

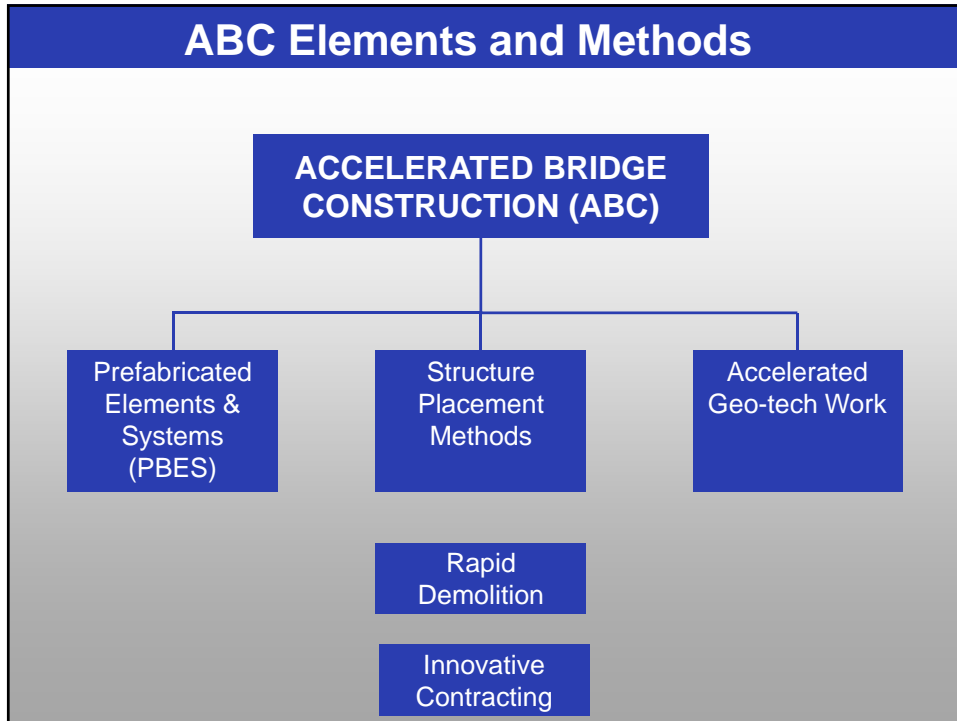


**SHRP2 ABC Toolkit and Projects using the Toolkit.**  
Bala Sivakumar, HNTB Corp. 2.16.2016  
Indiana DOT **HNTB**

## Outline

- Introduction to SHRP2 R04
- Obstacles to ABC Implementation
- SHRP 2 Project R04 – making ABC standard practice
- SHRP2 ABC Toolkit
- Lateral Slide Addendum to the Toolkit
- ABC Projects

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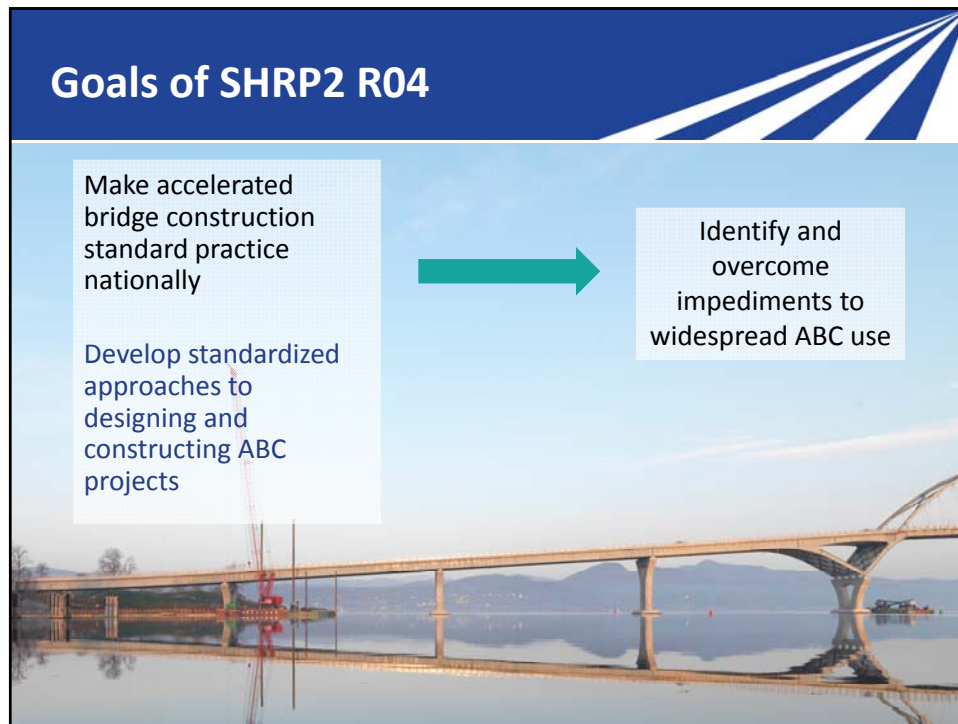


**SHRP2 Project R04 – Making  
ABC Standard Practice**

***Innovative Bridge Designs for Rapid  
Renewal***

2007 – 2013

**HNTB – Prime Contractor**  
Iowa State University  
Genesis Structures  
Structural Engineering Assoc.



## Obstacles to Implementing ABC Owners' Perspective

- Seek ability to balance the increase in construction costs for ABC projects against the user costs savings.
- Durability of connections.
- Need to standardizing components for ABC
- Challenges in getting industry support

## Obstacles to Implementing ABC Contractors' Perspective

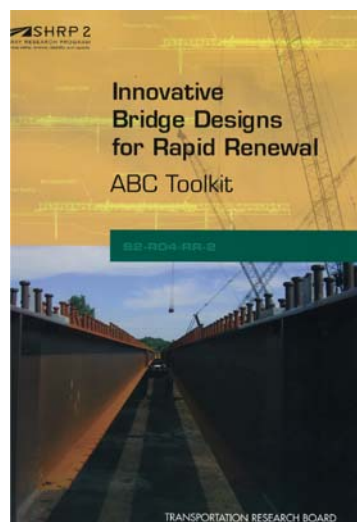
- ABC is perceived as raising the level of risk.
- Contractors concerns about the diminished profitability
- Greater outsourcing of work to precasters and specialty subcontractors.
- Contractors will be more willing to make equipment purchases if there are a greater number of projects to use the same equipment.

## Obstacles to Implementing ABC Engineers' Perspective

- Lack of familiarity with ABC methods
- Looking for design manuals, specifications and design aids for ABC.
- Erection methods for large prefabricated elements
- Need for ABC training.

**Engineers need to – “Think like a Contractor”**

## SHRP2 ABC Toolkit



## SHRP2 Toolkit Published 2012

- **SHRP2 ABC Toolkit** was developed for PBES and Lateral slide (2014 addendum)
- Focus on “workhorse” bridges / adaptable for more complex bridges
- Standards will foster more widespread use of ABC
- Make best use of program dollars by standardizing design through pre-engineered systems
- ABC standards can be incrementally improved through repeated use

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## SHRP2 R04 Websites

- FHWA’s GoSHRP2 site:  
[http://www.fhwa.dot.gov/goshrp2/Solutions/all/R04/Toolkit\\_for\\_Rapid\\_Bridge\\_Construction/](http://www.fhwa.dot.gov/goshrp2/Solutions/all/R04/Toolkit_for_Rapid_Bridge_Construction/)
- AASHTO’s SHRP2 site:  
<http://shrp2.transportation.org/Pages/Bridge-Designs-for-Rapid-Renewal.aspx>
- TRB Document Repository:  
<http://www.trb.org/Main/Blurbs/168046.aspx>

## SHRP2 R04 ABC Toolkit Contents

<b>1</b> ABC Standard Design Concepts	<b>2</b> ABC Erection Concepts	<b>3</b> ABC Sample Design Calculations	<b>4</b> ABC Design Calculations (LRFD)	<b>5</b> ABC Construction Specifications
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## ABC Toolkit – Benefits

<b>ALLOWS STANDARDIZATION OF DESIGN SECTIONS</b>	<ul style="list-style-type: none"><li>• Decks</li><li>• Superstructure</li><li>• Wingwalls</li><li>• Columns</li><li>• Footings</li></ul>
<b>CAN BE BUILT BY ANY BRIDGE CONTRACTOR</b>	<ul style="list-style-type: none"><li>• Increases competition</li><li>• Enables use of local contractors</li></ul>
<b>NO SPECIAL EQUIPMENT NEEDED</b>	<ul style="list-style-type: none"><li>• No SPMTs</li><li>• No large gantry cranes</li><li>• No specialized contractors needed</li><li>• Onsite fabrication of bridge elements</li></ul>

## Franklin Avenue Arch Rehabilitation *Minneapolis, MN*

### SELF-PERFORMING THE PRECASTING



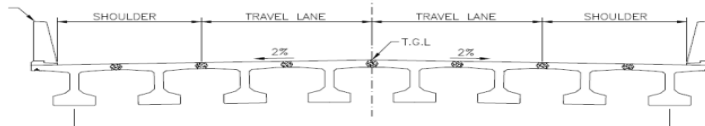
## Standard Design Concepts for PBES

- Decked steel girders
- Decked concrete girders
- Precast abutments and wingwalls
- Precast piers
- Precast footings
- Precast approach slabs
- ABC connections

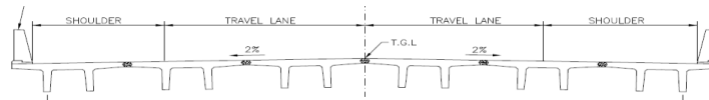


## Prefabricated Decked Beam Elements

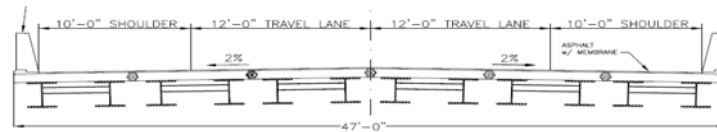
### Deck Bulb Tees



### Double Tees



### Composite Steel System



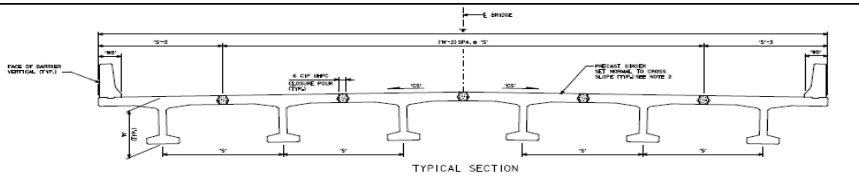
## NJDOT Rte 18 Bridge Weekend Replacement



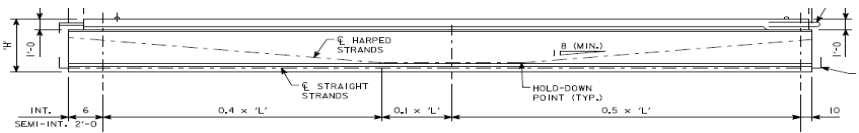
## Superstructure ABC Design

- Simple / continuous spans from 40 ft to 130 ft.
- Simple for DL; Continuous for LL; No Open Joints
- Plans are grouped in the following span ranges:
  - 40 ft to 70 ft
  - 70 ft to 100 ft
  - 100 ft to 130 ft.

## Sample Drawings from ABC Toolkit

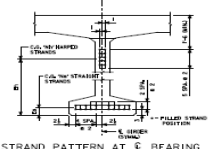


TYPICAL SECTION



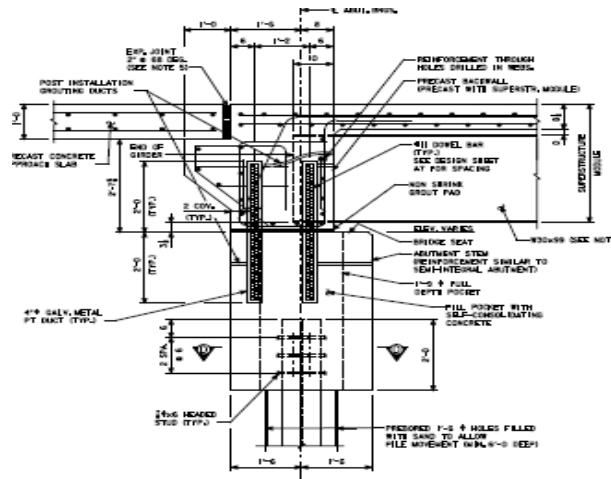
EXAMPLE STRAND LAYOUT - INTERIOR GIRDER

SPAN TYPE	S/C (FT)	T/C (FT)	# OF STRANDS (WS)	TENSION			MOMENT			TOTAL	
				NO.	AREA (SQ IN)	AREA (SQ IN)	NO.	AREA (SQ IN)	NO.	AREA (SQ IN)	NO.
DBT 40	40	8	8	8	6.300	4	23.200	12	17.000	18	5.800
	70	8	8	8	6.300	6	23.200	12	17.000	24	8.300
	100	8	8	8	6.300	10	31.800	22	15.200	40	11.300
DBT 45	70	8	8	8	6.300	10	31.800	20	14.000	48	16.300
	100	8	8	8	6.300	14	44.200	28	19.700	62	21.700
	130	8	8	8	6.300	18	58.200	32	25.200	80	28.200
DBT 60	100	8	8	8	6.300	18	58.200	32	25.200	80	28.200
	130	8	8	8	6.300	22	70.200	38	30.200	100	34.200
	160	8	8	8	6.300	26	82.200	44	35.200	120	39.200



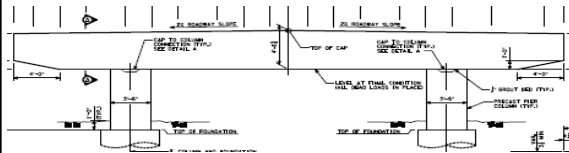
STRAND PATTERN AT  $\bar{C}$  BEARING  
EXAMPLE PATTERN SHOWN, SEE TABLE

## Integral Abutment

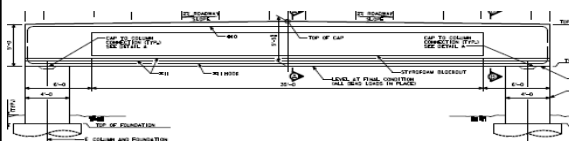


- Only one row of vertical piles
- Fast construction

## Precast Piers



Conventional Pier

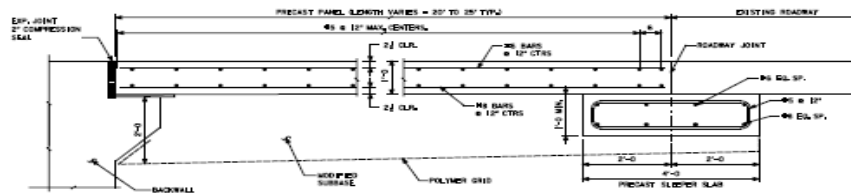


Straddle Bent



- Non-prestressed so contractor can self-perform precasting
- Fast erection using grouted splice couplers

## Precast Approach Slab



## Using the ABC Toolkit

- **General Information Sheets** Introduce the intent and scope of the ABC standard plans and details -- includes instructions to designers on key ABC issues
- Engineer of Record (EOR) should perform own ABC design calculations for the project using the examples as a guide
- EOR to customize the standard plans for the site --- span lengths / bridge width / module size / skew / foundations / etc
- Sample ABC Special Provisions for construction

# General Information Sheet

## GENERAL INFORMATION: SUPERSTRUCTURE

PREFABRICATED COMPONENT BRIDGE SUPERSTRUCTURE CAN BE INSTALLED ASSEMBLED AND CHAIN BRIDGE SUPPORTS THE LOADS APPLIED AND IS DESIGNED FOR THE FULL BRIDGE LOADS. THE CONTRACTOR SHALL VERIFY THE DESIGN OF THE SUPERSTRUCTURE IS IN ACCORDANCE WITH THE DESIGN SPECIFICATIONS FOR THE BRIDGE. THE CONTRACTOR SHALL VERIFY THE DESIGN OF THE SUPERSTRUCTURE IS IN ACCORDANCE WITH THE DESIGN SPECIFICATIONS FOR THE BRIDGE.

THE SUPERSTRUCTURE SHALL BE DESIGNED TO WITHSTAND THE COMBINATION OF ALL APPLICABLE LOADS AND EFFECTS INCLUDING THE FULL BRIDGE LOADS AND THE FULL BRIDGE WEIGHT. THE CONTRACTOR SHALL VERIFY THE DESIGN OF THE SUPERSTRUCTURE IS IN ACCORDANCE WITH THE DESIGN SPECIFICATIONS FOR THE BRIDGE.

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## GENERAL INSTALLATION PROCEDURE:

1. SET UP ALREADY PRECAST ELEMENTS IN THE TANK PRIOR TO CASTING TO THE SITE.

2. DO NOT PLACE MOULD ON PRECAST SUPERSTRUCTURE UNTIL THE CONCRETE HAS REACHED THE SPECIFIED MINIMUM VALUE.

3. CHECK THE POSITION OF THE SUPERSTRUCTURE, POSITIONING BRIDGE AND OTHERS RELATIONS PRIOR TO PLACEMENT OF ALL MOULDS.

4. LIFT AND BRACE MOULDS WITH LIFTING DEVICES AS SHOWN ON THE SHOP DRAWING IN CONFORMANCE WITH THE MOULDER'S PLAN.

5. SET MOULDS ON THE PROPER LOCATION, SURVEY THE TOP SURFACE OF THE MOULDS, MARK POINTS AND SET UP WITH SUFFICIENT TOLERANCES.

6. PRECAST STEEL SHALL BE USED BETWEEN THE MOULDS AND THE FORMS TO BE REMOVED AFTER CASTING. TOLERANCES IN BRIDGE BETWEEN MOULDS AND APPROXIMATE SECTIONAL PLANS WITHIN TOLERANCES.

7. TEMPORARILY SUPPORT MOULDS AND BRACE ALL EXISTING MOULDS AS NECESSARY FOR STABILITY AND TO BESET WITH OTHER BRIDGE MOULDS AND CONFORMITY TO THE MOULDER'S PLAN.

8. DIFFERENCES IN CAMBER BETWEEN ADJACENT MOULDS, ASSIGNED TO THE SITE SHALL NOT EXCEED THE TOLERANCE LIMITS. IF THERE IS A SIGNIFICANT CHANGE, THE CONTRACTOR SHALL NOTIFY THE OWNER AND SHALL BE RESPONSIBLE FOR THE CORRECTIVE ACTION. THE MOULDS SHALL BE REMOVED AS SOON AS POSSIBLE AFTER THE CONCRETE HAS REACHED THE SPECIFIED MINIMUM VALUE.

9. THE MOULDS SHALL BE REMOVED AS SOON AS POSSIBLE AFTER THE CONCRETE HAS REACHED THE SPECIFIED MINIMUM VALUE. THE MOULDS SHALL BE REMOVED AS SOON AS POSSIBLE AFTER THE CONCRETE HAS REACHED THE SPECIFIED MINIMUM VALUE.

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## SAW CUT GROOVE TEXTURE FINISH:

SAW CUT GROOVING SHOULD BE DONE BY BRIDGE USER USING A MECHANICAL CUTTING DEVICE AFTER DAMPING JOINTS.

## GEOMETRY CONTROL:

CONSTRUCTION GEOMETRY CONTROL FOR SUPERSTRUCTURE ELEMENTS AND CROSS-SECTIONS ARE NOT TO EXCEED PROPER SET UP OF PREFABRICATED SYSTEMS. THE CONTRACTOR SHALL CHECK THE GEOMETRY AND ALIGNMENT OF THE STRUCTURE AT EVERY STAGE OF CONSTRUCTION TO ENSURE PROPER POSITION OF THE STRUCTURE TO THE FINAL BRIDGE LINE. AN ADJUSTMENT TO THE GEOMETRY OF THE STRUCTURE TO THE FINAL BRIDGE LINE SHALL BE MADE AS NECESSARY TO MEET THE ELEVATION TOLERANCES SHOWN ON THE PLANS.

BRIDGE CROSS SECTIONS OF A BRIDGE SHALL BE ACCORDING TO THE DESIGN. THE SUPERSTRUCTURE SHALL BE SET UP TO THE BRIDGE CROSS SECTION. THE BRIDGE CROSS SECTION SHALL BE SET UP TO THE BRIDGE CROSS SECTION. THE BRIDGE CROSS SECTION SHALL BE SET UP TO THE BRIDGE CROSS SECTION.

## CAMBER CONTROL:

DIFFERENTIAL CAMBER FOR BRIDGE SUPERSTRUCTURE WITH THE COMBINING EFFECTS OF DAMAGED BRIDGE FABRICATION IS REQUIRED TO BE SET UP TO THE BRIDGE CROSS SECTION. THE BRIDGE CROSS SECTION SHALL BE SET UP TO THE BRIDGE CROSS SECTION. THE BRIDGE CROSS SECTION SHALL BE SET UP TO THE BRIDGE CROSS SECTION.

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## REQUIREMENTS FOR UJRC JOINTS:

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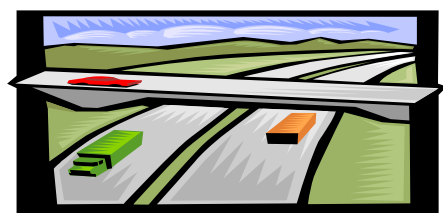
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<p>THE STRUCTURAL DESIGN PROGRAM IS PROJECT FOR PRECAST/PREFABRICATED GIRDER SUPERSTRUCTURE GENERAL INFORMATION</p> <p>REV. # 001 GENERAL OCTOBER 2011</p>
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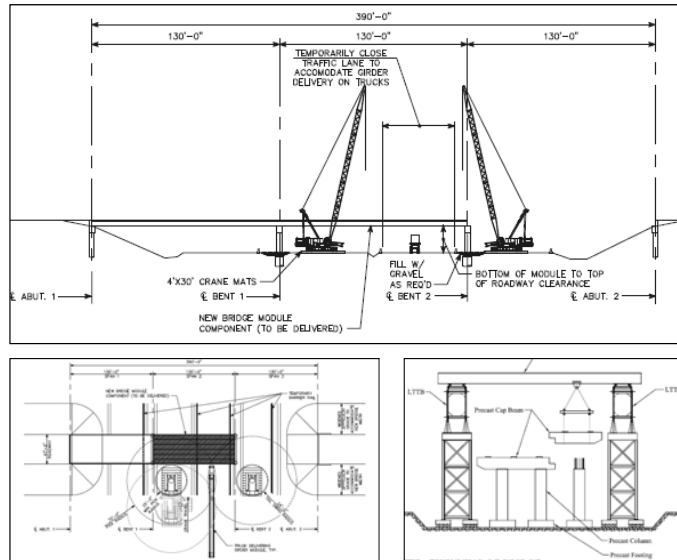
# Erection Concepts for ABC

## Erection methods in the ABC Toolkit:

1. Erection using mobile cranes
2. Erection using gantry cranes / ABC construction technologies



## Sample Erection Concepts Drawing



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## Gantry Cranes / Above Deck Driven Carriers

- Allows fast rate of erection
- Rides on existing bridge or new bridge
- Ideal for bridges with many spans, long viaducts



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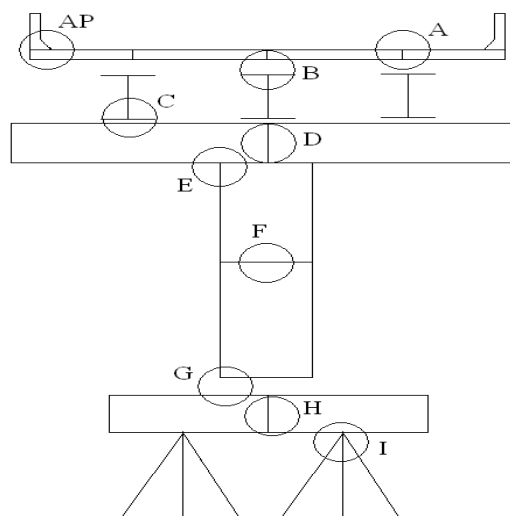
## Launched Temporary Bridge

- Sites with limited ground access or long spans
- Launched across to act as a “temporary bridge”
- Used to deliver the heavier modules without inducing large erection stresses.



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## PBES Connections *ABC Toolkit / SHRP2 R04 Report*



## Ultra High Performance Concrete (UHPC)

**Compressive Strength:**  
20,000 to 32,000 psi

**Flexural Strength:**  
3,000 to 7,000 psi

**Ductility:**  
Greater capacity to deform and support flexural and tensile loads, even after initial cracking

**Abrasion Resistance:**  
Similar to natural rock

**Impermeability:**  
Almost no carbonation and penetration of chlorides



## UHPC Joints in Bridge Deck

- Full moment transfer – no post tensioning required
- Only 6 inches wide–high strength; low permeability

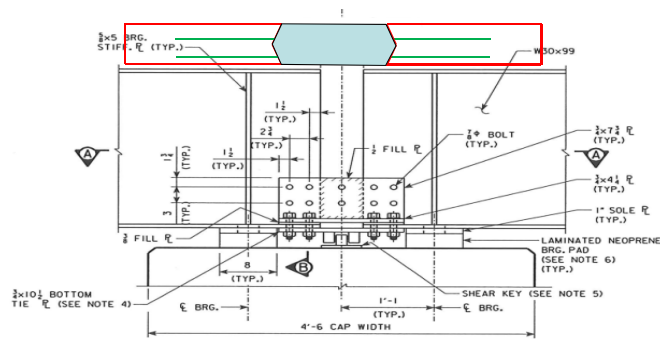




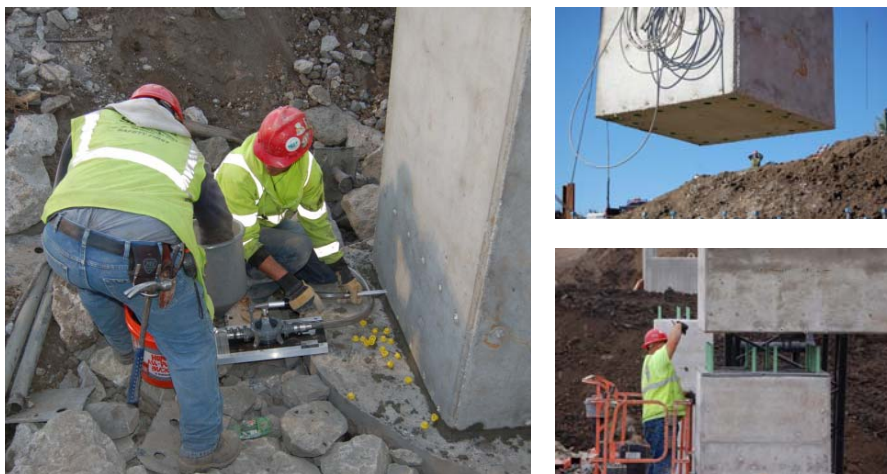
## Transverse UHPC Joints in Deck at Pier

### Iowa State Univ. Lab Tests

- Simple for DL; Continuous for LL
- UHPC joint reinforced to carry the full LL tension
- First use on the Keg Creek Bridge replacement, Iowa

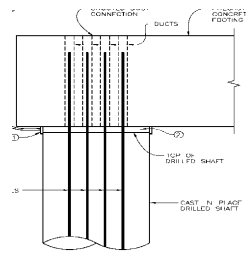
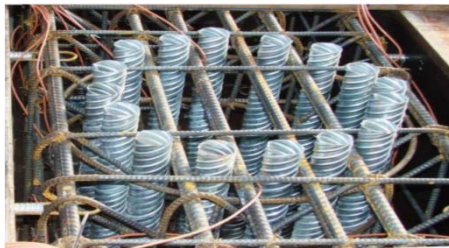
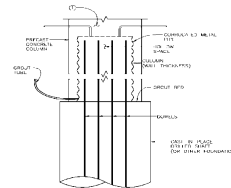
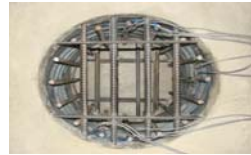


## Grouted Splice Sleeve Couplers --- Substructure



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## Cap Pockets & Grouted Ducts for Precast Piers



Suitable for moderate seismic regions

## Sample ABC Design Calculations

### Three design examples for prefabricated systems

- Modular Decked Beams
- Decked Precast Prestressed Girder
- Precast Pier

### Stages for design are demonstrated

- Prefabrication Stage (many support options)
- Erection Stage (many lift options)
- Final Stage (Modules are assembled on site)

## Recommend LRFD Specs for ABC

### Address impediments in LRFD Specs to ABC implementation:

- Loads and load combinations for ABC
- Construction load cases, erection stresses
- Dynamic allowance
- Design of connections
- Design responsibility --- EOR / contractor's engineer
- Prefabrication tolerances, quality, rideability
- Limits on deformations during placement

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## ABC Construction Specifications

Recommended Special Requirements for ABC Construction

### PROPOSED SECTION IN LRFD CONSTRUCTION SPECIFICATIONS

- |                        |                                            |
|------------------------|--------------------------------------------|
| Xx.1 General           | Xx.7 Handling, Storing, and Transportation |
| Xx.2 Responsibilities  | Xx.8 Geometry Control                      |
| Xx.3 Materials         | Xx.9 Connections                           |
| Xx.4 Fabrication       | Xx.10 Erection Methods                     |
| Xx.5 Submittals        | Xx.11 Erection Procedures                  |
| Xx.6 Quality Assurance |                                            |

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## Design Guide for Slide-in Construction *Toolkit Addendum 2013*

### Components of slide-in construction

- Permanent Bridge Design
- Temporary Support System



## Components of Slide-in Construction Bridge Design

### ABC Toolkit Addendum Contents

1. Permanent bridge design
2. Temporary support system
3. Push/pull system
4. Sliding bearings
5. Sliding forces

## 1. Permanent Bridge Design

- Consideration of the how the new bridge will be slid into place.
- Transfer of vertical and lateral loads during move
- Strengthening or modifying components of the superstructure and the substructure
  - Local areas where the push/pull system will be attached,
  - Where the sliding plates and/or rollers will support the structure, and
  - Where the sliding track will be installed.

## 2. Temp Support System (falsework)

- Contractor designed system
- Anticipated load effects applied by the sliding system.
- Relative stiffness of permanent support structures (likely relatively stiff) versus stiffness of temporary support structures (likely relatively flexible).
- Anticipated deflection / settlement of the temporary system.
- Provisions for vertical adjustment of track girder
- Attach the temp support to the permanent structure for lateral restraint

### 3. Push/Pull System

- Adequate force to overcome frictional forces
- Hydraulic jacks can either push or pull the system.
- Pairs of opposing strand jacks or winches can be used
- System controls to ensure all components work together
- Displacement control during the slide to ensure that the ends of the superstructure move at the same rate
- Contingency planning in the event of equipment failure

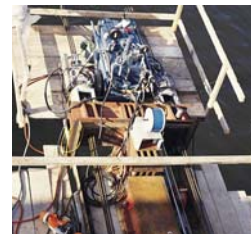
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### Movement Systems

Push/pull hydraulic jacks




Pulling with strand jacks/  
power winch

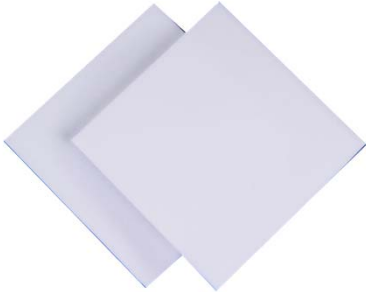


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## 4. Slide Bearings



**Roller Bearings**  
Coefficient of Friction:  
5% of Vertical Load

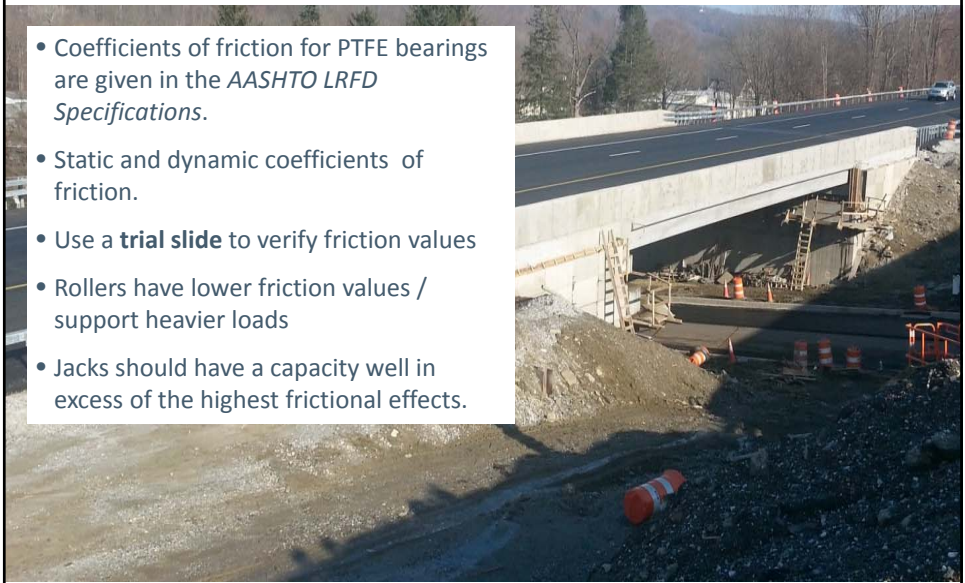


**Teflon-Coated Neoprene Bearing Pads**  
Coefficient of Friction:  
10% of Vertical Load

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## 5. Sliding Forces

- Coefficients of friction for PTFE bearings are given in the *AASHTO LRFD Specifications*.
- Static and dynamic coefficients of friction.
- Use a **trial slide** to verify friction values
- Rollers have lower friction values / support heavier loads
- Jacks should have a capacity well in excess of the highest frictional effects.



## ABC and Toolkit Training Courses



**ABC Training Courses (One Day)**

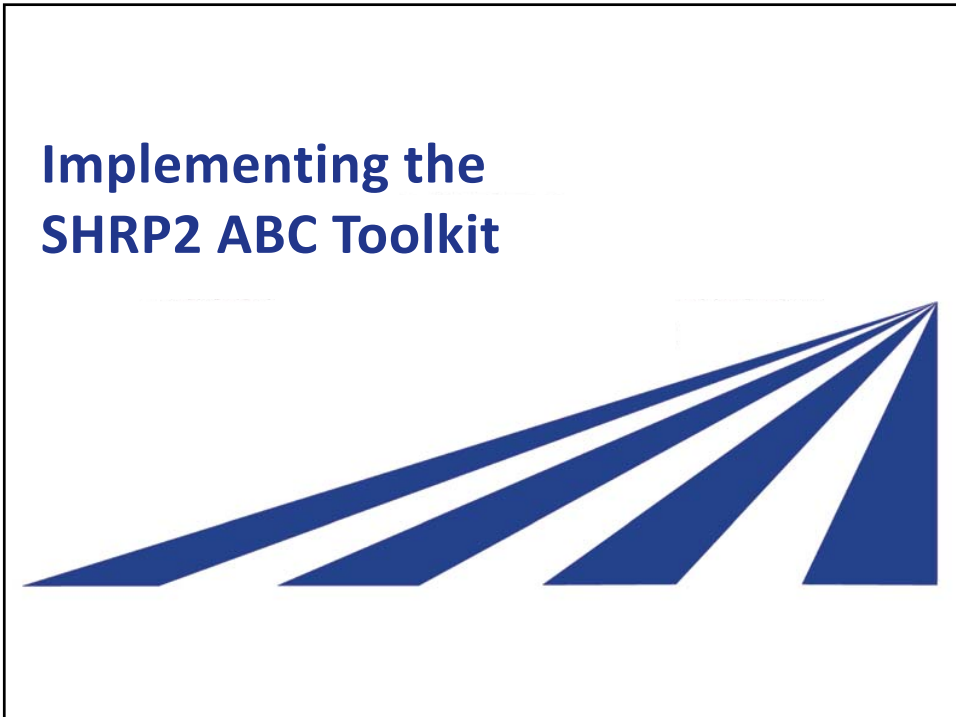
- PennDOT
- MIDOT
- MNDOT
- VTDOT
- National bridge conferences
- NYSDOT
- NJDOT
- MEDOT
- LADOTD

**National ABC Webinars**

- FIU Webinars
- FHWA Webinars

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## Implementing the SHRP2 ABC Toolkit





## Assist with ABC Implementation Apply the SHRP 2 Toolkit

**Vermont Agency of Transportation**  
Using the SHRP2 ABC Toolkit for Hurricane Irene damaged bridges  
(17 bridges replaced)



The main image shows a completed concrete bridge with a metal guardrail crossing a river. Two inset images are present: one in the top right shows a large concrete bridge component being transported on a red multi-axle trailer, and another in the middle right shows a bridge under construction with a steel truss structure.

## First Demonstration Project -- 14 Day Bridge Replacement Keg Creek Bridge, Iowa

**Use of ABC Toolkit Concepts  
Developed in SHRP2 R04**

- Total prefabricated bridge
- 14 day closure
- 14 day ABC period
- Opened November 1, 2011



The main image shows a concrete bridge under construction, supported by several concrete piers. A white truck and a yellow excavator are visible on the bridge deck. The background shows a rural landscape with fields and a house.

## Rapid Replacement 2011 Keg Creek Bridge

### IowaDOT Design – Conventional Construction

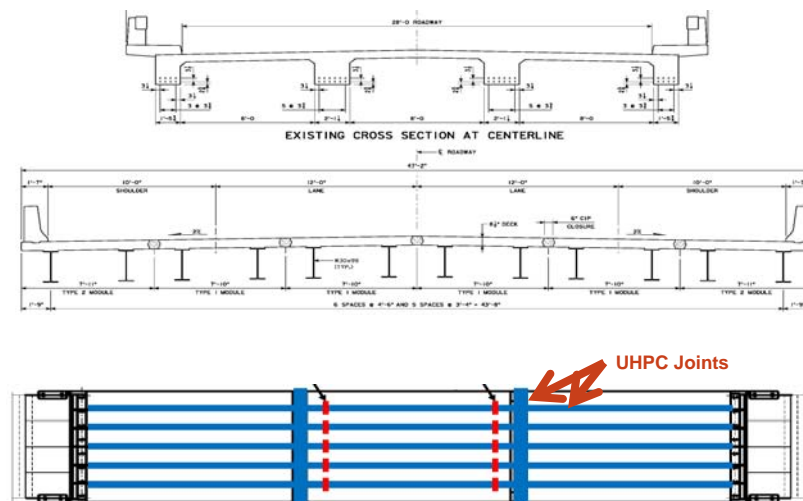
- 6-month closure
- ADT = 4000; 14 mile detour

### Redesigned for ABC by HNTB

- Modular construction
- 14 day ABC period (Road closure)
- 3 span bridge
- Jointless construction
- Predecked steel beam units



## Cross-Sections/Plan



## Bids – Keg Creek Bridge, Iowa

- Seven local bidders
- Contract letting: February 2011
- Contractor: Godbersen-Smith, Iowa
- Low bid: \$2.67 million
- Bridge cost = \$231 / SF
- Incentive / disincentive = \$ 22,000 / day during 14 day ABC period

## Prefabrication Yard Adjacent to Bridge – Iowa Bridge Farm



### Prefabrication of Abutments and Piers

52 K

93 K

168 K

### Rapid Demolition Day 1: October 17

- Completed within a single day
- Two hydraulic breakers mounted on excavators
- Crane with wrecking ball

CAT

CAT

**Precast Abutment Assembly  
Days 3 and 4**



**Precast Abutment Assembly  
Days 3 and 4**



## Precast Abutment Assembly Days 3 and 4



## Precast Pier Assembly Day 5

- Pier caps: 168 kips
- Required two 110 ton cranes to lift into place





## Semi-Integral Abutment – Suspended Backwall Days 7 and 8

- Allows superstructure expansion / contraction
- Easy fit up
- Well suited for rapid construction

## UHPC Deck Closure Pours Day 10

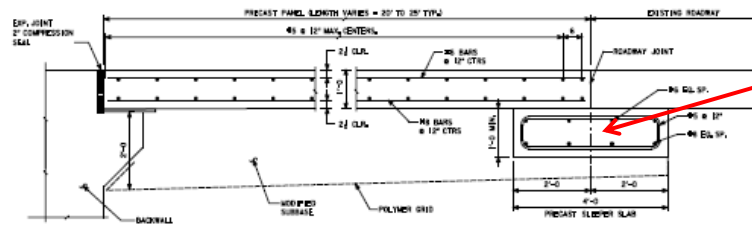
- Full moment transfer
- No post-tensioning required
- Only 6 in. wide; low-permeability
- Hairpin bars or straight bars

**Longitudinal Joint**

LONGITUDINAL CLOSURE POUR DETAIL



## Precast Approach Slab — Day 10



Precast Sleeper Slab




## Deck Riding Surface – Day 13

- No open deck joints
- Integral wearing surface --- overlay not required
- Extra ½ inch for grinding for smooth riding surface
- Longitudinal grooving for skid resistance



### Second Demonstration Project I-84 Bridges Slide-In Replacement — New York

- Weekend Replacements
- 20 Hr Closure



### NY I-84 Bridges Over Dingle Ridge Road

- Over 75,000 ADT
- 16% trucks
- Existing bridges are too narrow for cross-overs
- Elevation differences between EB & WB roadways
- Underpassing road at 16% grade



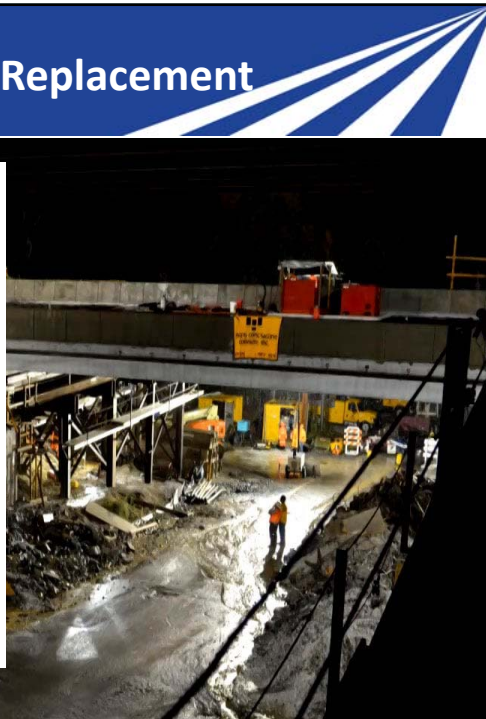
## Original Plan

- Build new temporary bridge in the median
- Build substantial cross-over roadway system due to grade differences
- Additional cost of approximately \$2.0 M
- One construction season for each bridge
- Significant traffic impact
- Planned construction duration: 2 years



## ABC Design – Slide-In Replacement

- Slide-In replacement over two weekend nights
- Traffic disruption on I-84 reduced from two years to two Saturday nights (20 hour closures).
- Incentive/disincentive clause: \$10,000 per hour for early or late completion (\$50K max incentive)
- Eliminates need for a temporary bridge and cross-overs – over; \$2M savings (\$2M HFL funds)
- Both slides completed within 10 months after NTP

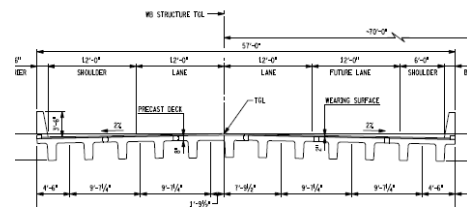
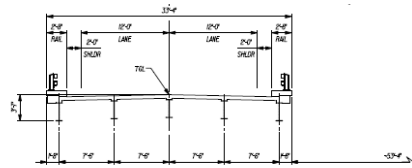


## Slide-In Construction NY I-84 Twin Bridges



## Superstructure Sections

- NEXT (Double Tee) beams
- Precast approach slabs
- UHPC closure pour

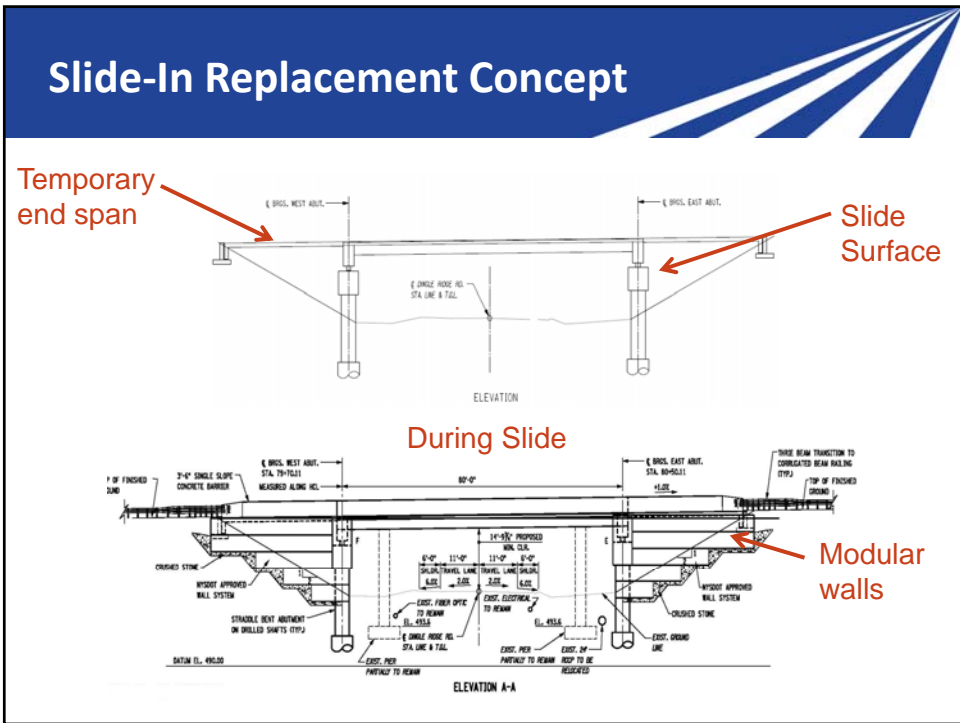
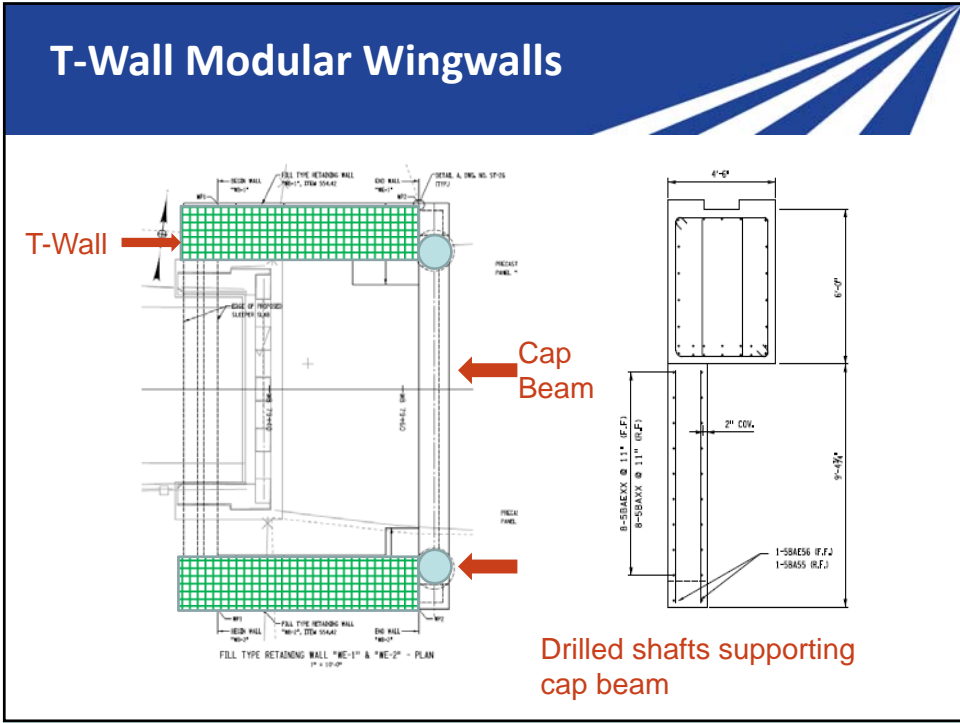


## Abutment Construction -- Drilled Shafts Outside Existing Footprint

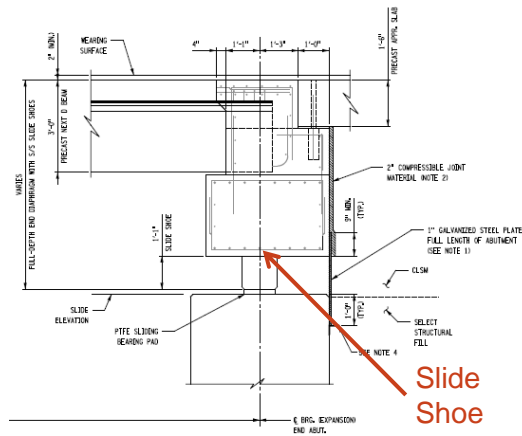


## New Straddle Bent Abutment



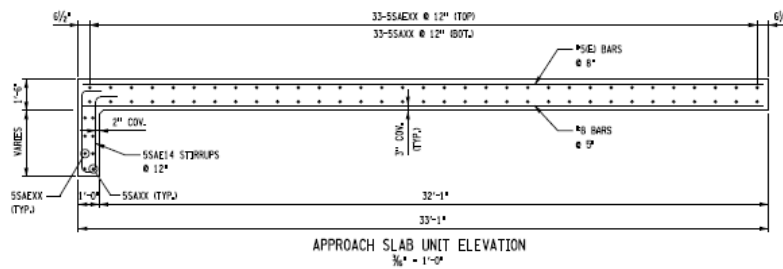


## End Diaphragm and Slide Shoe

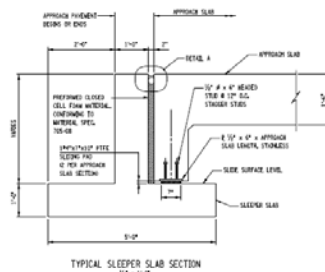


Slide Shoe

## Precast Approach Slabs -- Temporary End Spans Carrying



APPROACH SLAB UNIT ELEVATION  
3/8" ± 1'-0"



## Bridge Slide – October 21, 2013

7 hours to demolish existing bridge and slide in new bridge



## Both Bridge Slides Completed 10 Months After NTP





