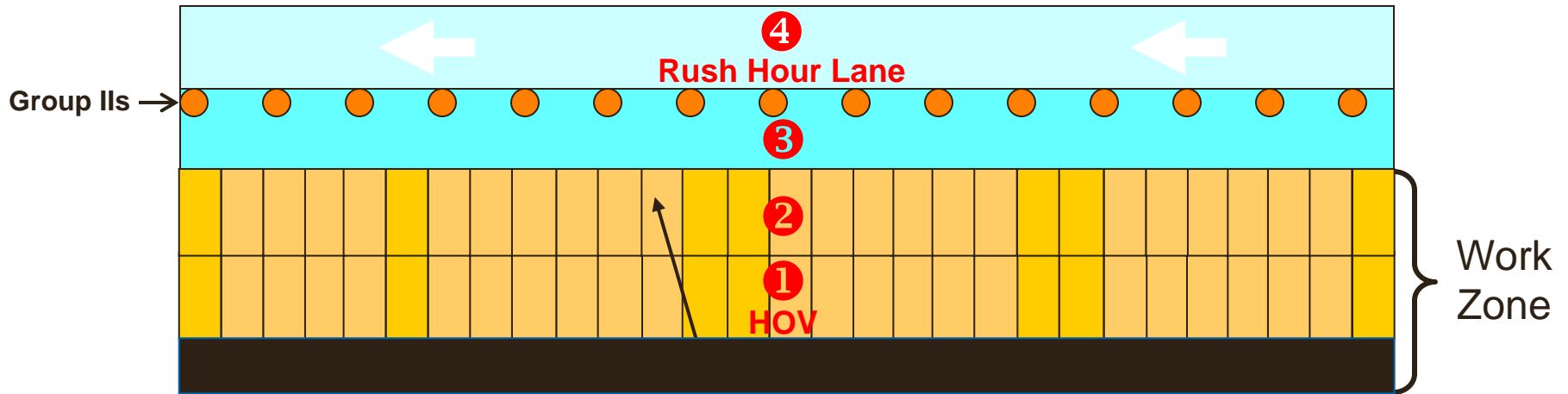


PPCP – Sequence of Construction



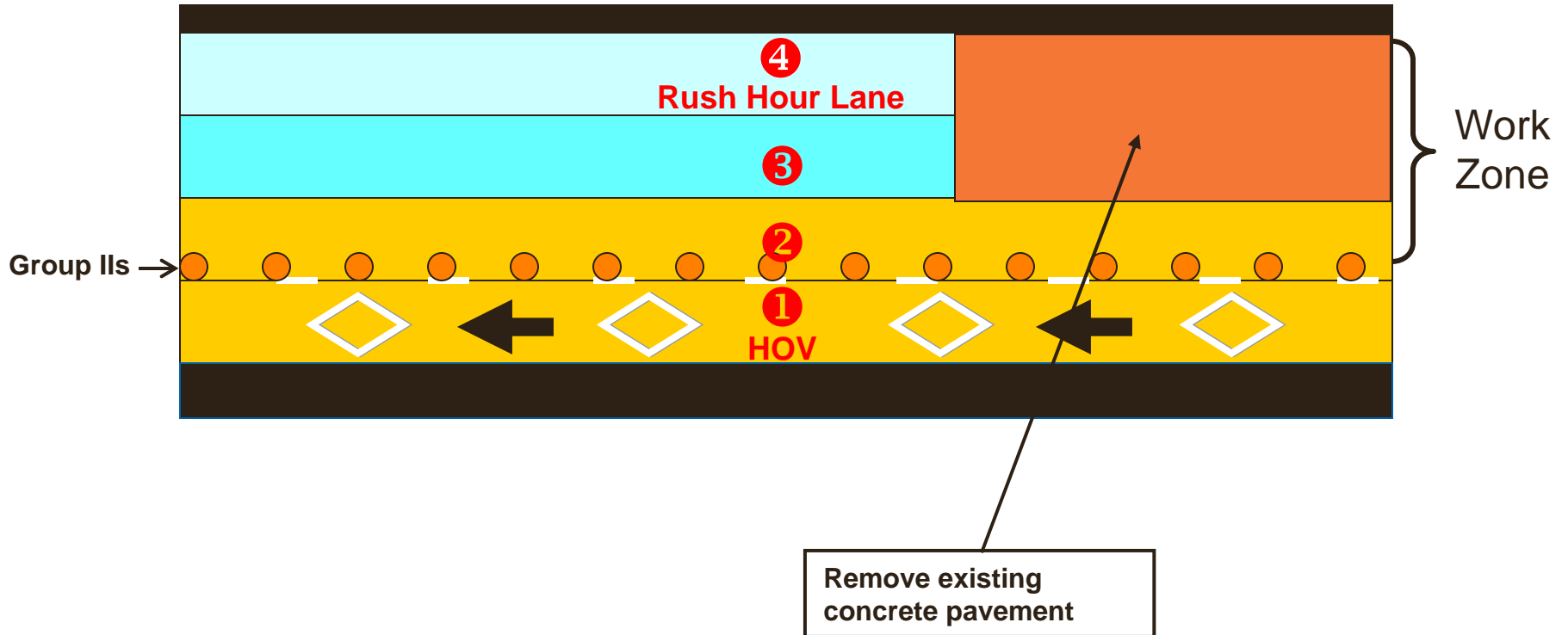
Install PPCP panels and initial post-tensioning in lane 2

PPCP – Sequence of Construction

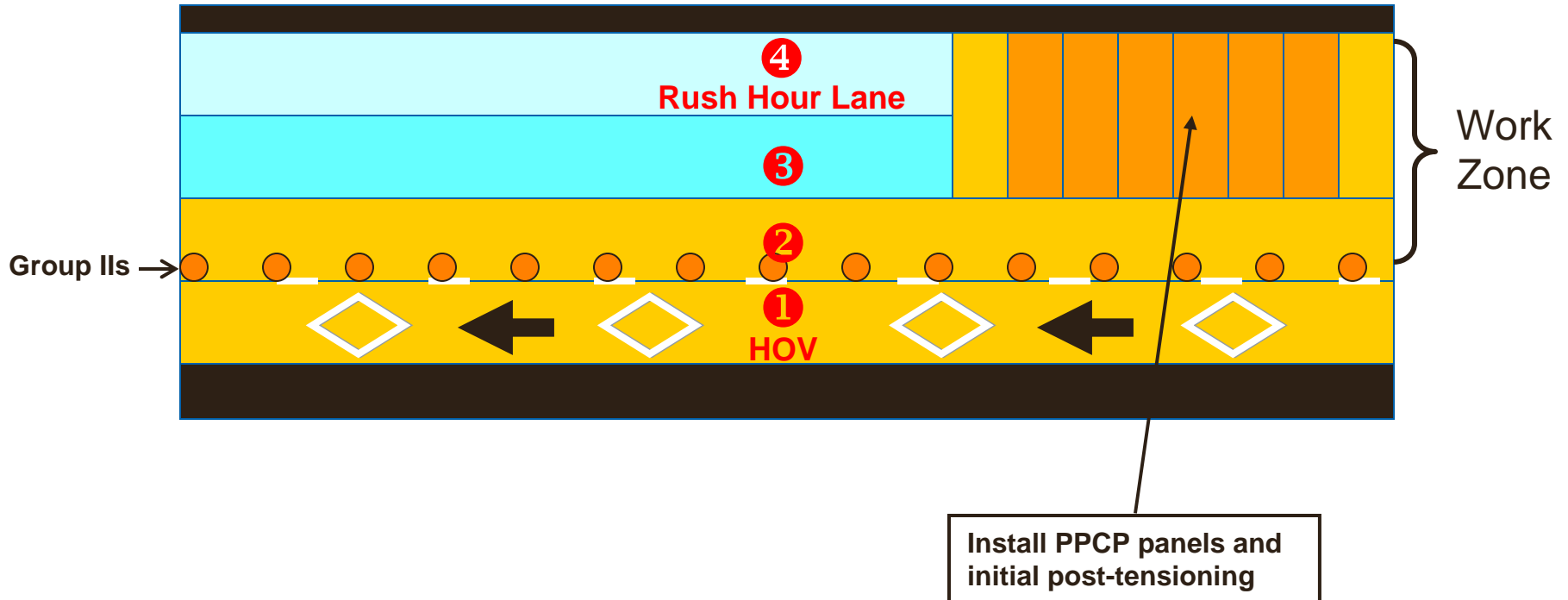


Complete removal of existing concrete and installation of PPCP for the entire length of project, final post-tensioning, duct and underslab grouting, fill post-tensioning block-outs and closure pour

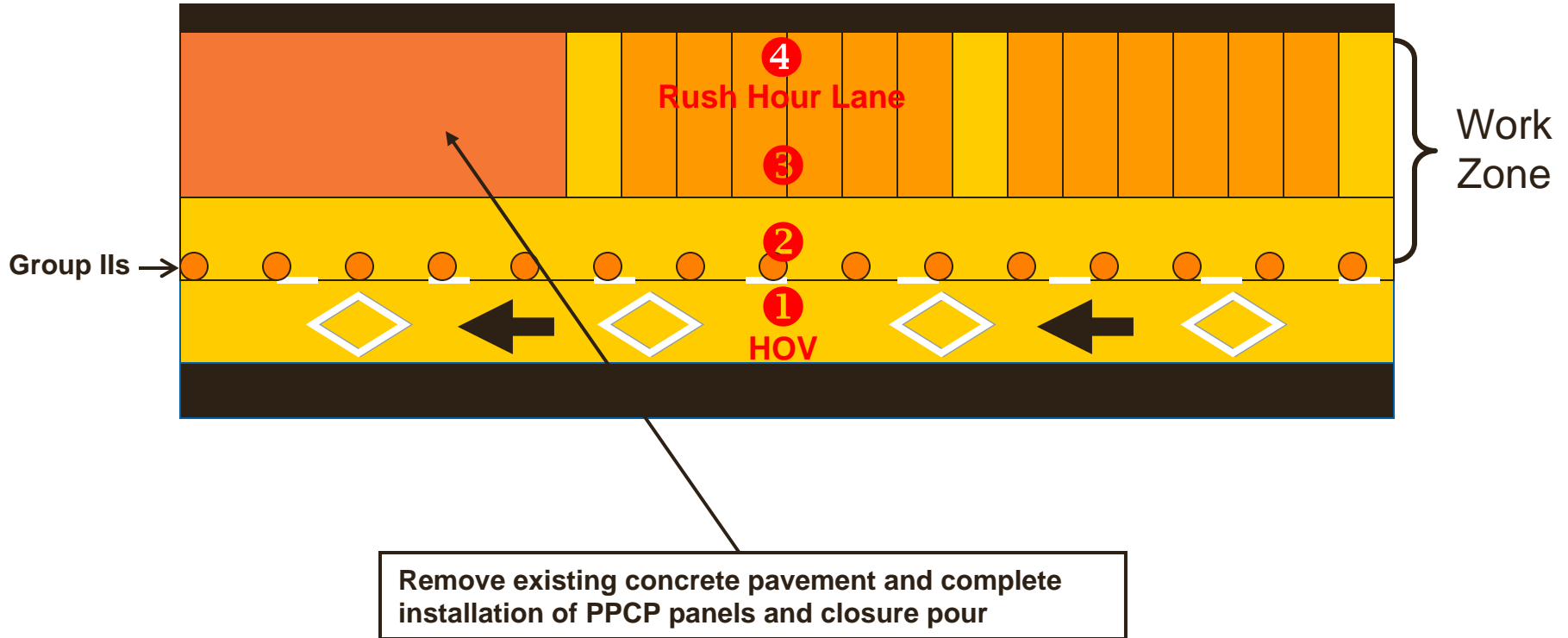
PPCP – Sequence of Construction



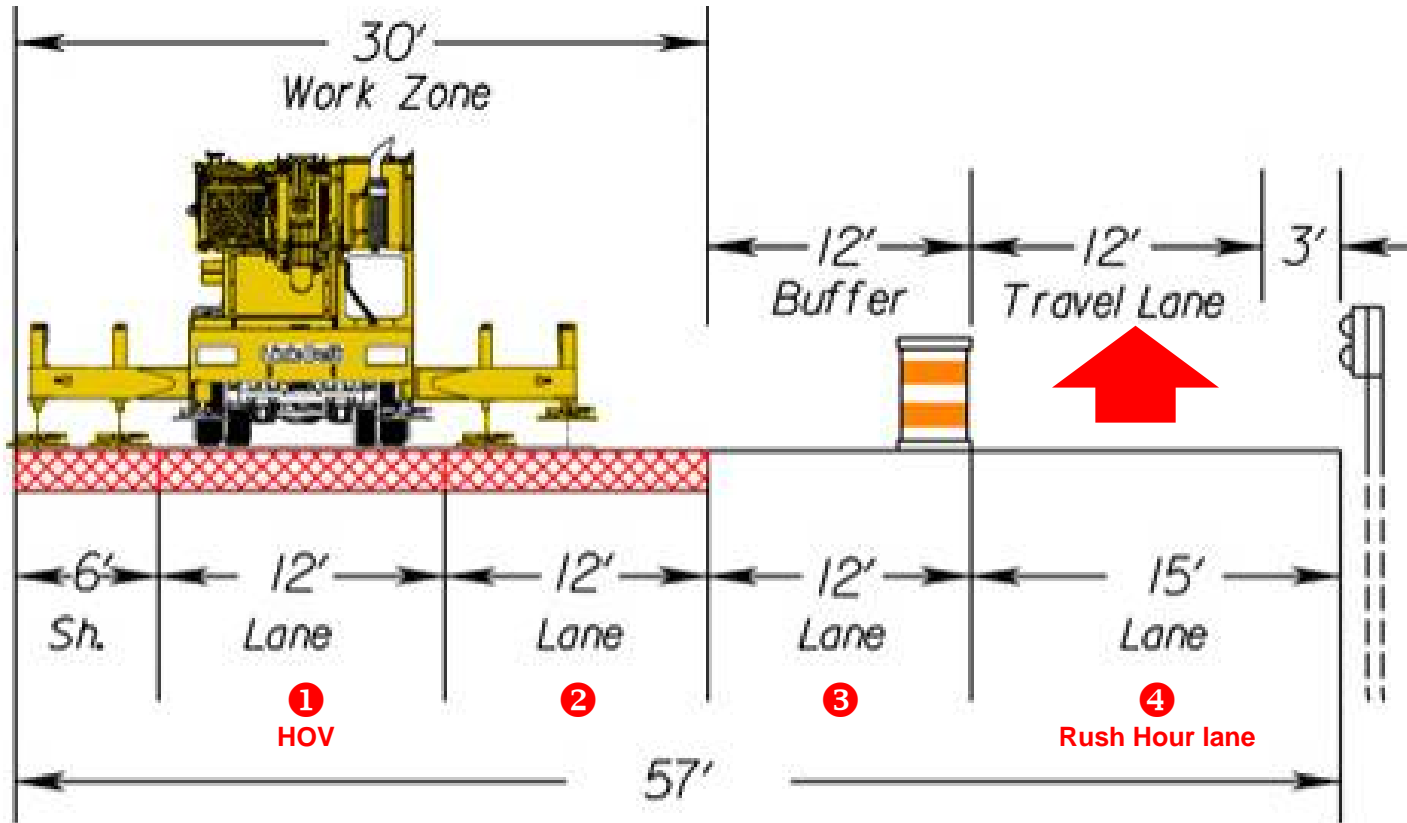
PPCP – Sequence of Construction



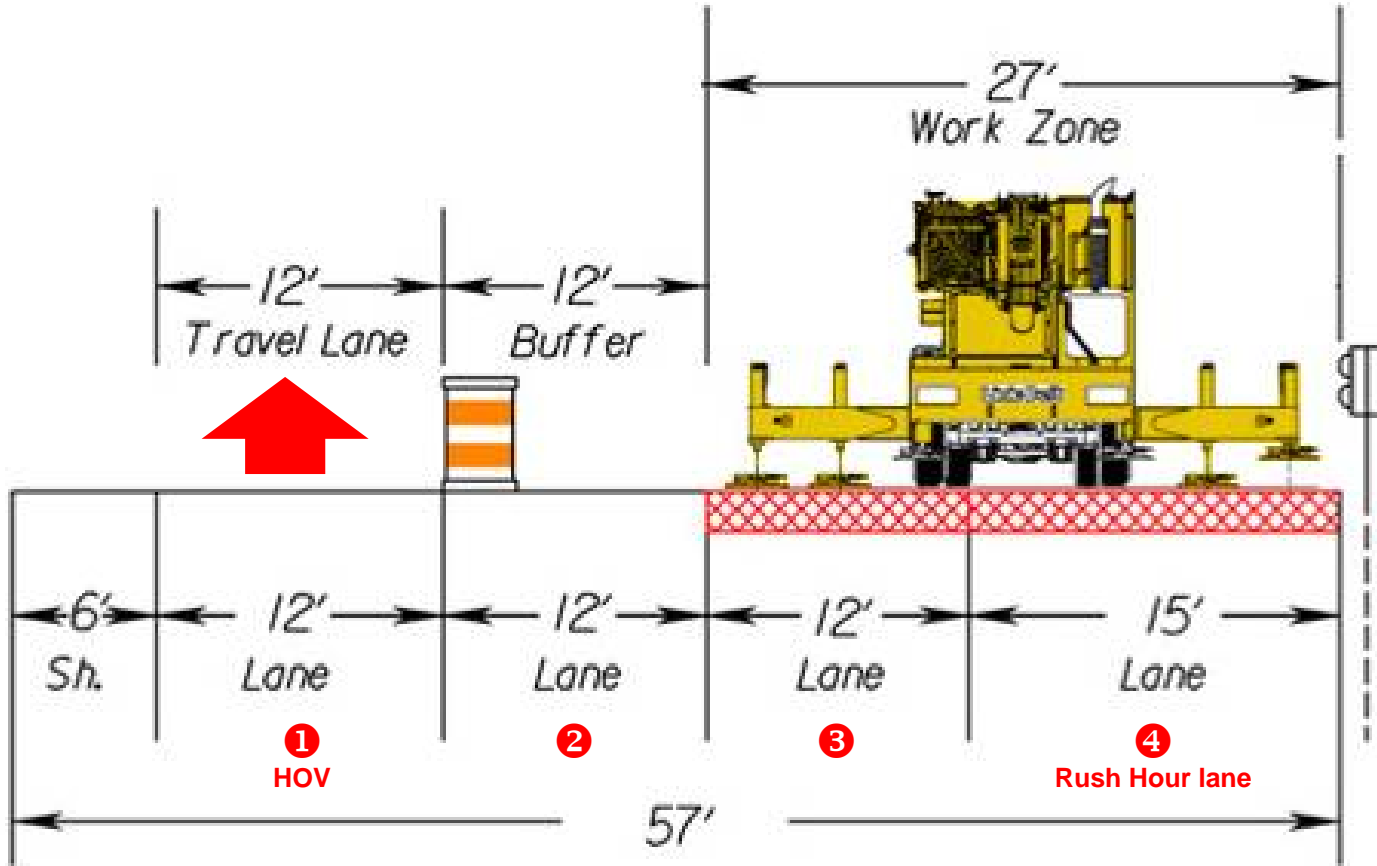
PPCP – Sequence of Construction



Working Space Requirements Inside Lanes – Two 12' Panels



Working Space Requirements Outside and Shoulder Lanes – One 27' Panel



Project Challenges and Solutions

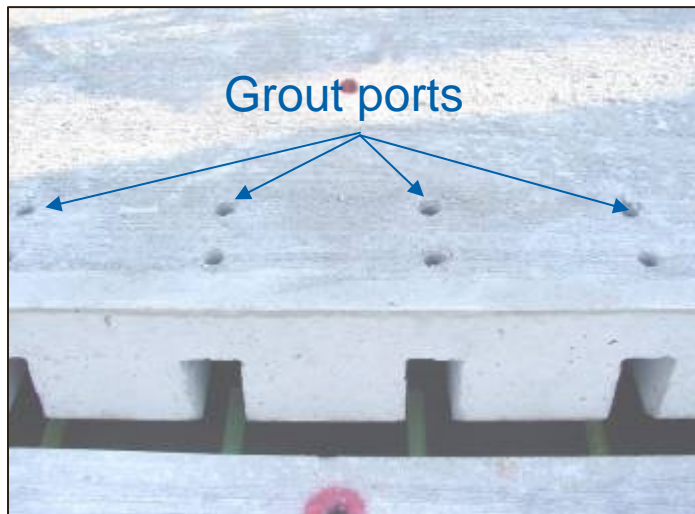
Challenges

- 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



Trial Installations

PCP and PPCP

- *Off-site* prior to installation under traffic
- Separate pay item
- FWD testing and cores



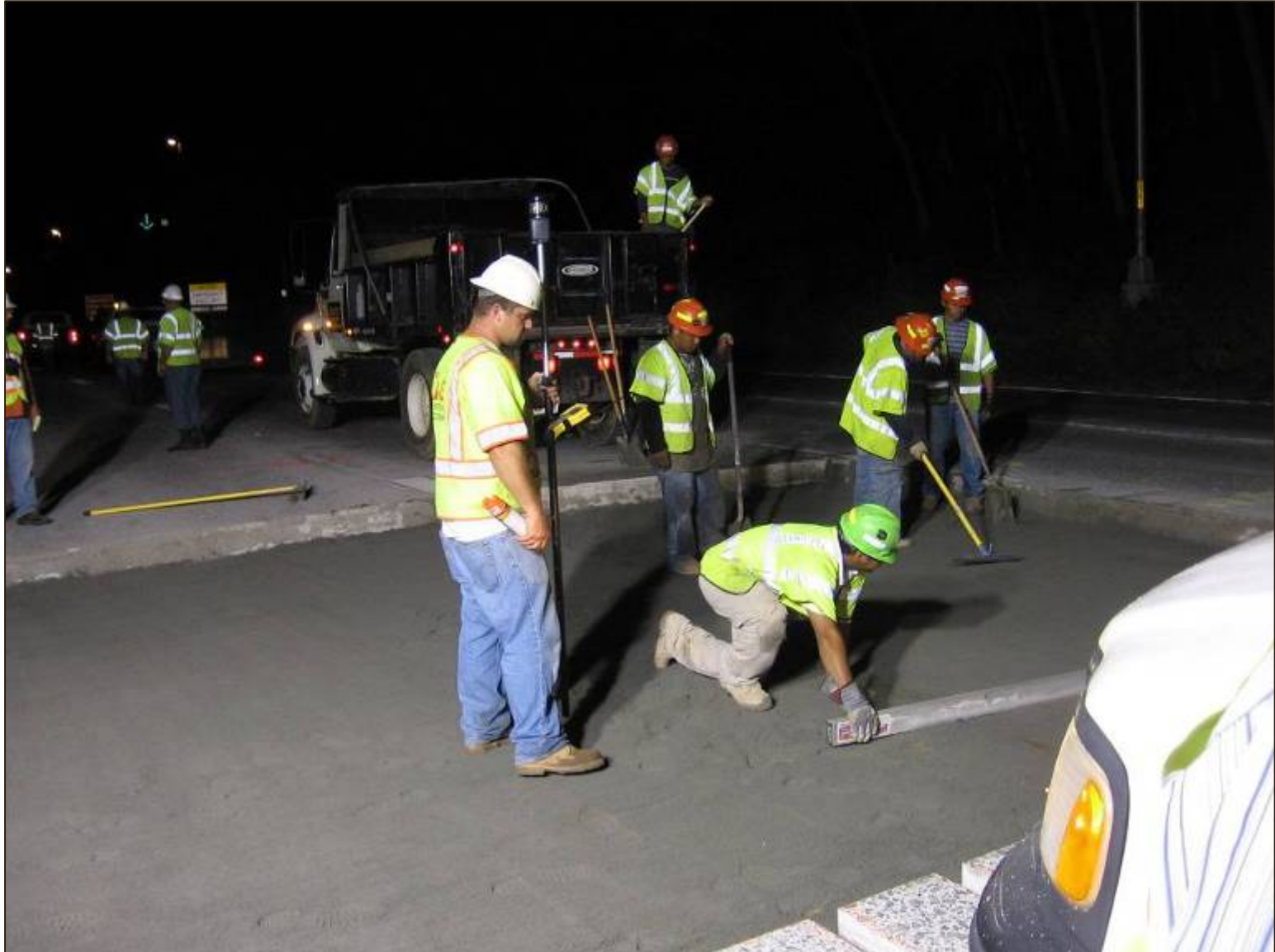
PPCP - Panel Fabrication



PCP - Panel Fabrication (SuperSlab®)



PPCP - Grading Leveling Aggregate



PPCP - Friction Reducing Membrane



PPCP - Installation of Panels



PPCP – Initial Post-Tensioning



PPCP - Placement of Temporary Panel



PPCP - Cold Patch in Block-outs



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 – 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

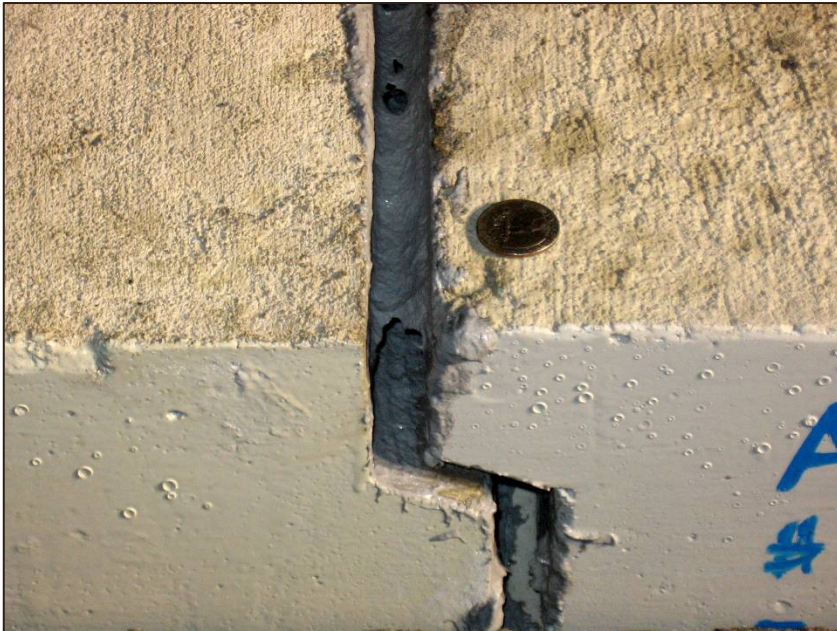
- Tendon grouting before underslab grout per specification
- Foam gaskets at duct openings



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

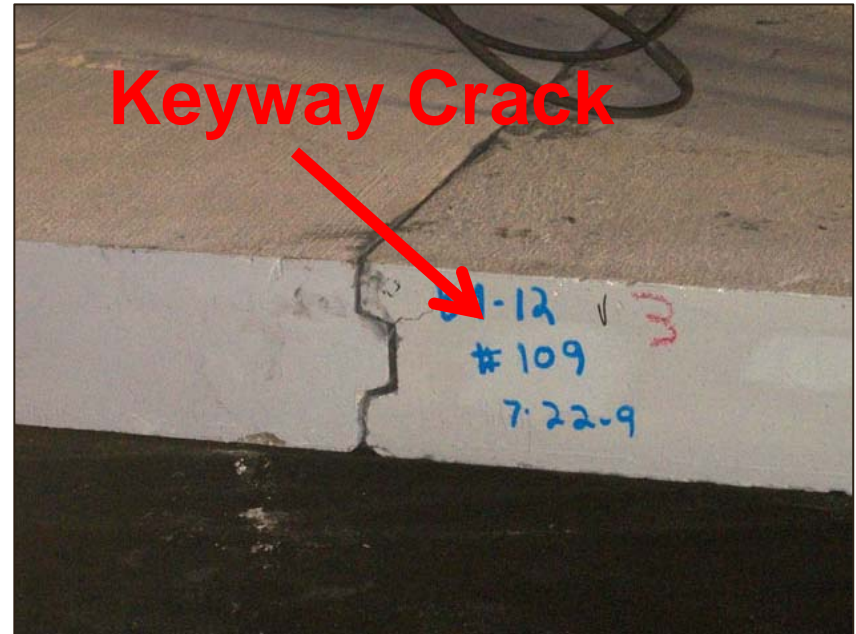
- Difficult to maintain alignment of smaller panels
- All panels set to survey baseline
- Temporary cold patch



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

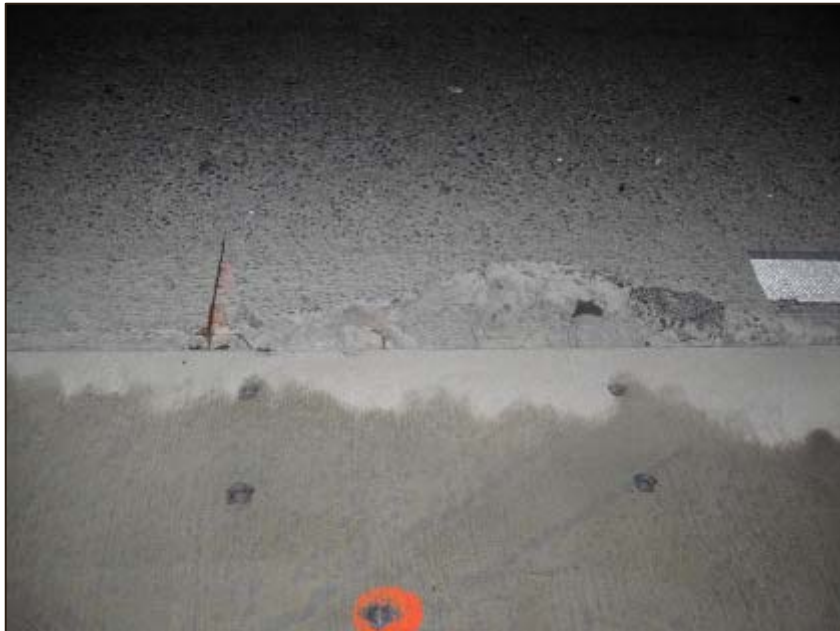
- Occurred after being subjected to traffic
- Generally when corners of panels were in contact



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



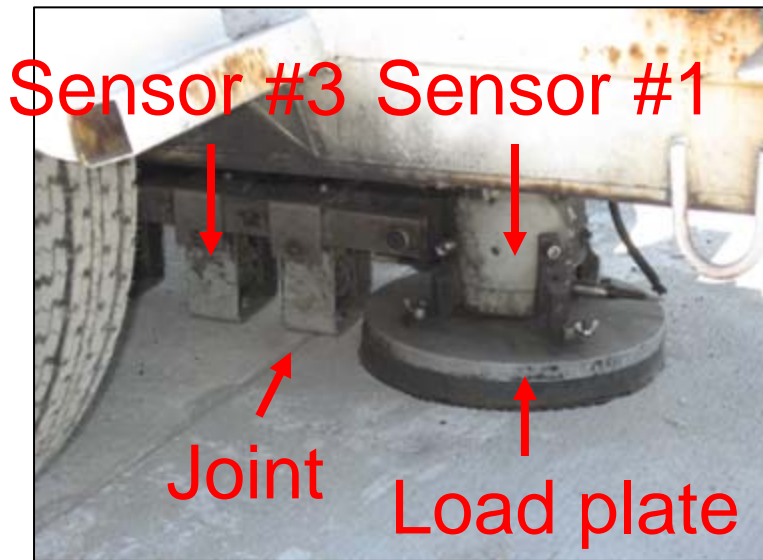
Construction Challenges

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,
 $LTE = D_1/D_3 \times 100\%$

$D_{1,3}$ = deflection (mils)

Falling Weight Deflectometer Testing

System/Measure	PCP	PPCP
LTE (%)	89.5 (range 77.3 to 99.6)	88.5 (range 60.1 to 109.2)
D ₁ Defl. (mils)	7.5 (range 3.5 to 10.9)	5.8 (range 2.51 to 18.5)
Diff. Defl. (mils)	0.78 (range 0.01 to 2.52)	0.66 (range 0.0 to 3.0)

Notes:

1. Not all joints were tested for each system
2. Higher D₁ 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*

System/ Measure	CIP	PCP	PPCP	PPCP
Panels/Size	--	12 No. 16' x 12'	12 No. 10' x 12'	6 No. 10' x 27'
Lane Length (LF)	40	192	120	120
Area (SY)	53	256	160	180

* 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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