


SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Innovative Bridge Designs for Rapid Renewal

ABC Toolkit

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November 17, 2015

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

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

SHRP2 Project R04 – Making ABC Standard Practice

Innovative Bridge Designs for Rapid Renewal

2007 – 2013

HNTB – Prime

Iowa State University

Genesis Structures

Structural Engineering Assoc.

Goals of SHRP2 R04

Make accelerated bridge construction standard practice nationally

Develop standardized approaches to designing and constructing ABC projects

→ Identify and overcome impediments to widespread ABC use

What has been accomplished?

- **Identified obstacles to ABC Implementation**
  - Owner/engineer/contractor surveys, interviews, review of past ABC projects
- Plan to overcome obstacles
- ABC Toolkit
- ABC Training Course
- Two ABC demonstration projects
- ABC implementation assistance

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

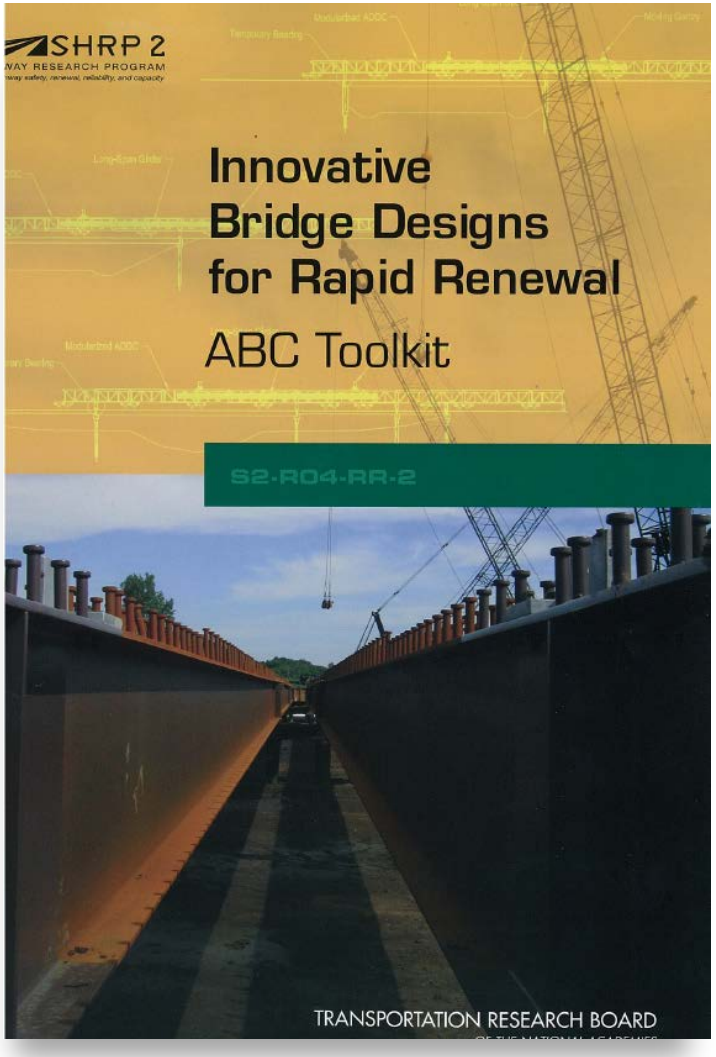
- ABC is perceived as raising the level of risk.
- Contractors concerns about the diminished profitability
- Greater outsourcing of work to precasters and specialty subcontractors.
- Contractors will be more willing to make equipment purchases if there are a greater number of ABC projects.

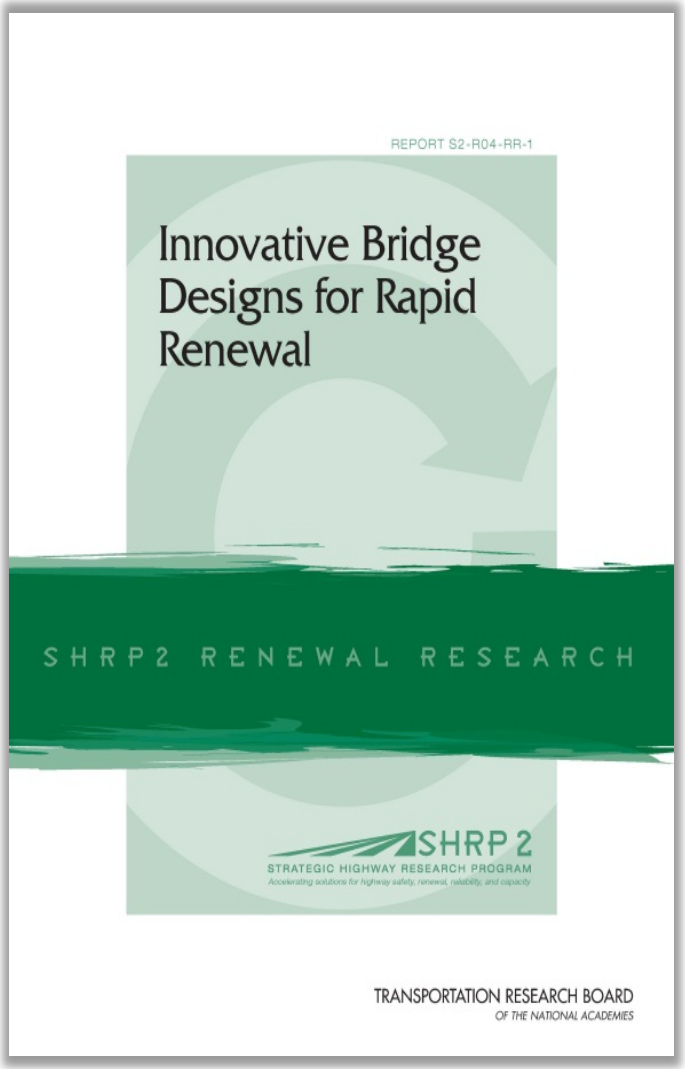
Obstacles to Implementing ABC
Engineers' Perspective

- 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.

"Engineer should 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

SHRP2 R04 ABC Toolkit Contents

1. ABC Standard Design Concepts
2. ABC Erection Concepts
3. ABC Sample Design Calculations
4. ABC Design Calculations (LRFD)
5. ABC Construction Specifications

ABC Toolkit – Benefits

ALLOWS STANDARDIZATION OF DESIGN SECTIONS

- Decks
- Superstructure
- Wingwalls
- Columns
- Footings

CAN BE BUILT BY ANY BRIDGE CONTRACTOR

- Self-perform precasting
- Can be built by local contractors

NO SPECIAL EQUIPMENT NEEDED

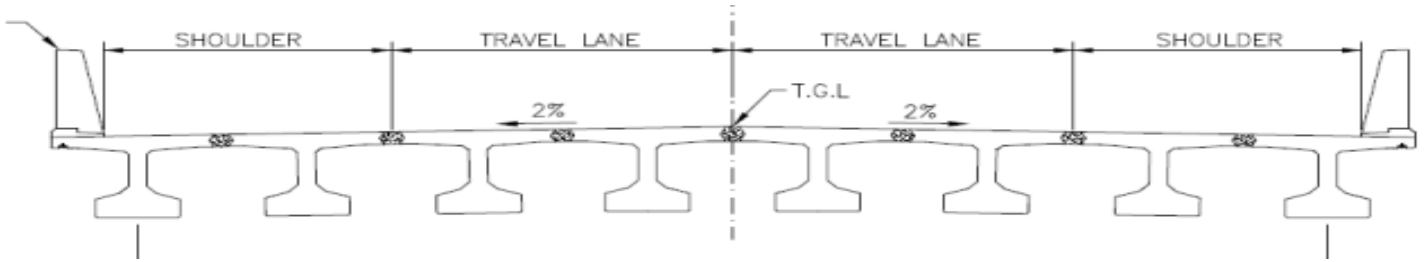
- No SPMTs
- No large gantry cranes
- No specialized contractors needed
- Onsite fabrication of bridge elements

Standard Design Concepts for PBES

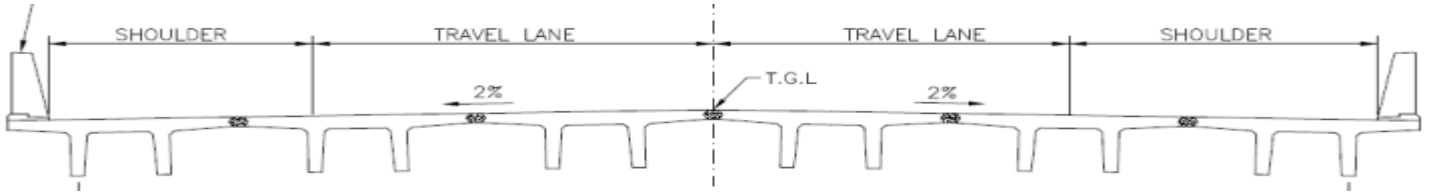
- Decked steel girders
- Decked concrete girders
- Precast abutments and wingwalls
- Precast piers
- Precast footings
- Precast approach slabs
- ABC connections

Prefabricated Decked Beam Elements

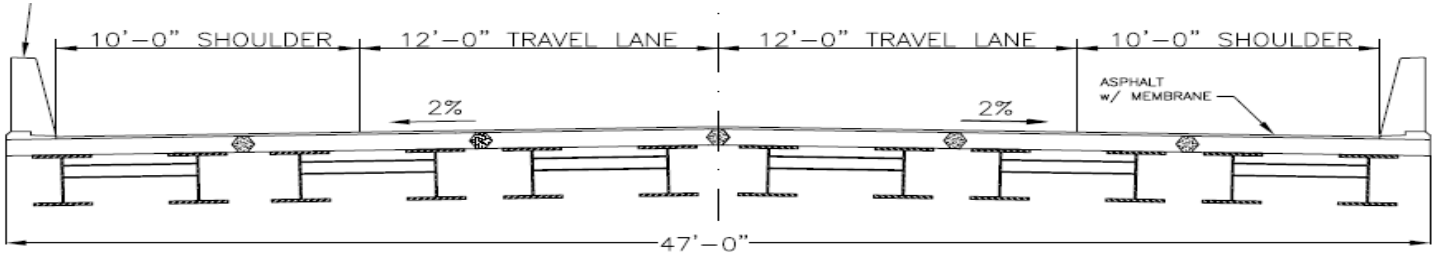
Deck Bulb Tees



Double Tees



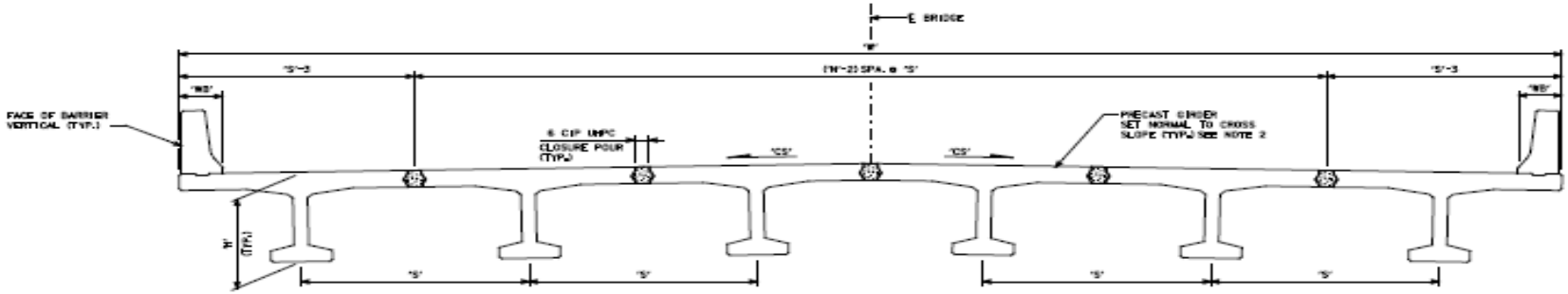
Composite Steel System



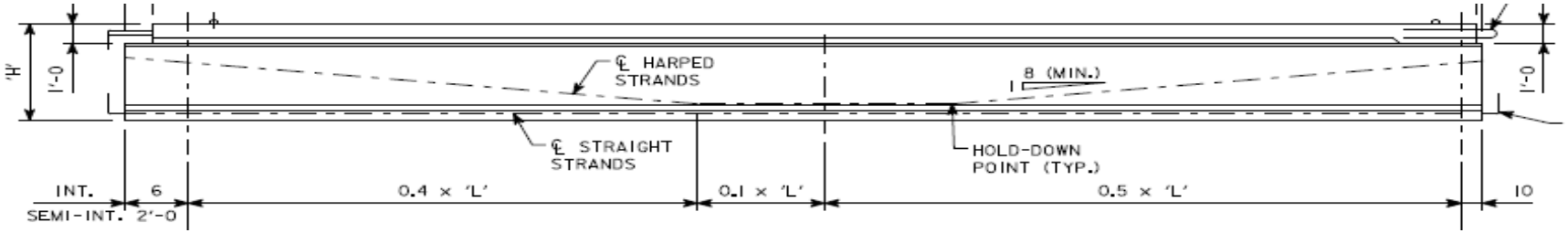
Superstructure ABC Design

- 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

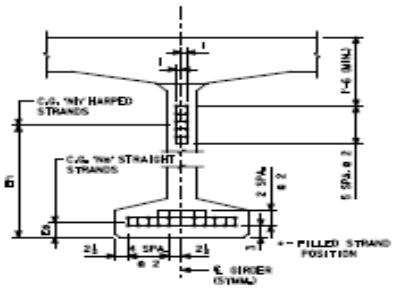


TYPICAL SECTION



EXAMPLE STRAND LAYOUT - INTERIOR GIRDER

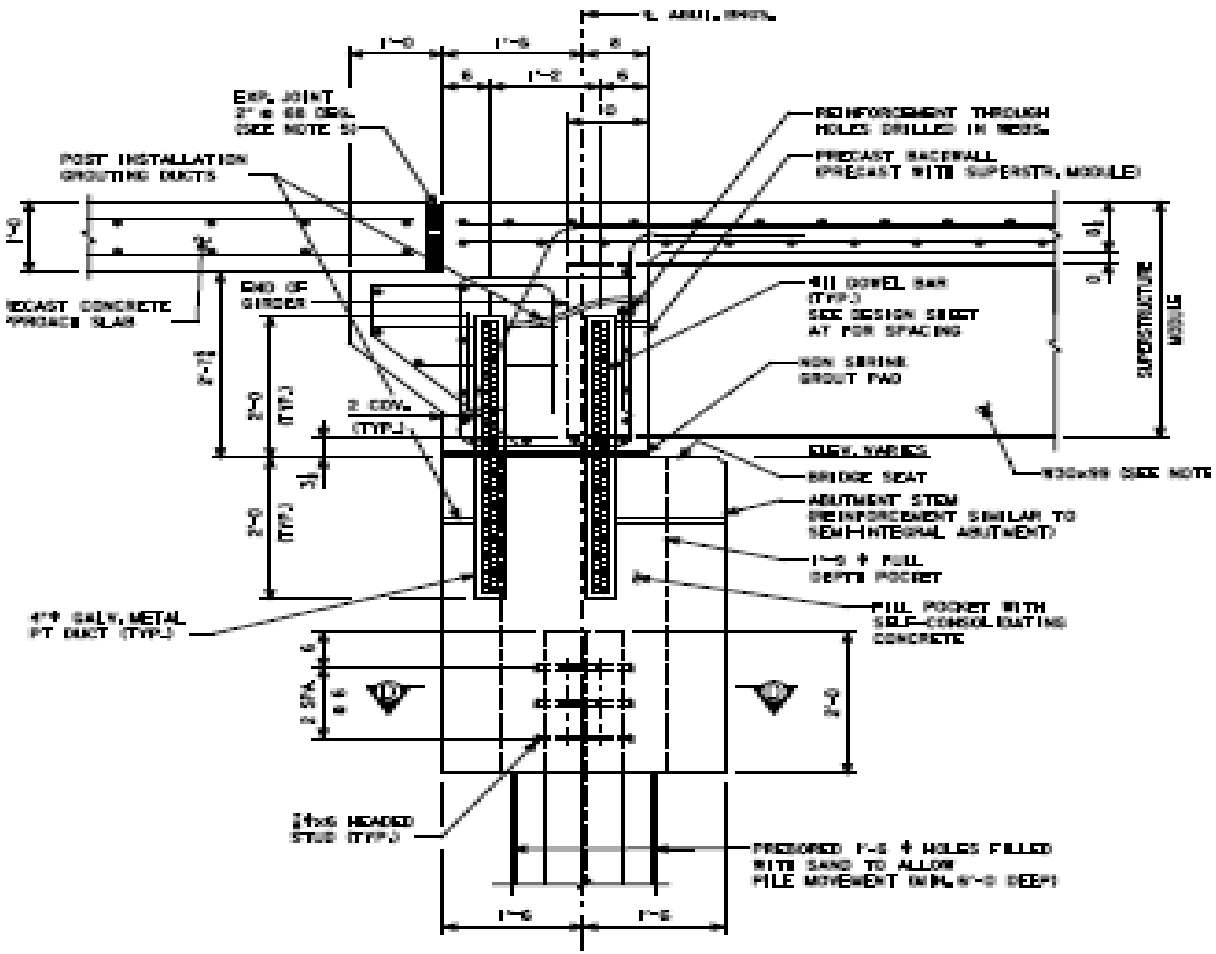
BEAM TYPE	'L' (FT)	'S' (FT)	f'c (KSI)	STRAND SIZE (IN)	STRAIGHT 'Ns'	STRAIGHT 'Es' (IN)	HARPED 'Nh'	HARPED 'Eh' (IN)	TOTAL 'N'	TOTAL 'E' (BRG.) (IN)	TOTAL 'E' (MID.) (IN)
DBT42	40	5	8	0.5	6	3.00	4	23.00	10	11.00	3.80
		8	8	0.5	6	3.00	6	22.00	12	12.50	4.00
	70	5	8	0.5	12	3.33	10	20.00	22	10.91	4.09
		8	8	0.5	16	3.75	14	18.00	30	10.40	4.33
DBT48	70	5	8	0.5	10	3.00	10	26.00	20	14.50	4.00
		8	8	0.5	14	3.57	14	24.00	28	13.79	4.29
	100	5	8	0.6	14	3.57	14	24.00	28	13.79	4.29
		7	8	0.6	16	3.75	16	23.00	32	13.38	4.38
DBT60	100	5	8	0.6	12	3.33	10	38.00	22	19.09	4.09
		8	8	0.6	14	3.57	14	36.00	28	19.79	4.29
	130	5	10	0.6	16	3.75	16	35.00	32	19.38	4.38
		7	10	0.6	24	4.50	16	35.00	40	16.70	4.70

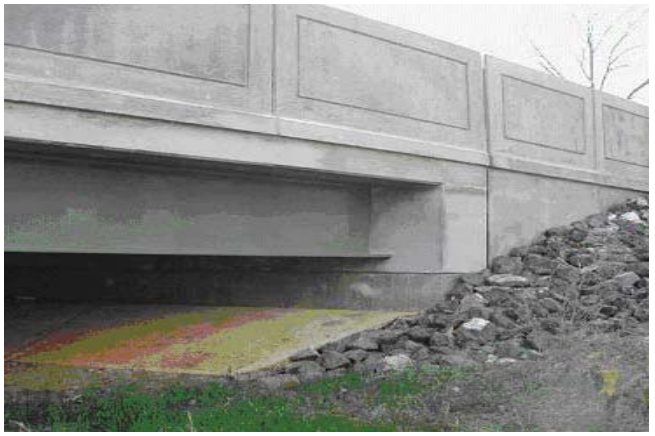


STRAND PATTERN AT ℄ BEARING

(EXAMPLE PATTERN SHOWN, SEE TABLE)

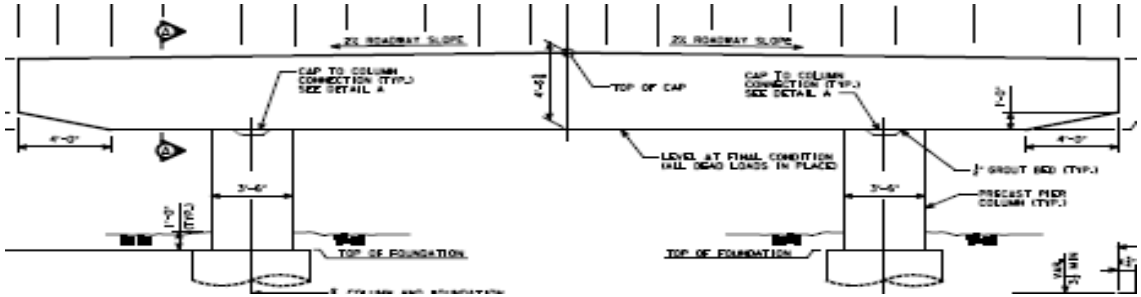
Integral Abutment



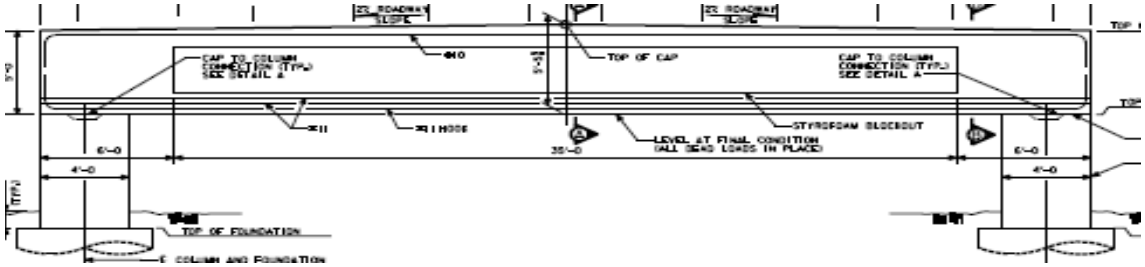


- Only one row of vertical piles
- Fast construction

Precast Piers



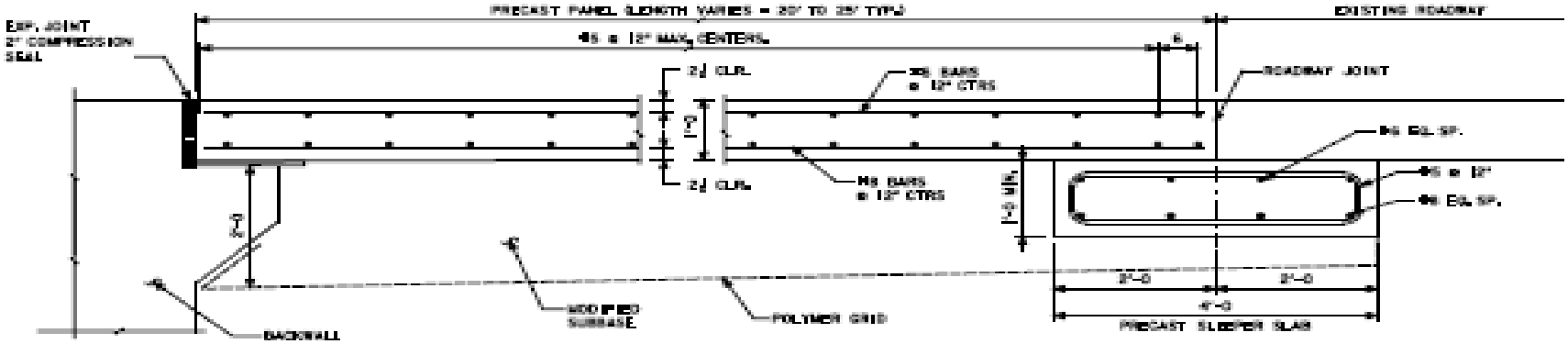
Conventional Pier



Straddle Bent

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

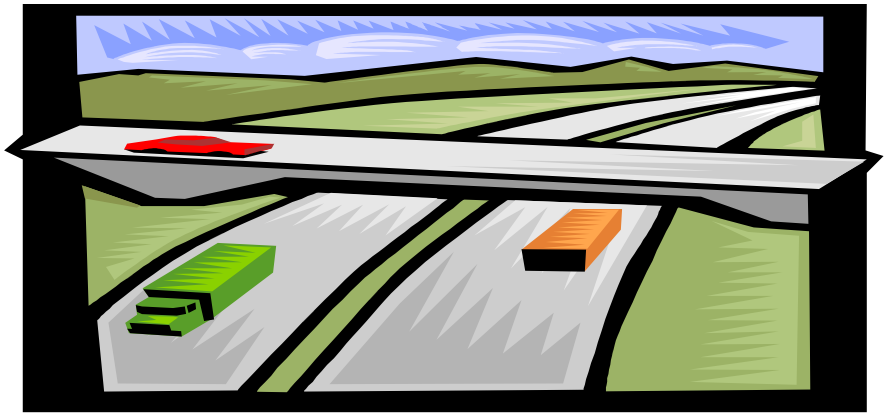
Precast Approach Slab



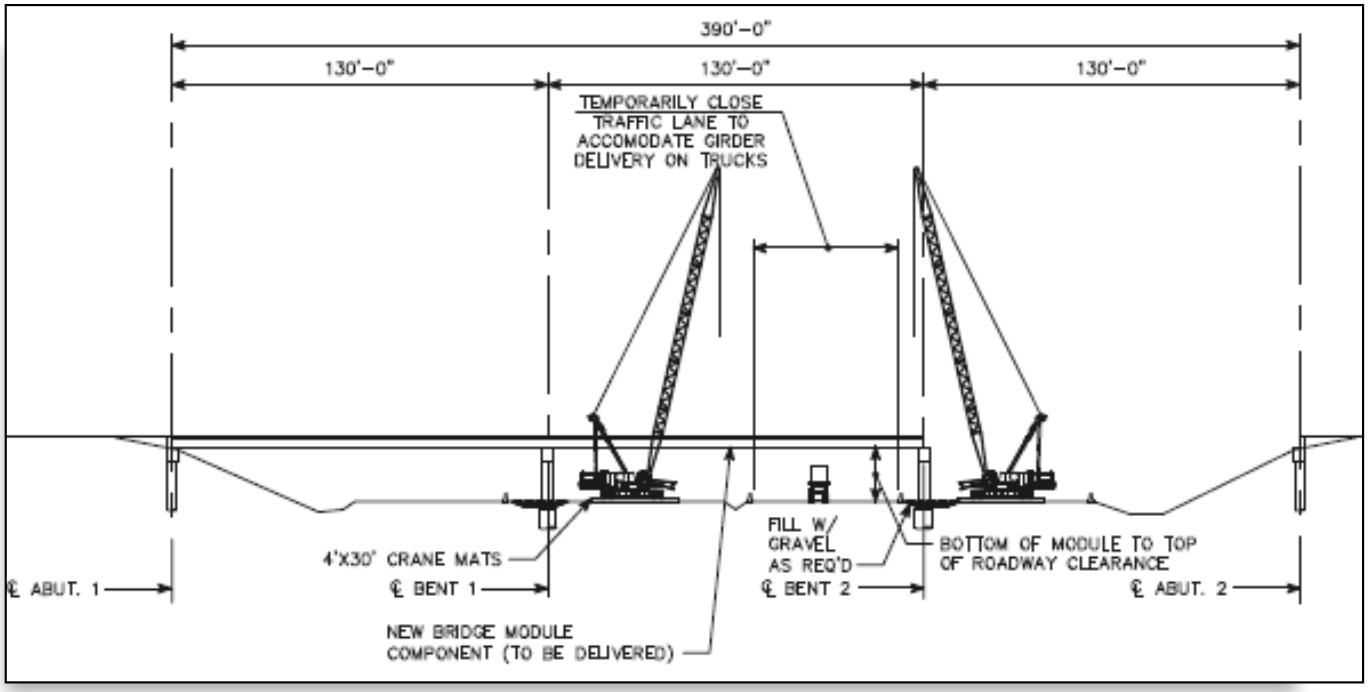
Erection Concepts for ABC

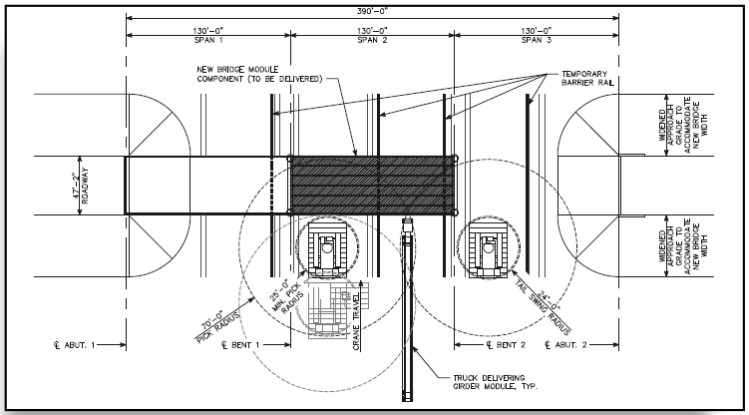
Erection methods in the *ABC Toolkit*:

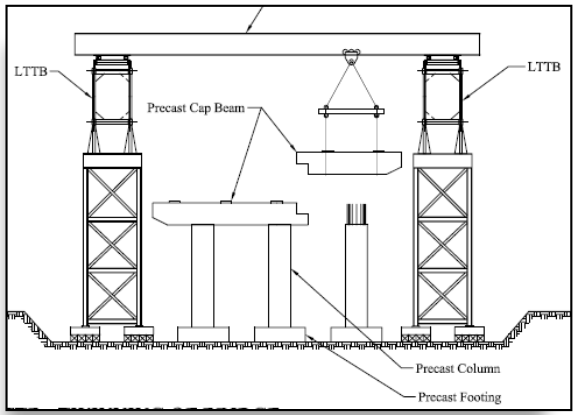
1. Erection using mobile cranes
2. Erection using gantry cranes / ABC construction technologies



Sample Erection Concepts Drawing

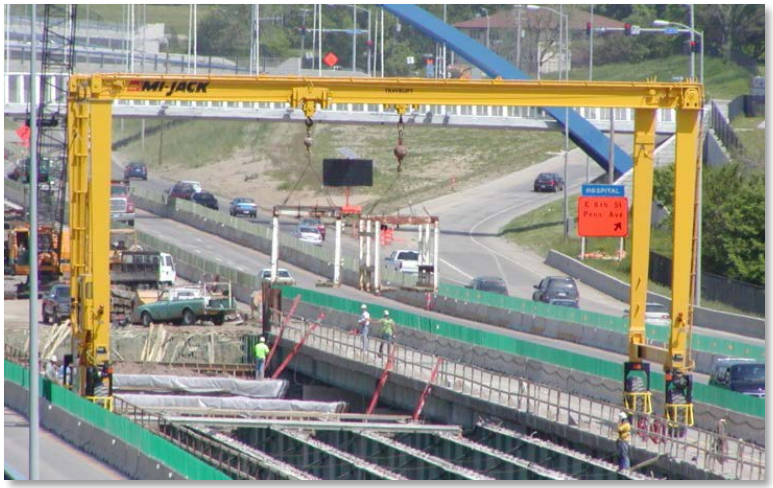






Gantry Cranes / Above Deck Driven Carriers

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

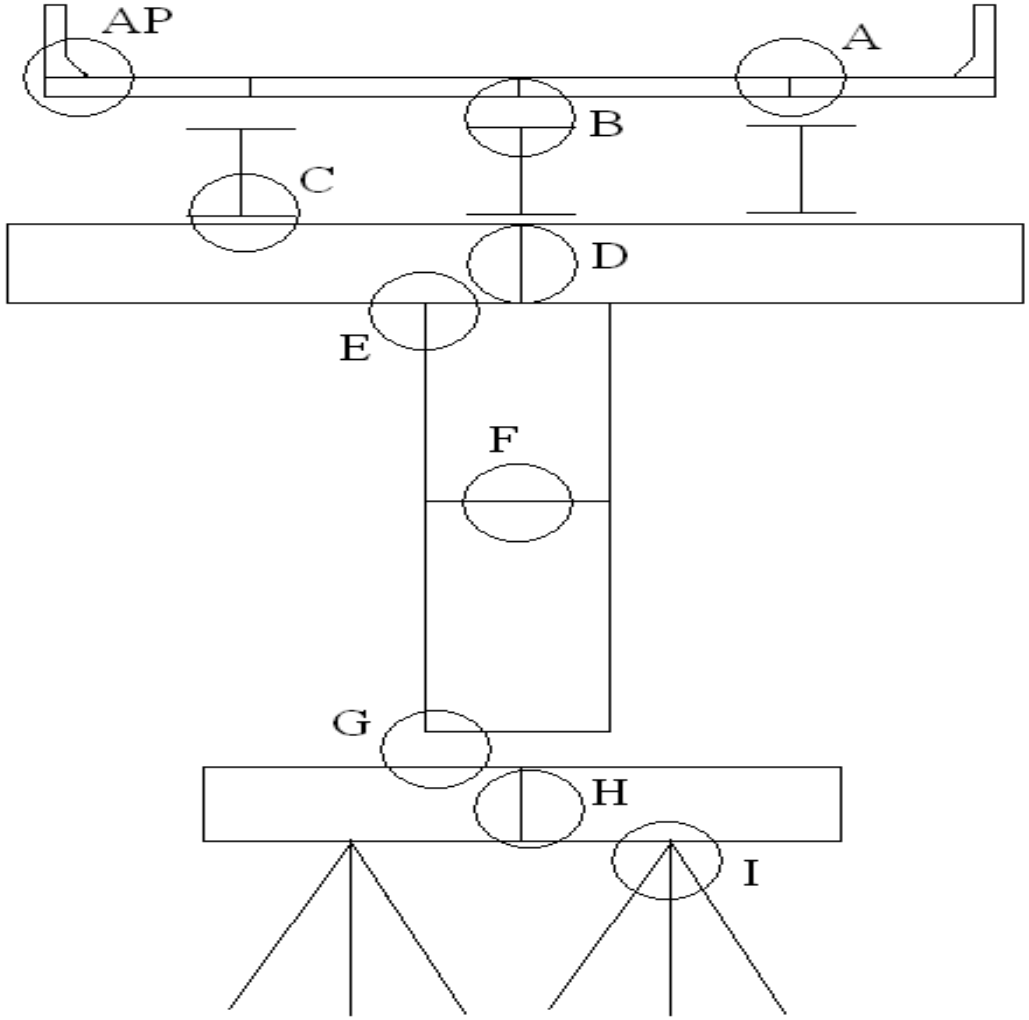


Launched Temporary Bridge

- 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.

PBES Connections

ABC Toolkit / SHRP2 R04 Report



UHPC Joints in Bridge Deck

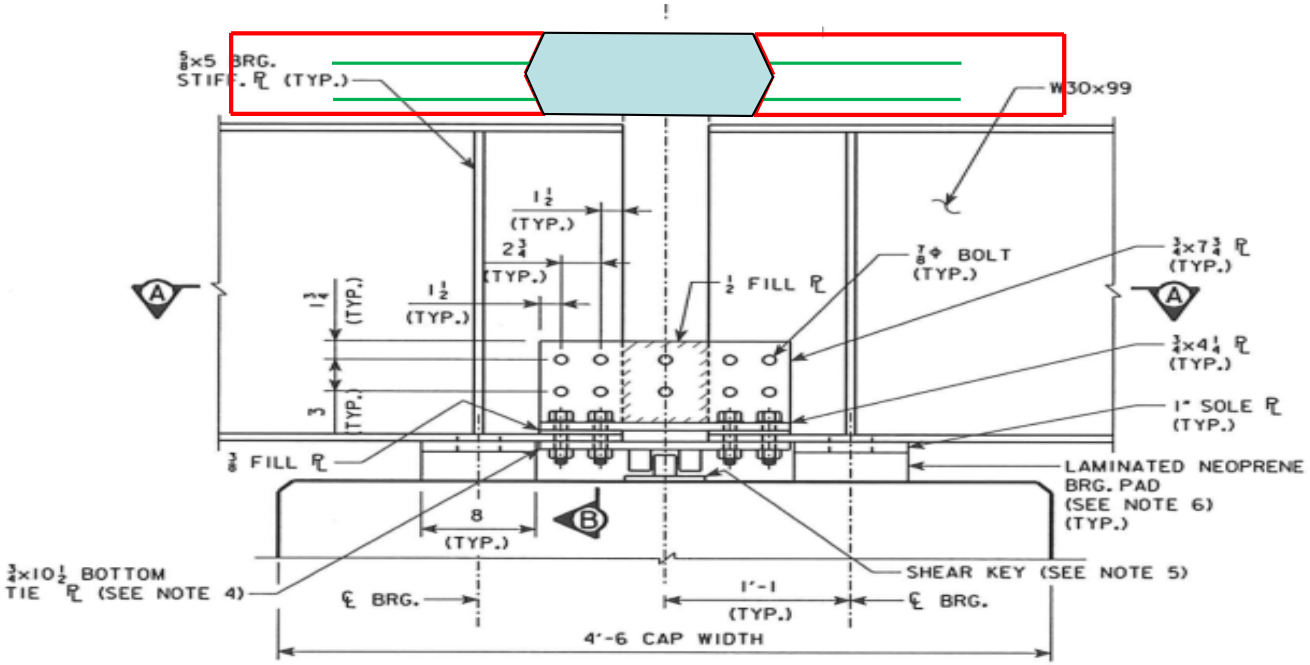
- Full moment transfer – no post tensioning required
- Only 6 inches wide– high strength; low permeability

Longitudinal Joint

Transverse UHPC Joints in Deck at Pier

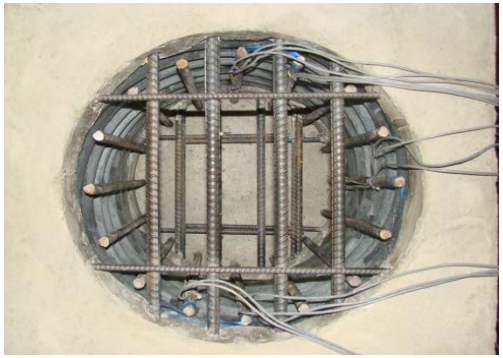
Iowa State Univ. Lab Tests

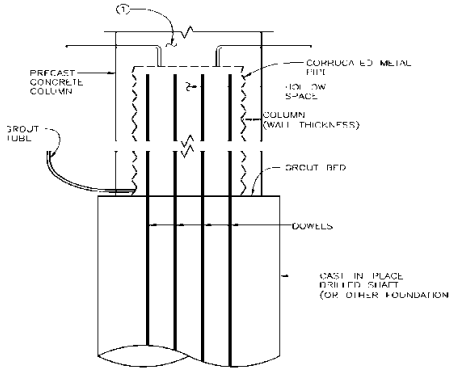
- Simple for DL; Continuous for LL
- UHPC joint reinforced to carry the full LL tension
- First use on the Keg Creek Bridge replacement, Iowa

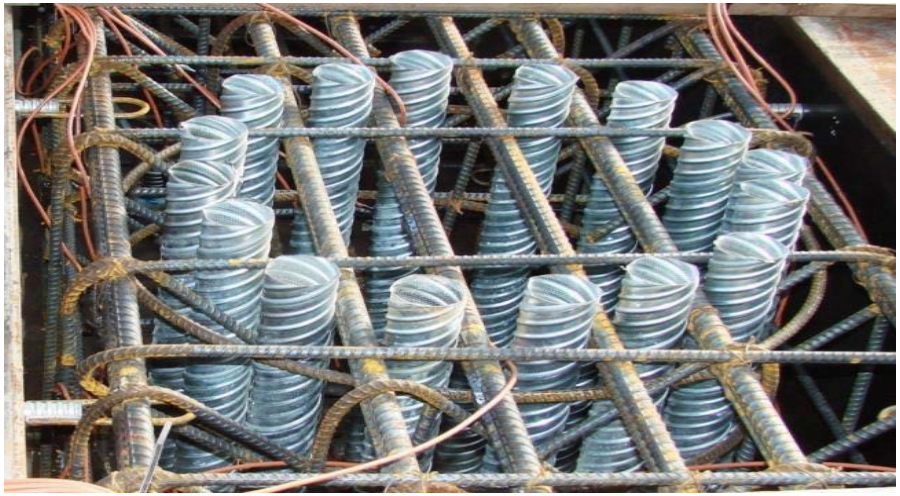


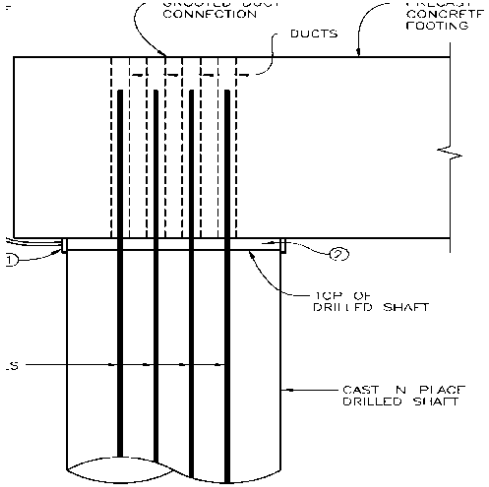
Grouted Splice Sleeve Couplers --- Substructure

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

ABC Construction Specifications

Recommended Special Requirements for ABC Construction

PROPOSED SECTION IN LRFD CONSTRUCTION SPECIFICATIONS

Xx.1 General

Xx.2 Responsibilities

Xx.3 Materials

Xx.4 Fabrication

Xx.5 Submittals

Xx.6 Quality Assurance

Xx.7 Handling, Storing, and Transportation

Xx.8 Geometry Control

Xx.9 Connections

Xx.10 Erection Methods

Xx.11 Erection Procedures

Design Guide for Slide-in Construction
Toolkit Addendum 2013

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

- 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

2. Temp Support System (falsework)

- Loads applied by the sliding system.
- Relative stiffness of permanent structures (likely relatively stiff) vs. 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
- Contractor designed system

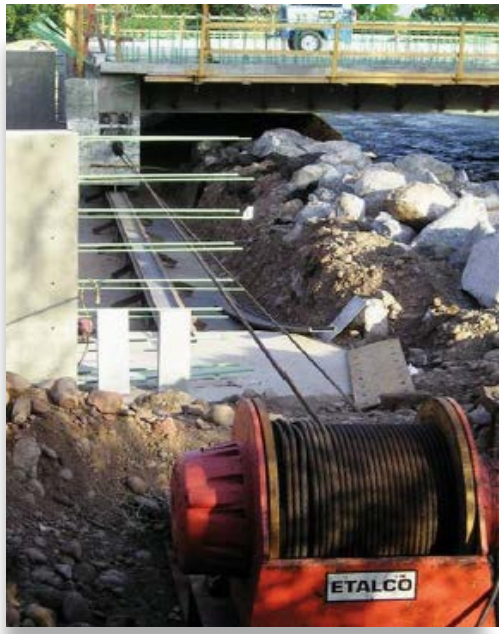
3. Push/Pull System

- 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

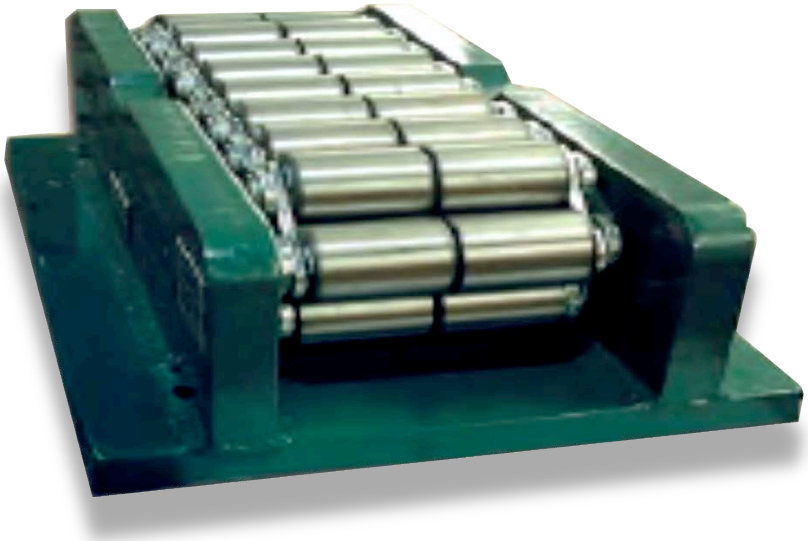
Movement Systems

Push/pull hydraulic jacks

Pulling with strand jacks/ power winch

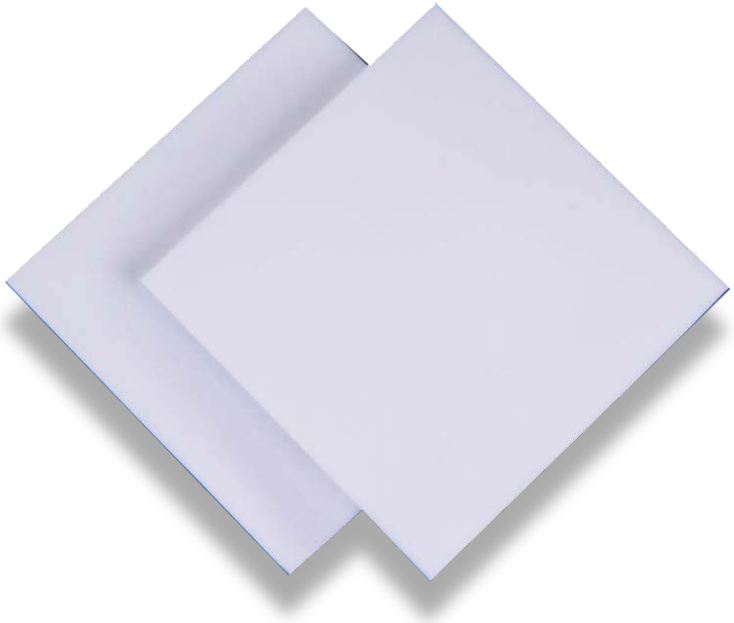


4. Slide Bearings



Roller Bearings

Coefficient of Friction:
5% of Vertical Load



Teflon-Coated Neoprene Bearing Pads

Coefficient of Friction:
10% of Vertical Load

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

ABC Essentials
Workshop at 2015 ABC Conference Miami

Implementing the SHRP2 ABC Toolkit

Assist with ABC Implementation
Apply the Tookit

Vermont Agency of Transportation

Using the SHRP2 ABC Toolkit for Hurricane Irene damaged bridges (17 bridges replaced)

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

Rapid Replacement 2011
Keg Creek Bridge

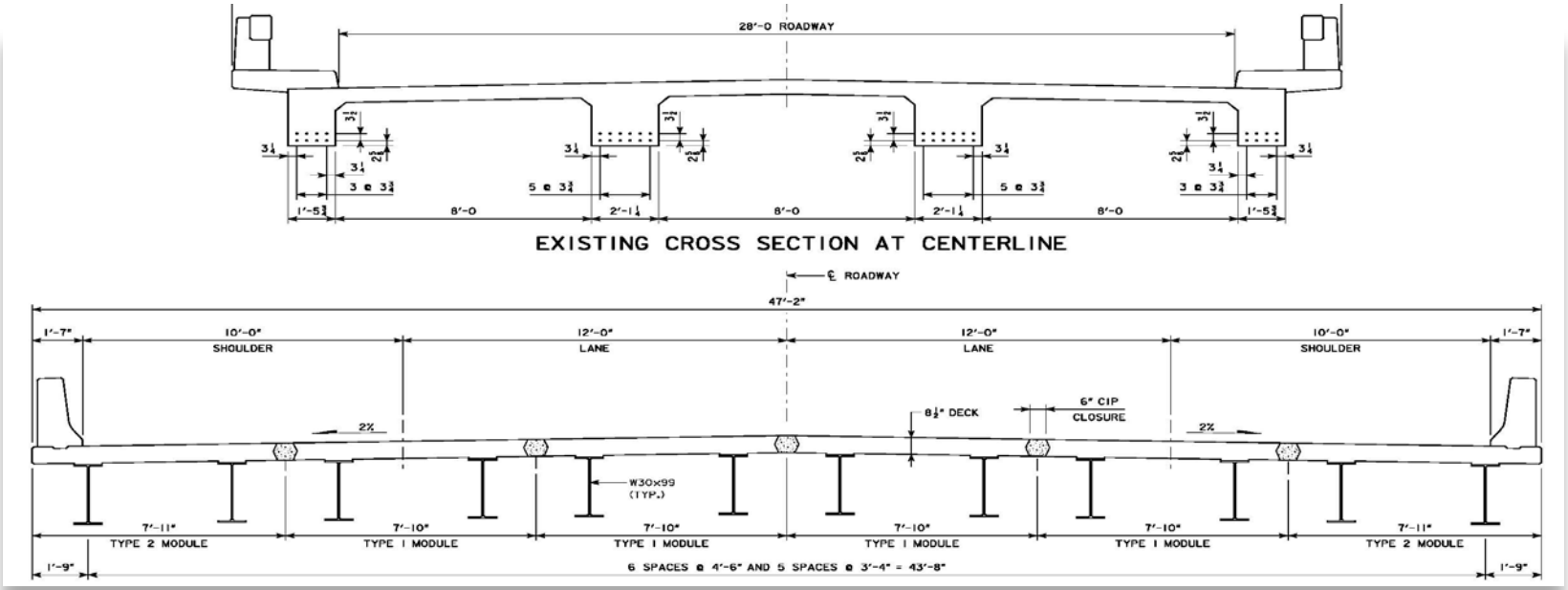
IowaDOT Design – Conventional Construction

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

Redesigned for ABC by HNTB

- Modular construction
- 14 day ABC period (Road closure)
- 3 span bridge
- Predecked steel beam units
- $ 2.6 M low bid

Cross-Sections/Plan



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

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

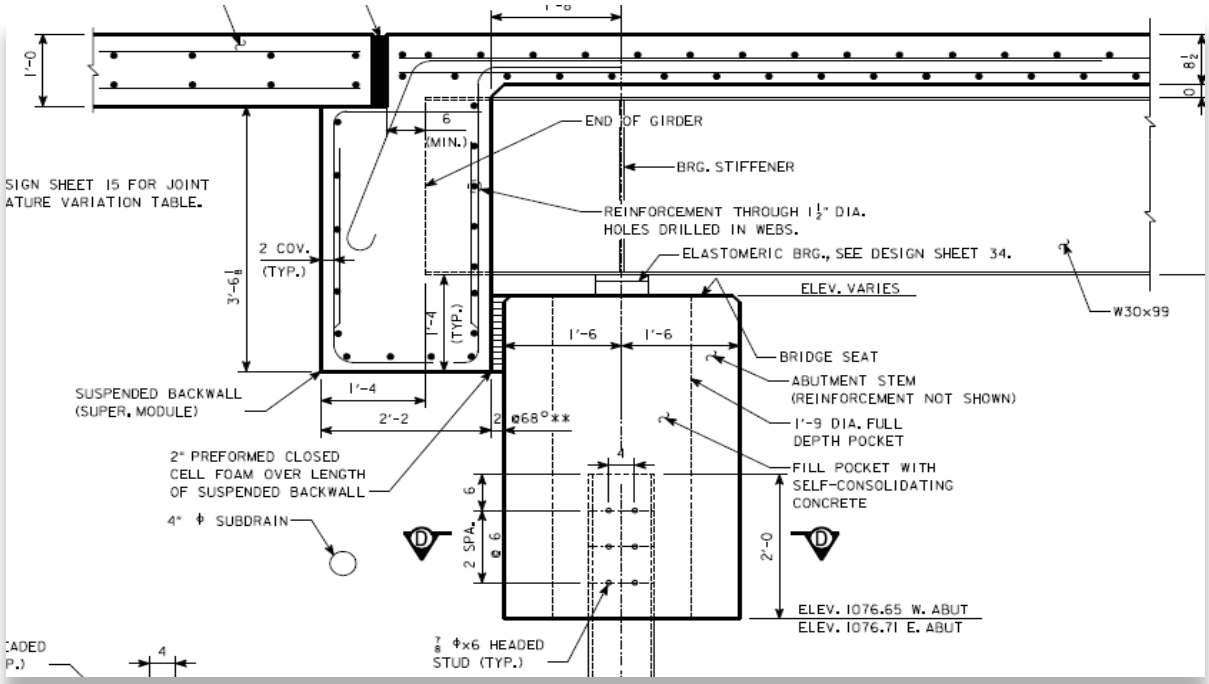
- Pier caps: 168 kips
- Required two 110 ton cranes to lift into place

Erection of Superstructure Elements Days 7 and 8

Erection of Superstructure Elements Days 7 and 8

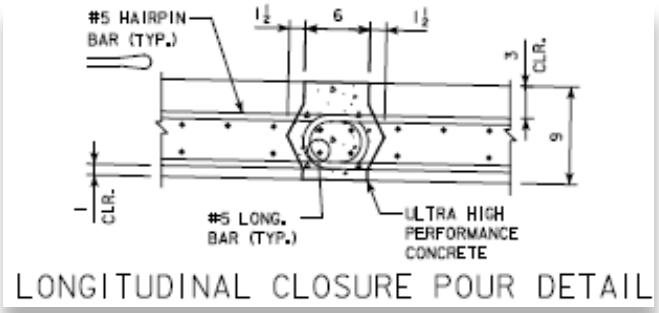
Semi-Integral Abutment – Suspended Backwall Days 7 and 8

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



UHPC Deck Closure Pours
Day 10

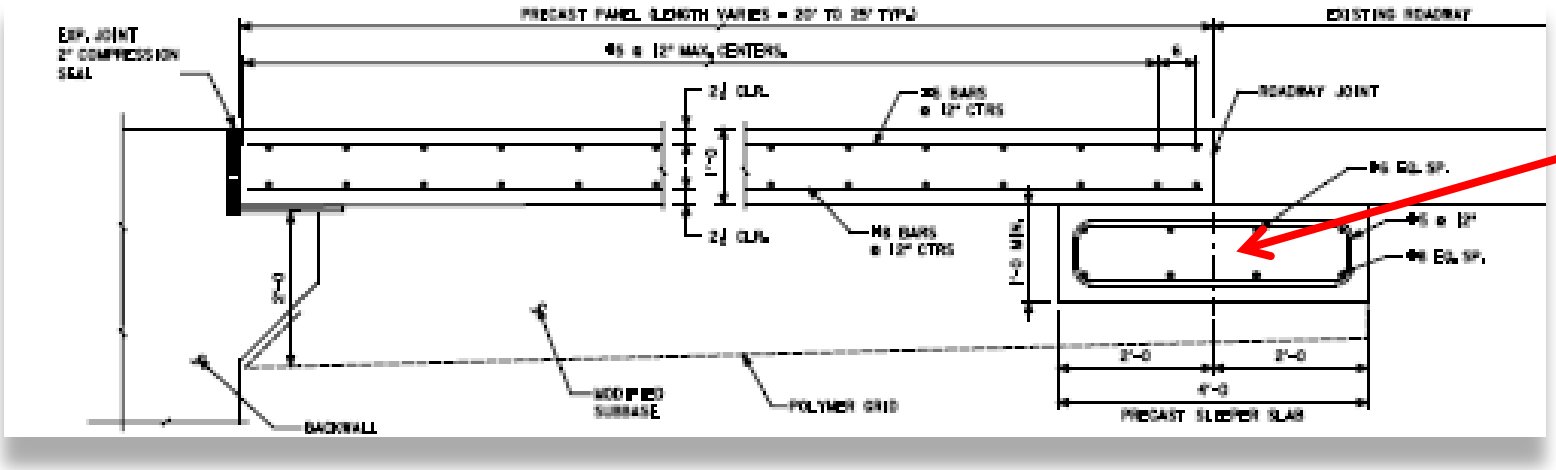
- Full moment transfer
- No post-tensioning required
- Only 6 in. wide; low-permeability
- Hairpin bars or straight bars



LONGITUDINAL CLOSURE POUR DETAIL

Longitudinal Joint

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

Deck Riding Surface – Day 13

Second Demonstration Project
I-84 Bridges Slide-In Bridge 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

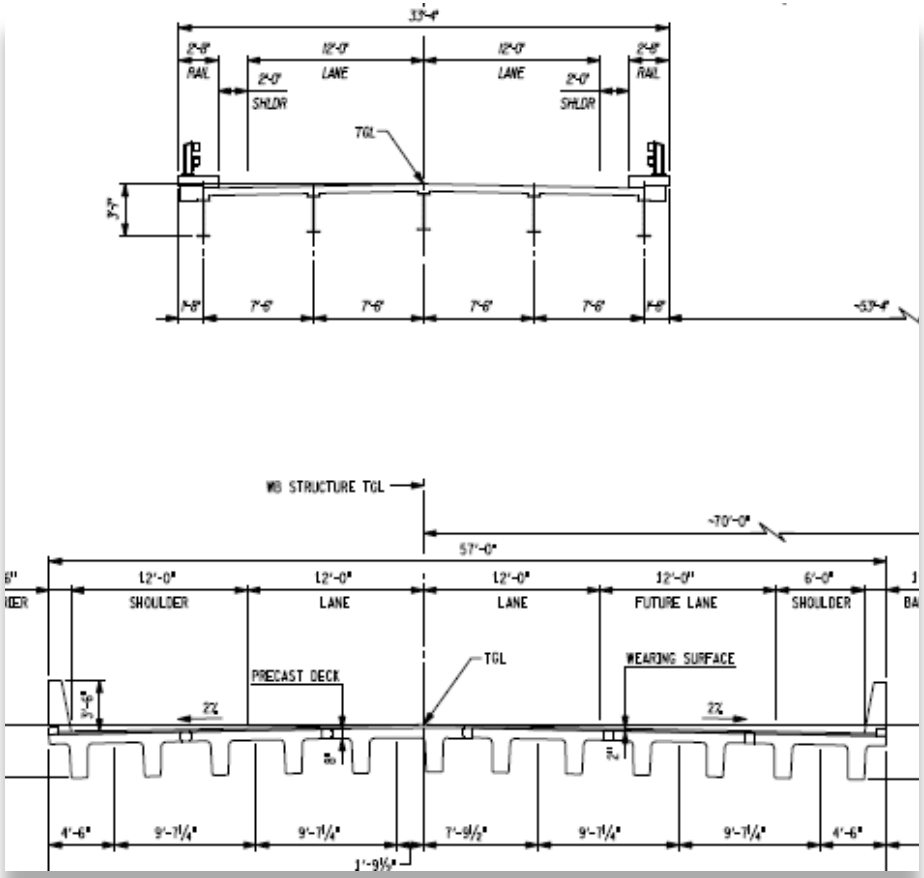
ABC Design – Slide-In Replacement

- Slide-In replacement over two weekend nights
- Two Saturday nights (20 hour closures).
- Incentive/disincentive clause: $10,000 per hour
- Eliminates temporary bridge in median : $2M savings

Slide-In Construction
NY I-84 Twin Bridges

Superstructure Sections

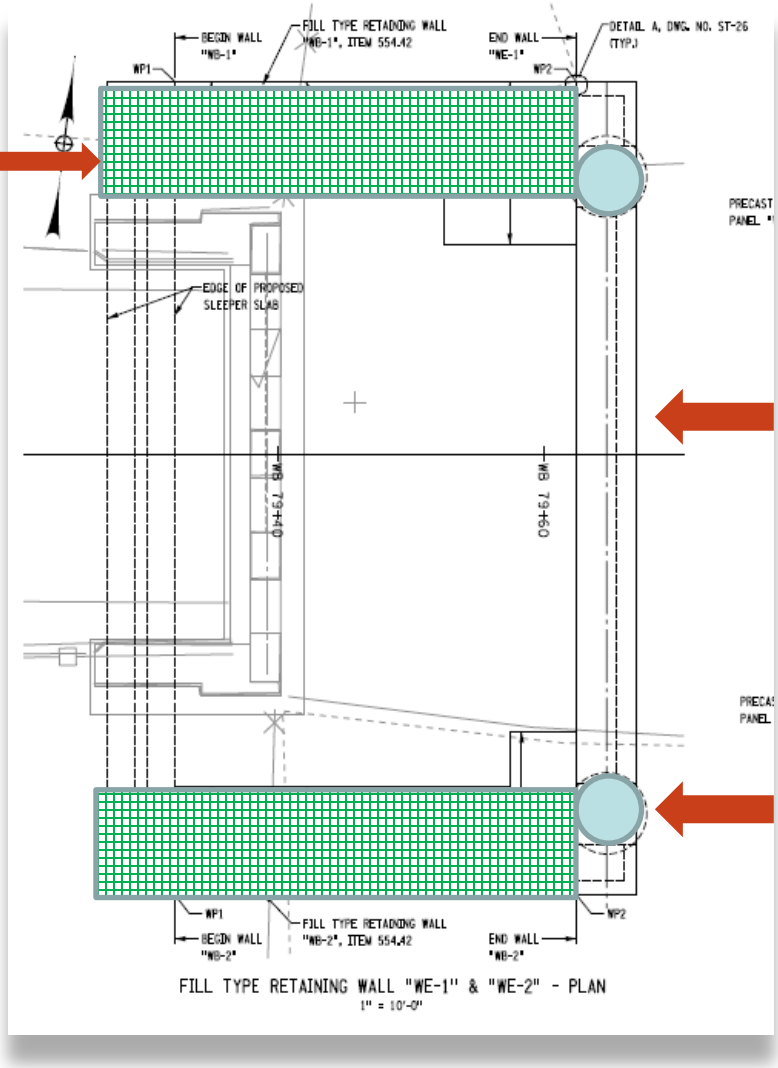
- Double Tee (NEXT) beams minimize structure depth
- Precast approach slabs
- UHPC closure pour



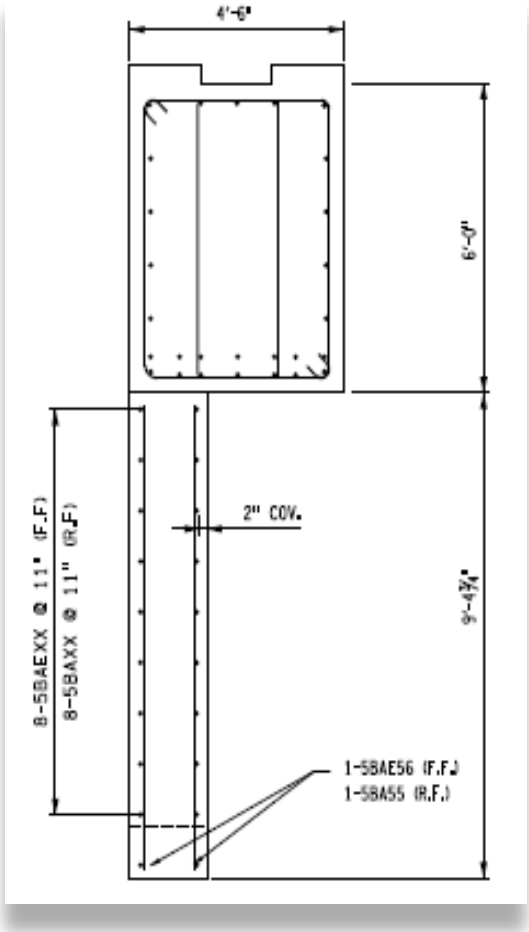
New Abutment Construction

New Straddle Bent Abutment Modular Wingwalls

T-Wall



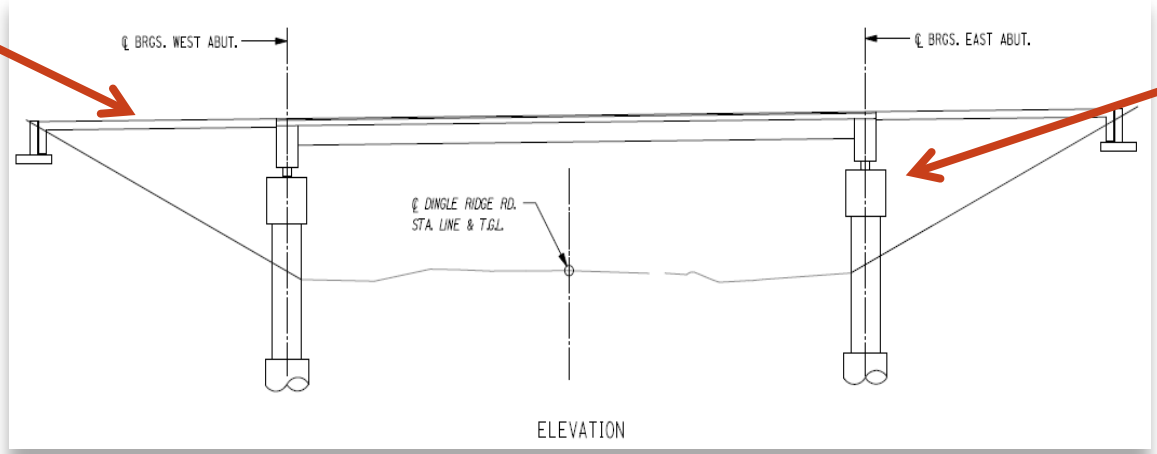
Cap Beam



Drilled shafts supporting cap beam

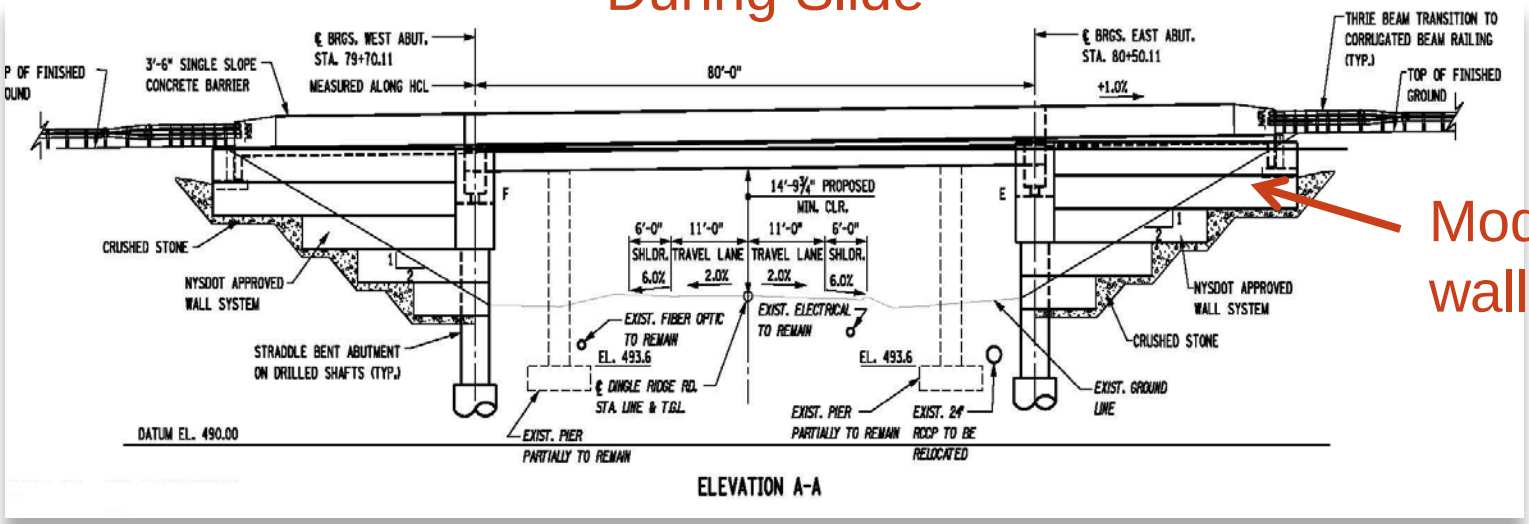
Slide-In Replacement Concept

Temporary end span



Slide Surface

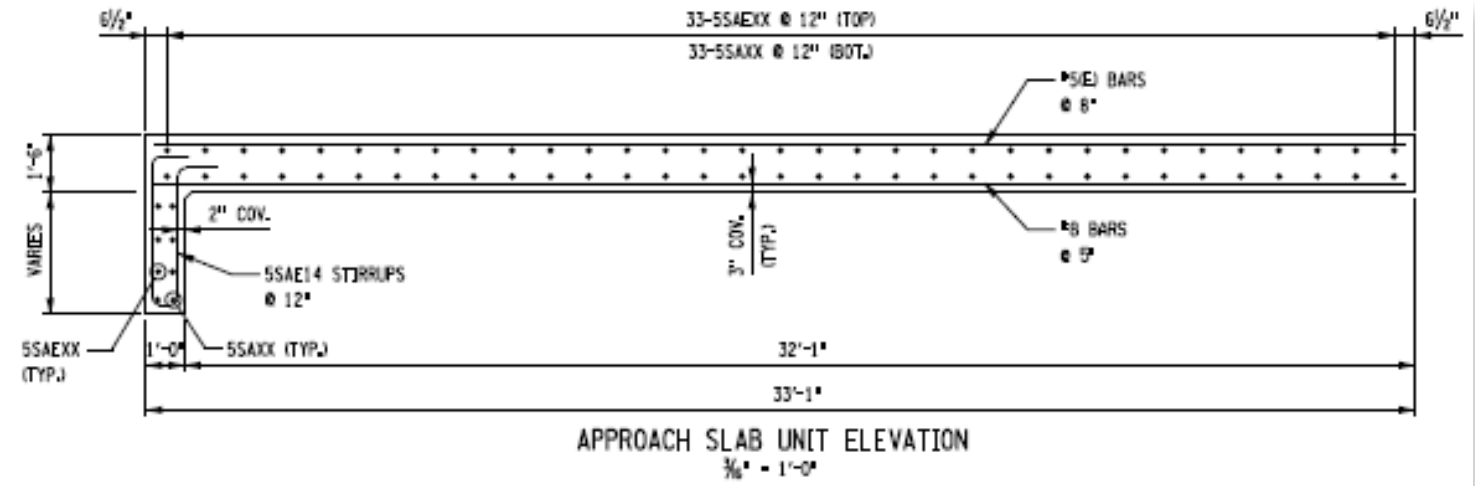
During Slide



Modular walls

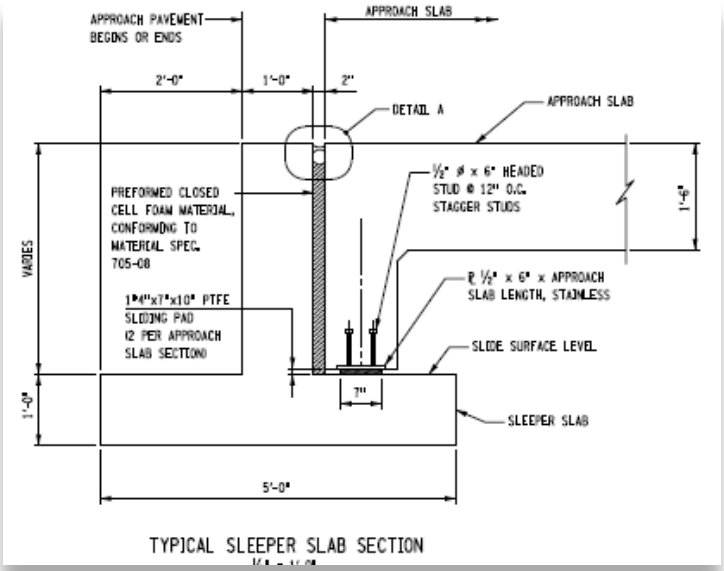
Slide Shoe

Precast Approach Slabs Temporary End Spans Carrying Traffic



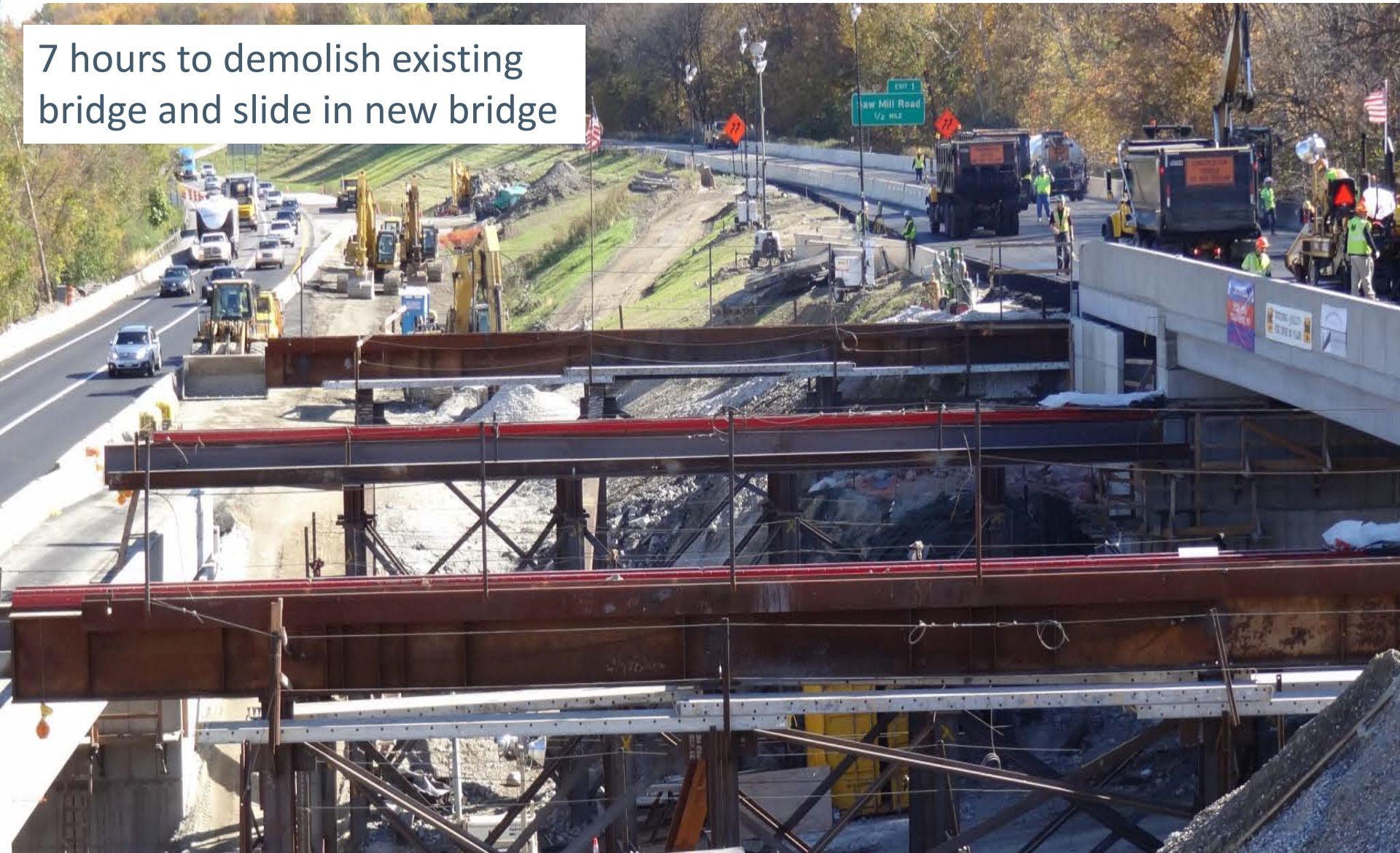
APPROACH SLAB UNIT ELEVATION

3/8" = 1'-0"



TYPICAL SLEEPER SLAB SECTION

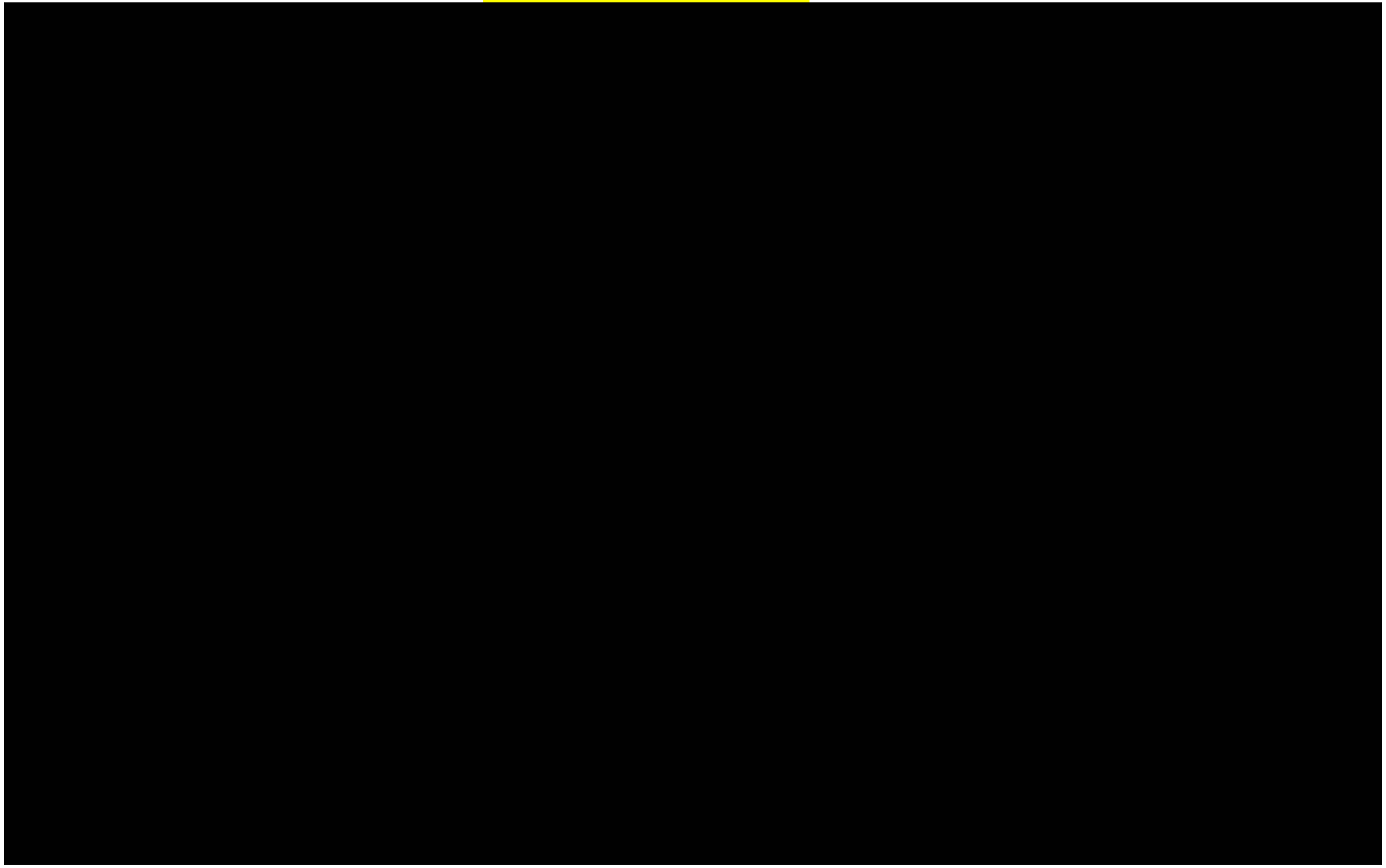
Bridge Slide – October 21, 2013



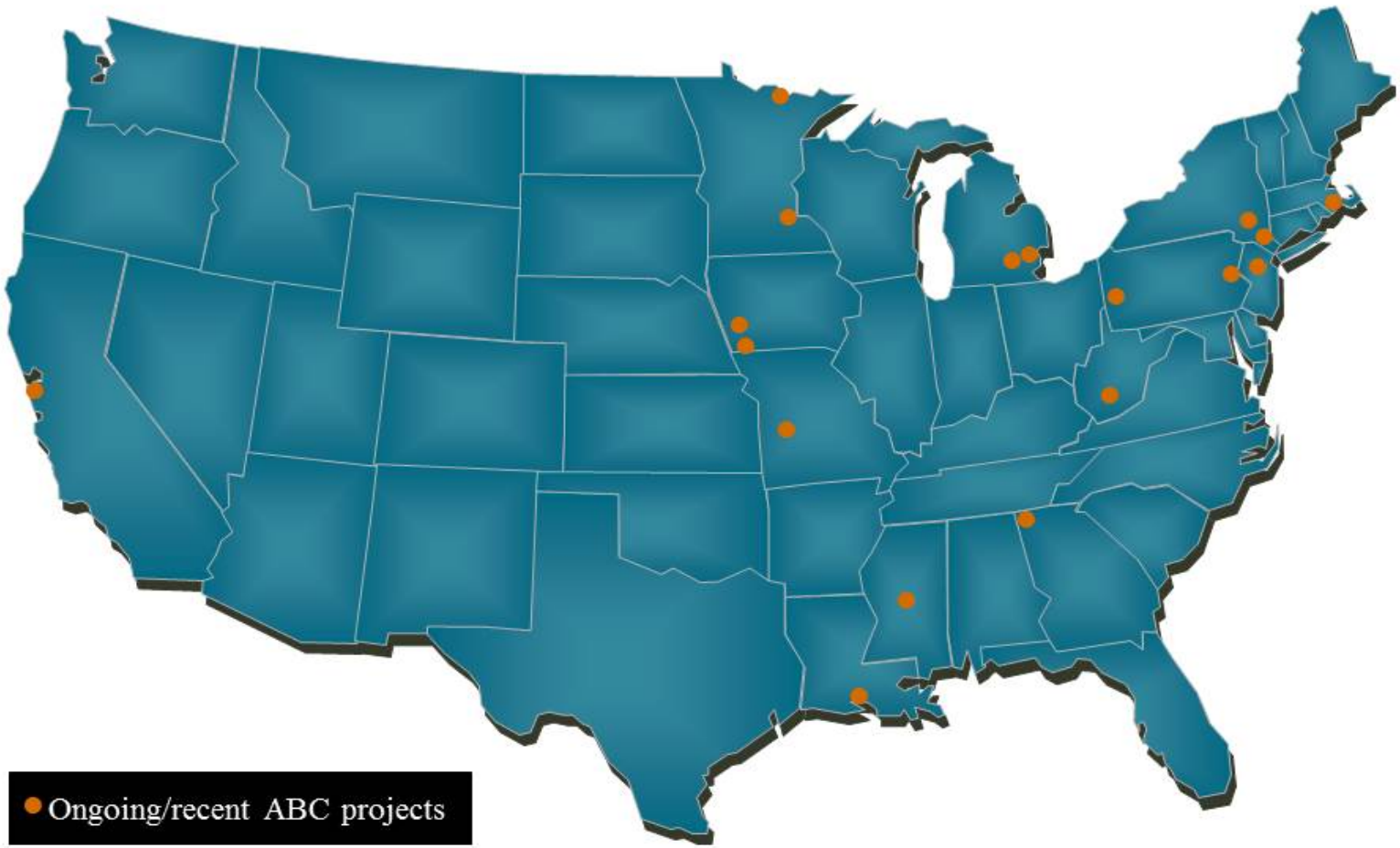
Both Bridge Slides Completed 10 Months After NTP

Publications

Time Lapse



Assisting States with ABC Implementation

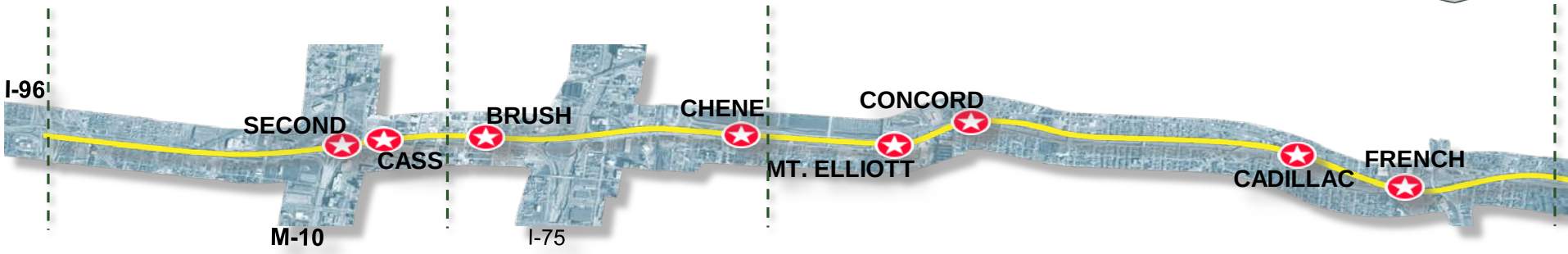


Weekend Replacement
NJDOT Rte 18 Bridge

I-94 MODERNIZATION PROJECT

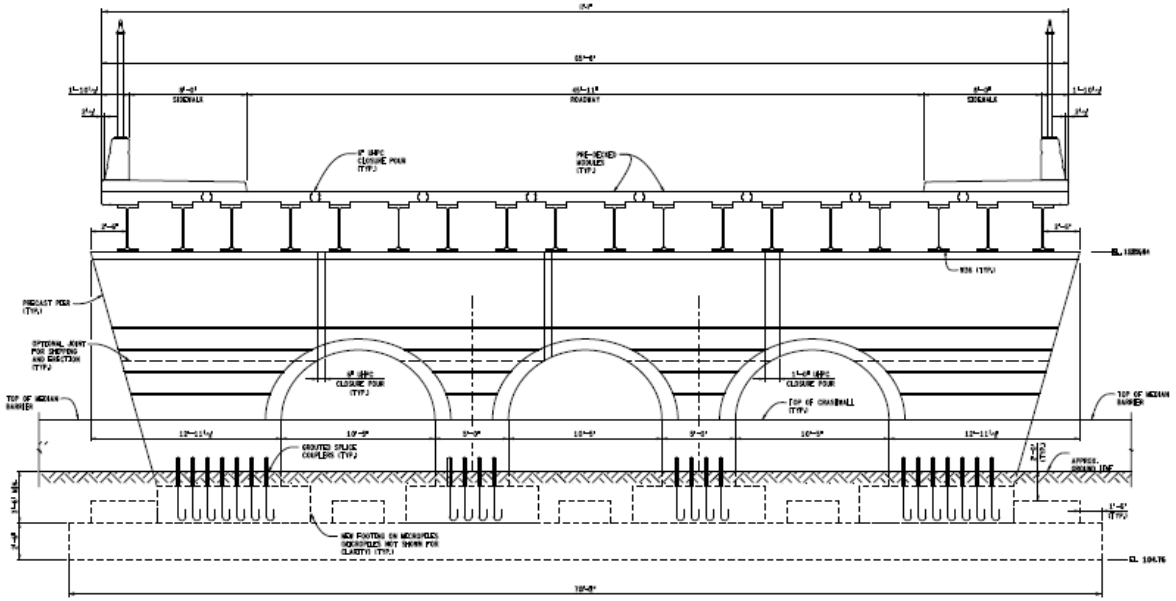
Detroit, MI

- 67 Bridges to be replaced
- ABC Solutions for 8 Advanced Bridges

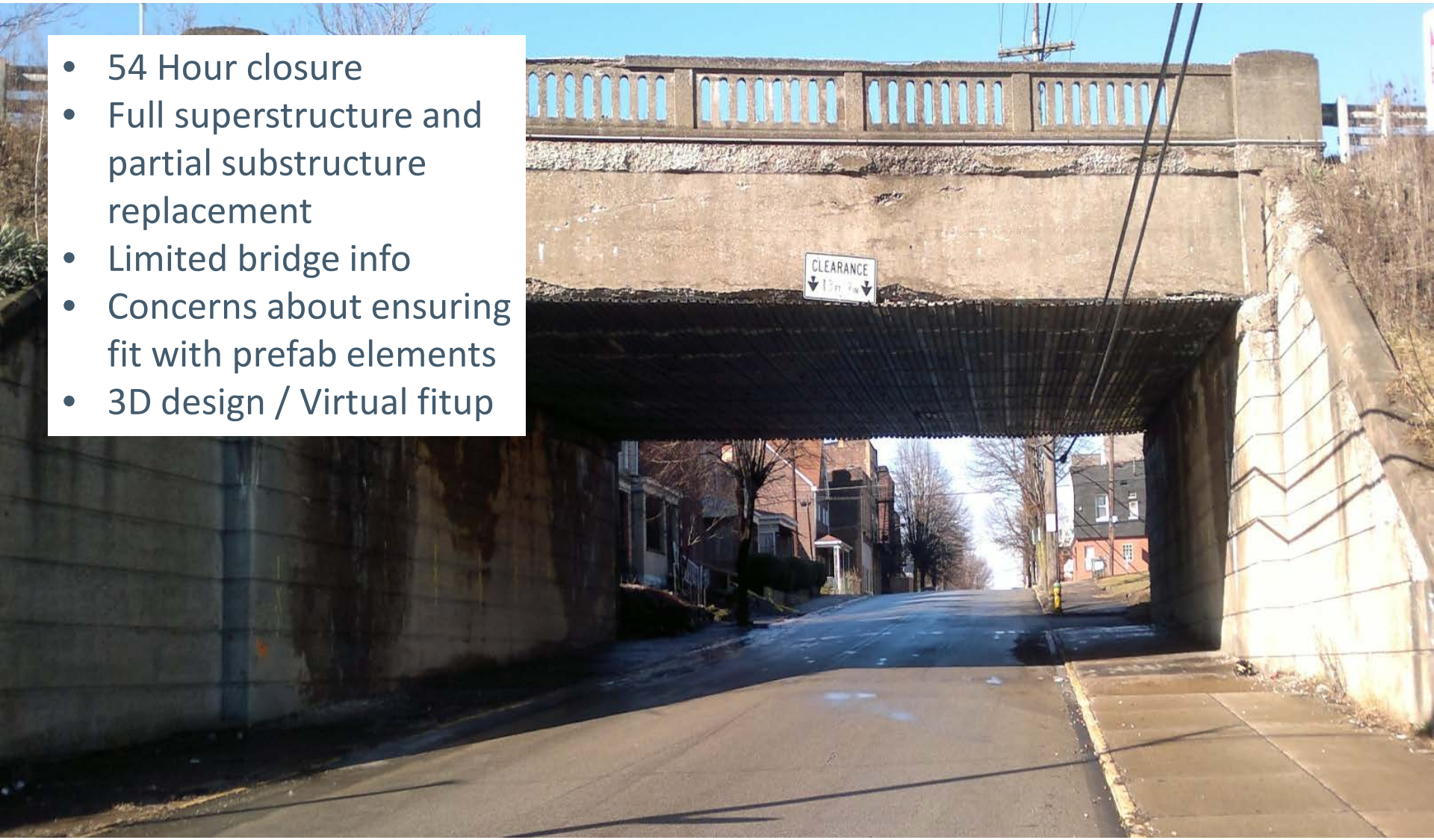


I-94 MODERNIZATION PROJECT

Detroit, MI

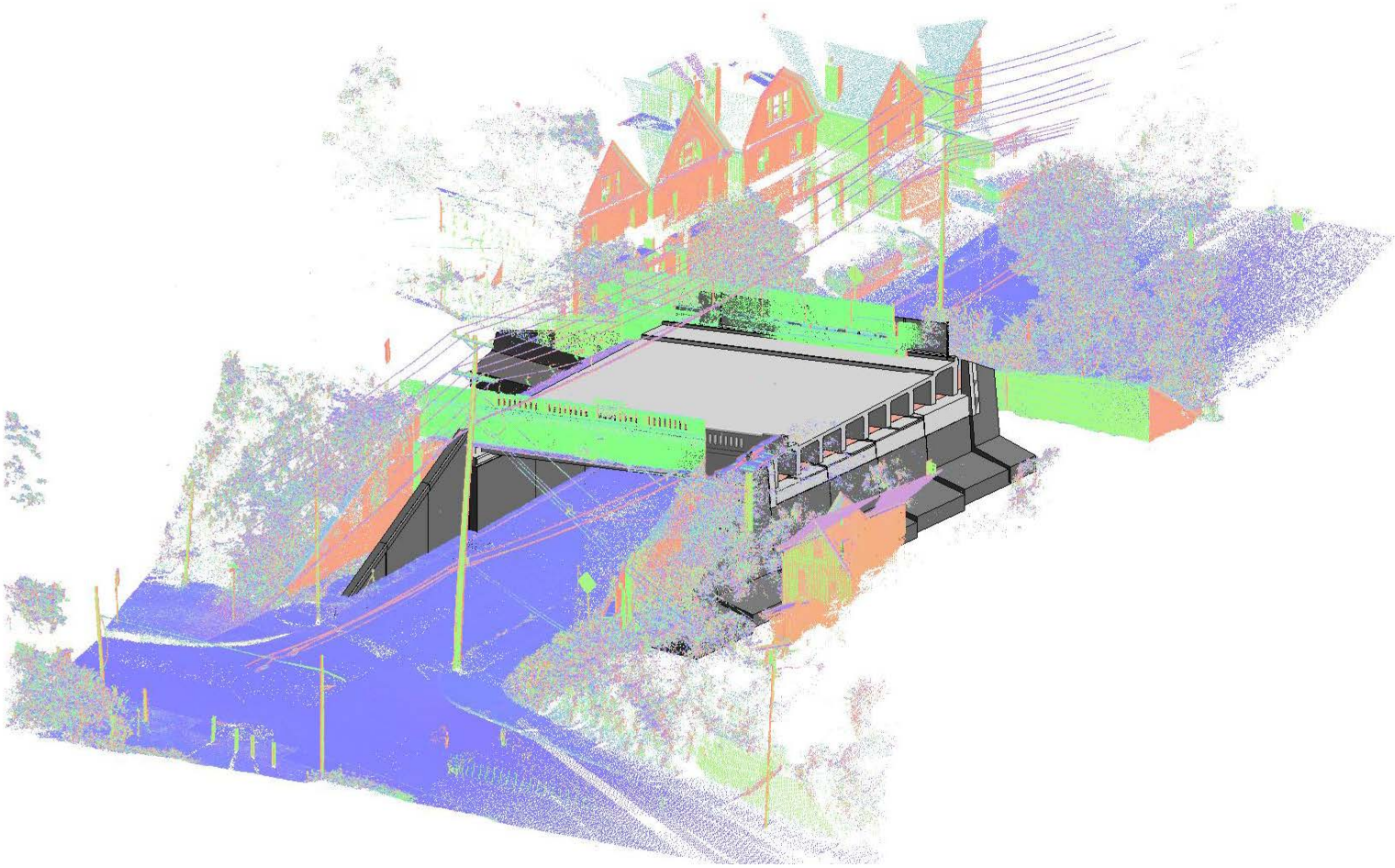


PennDOT State Route 30 Bridge – Weekend Replacement

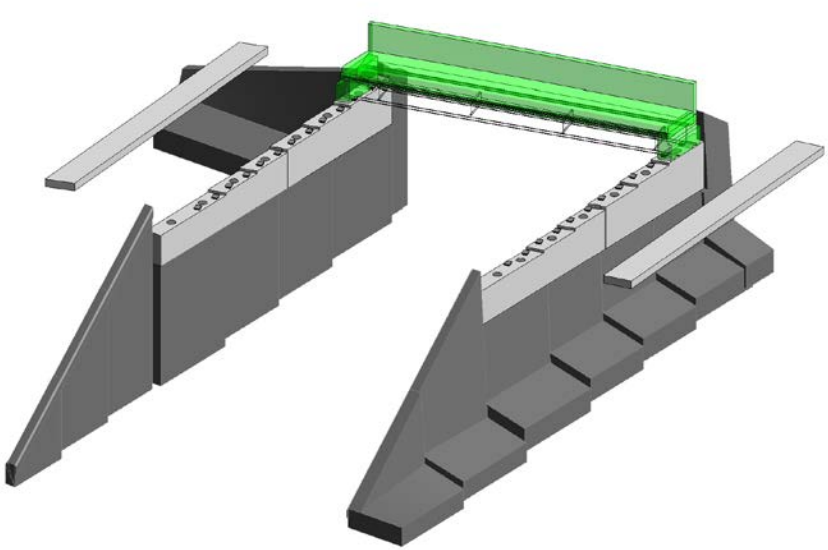


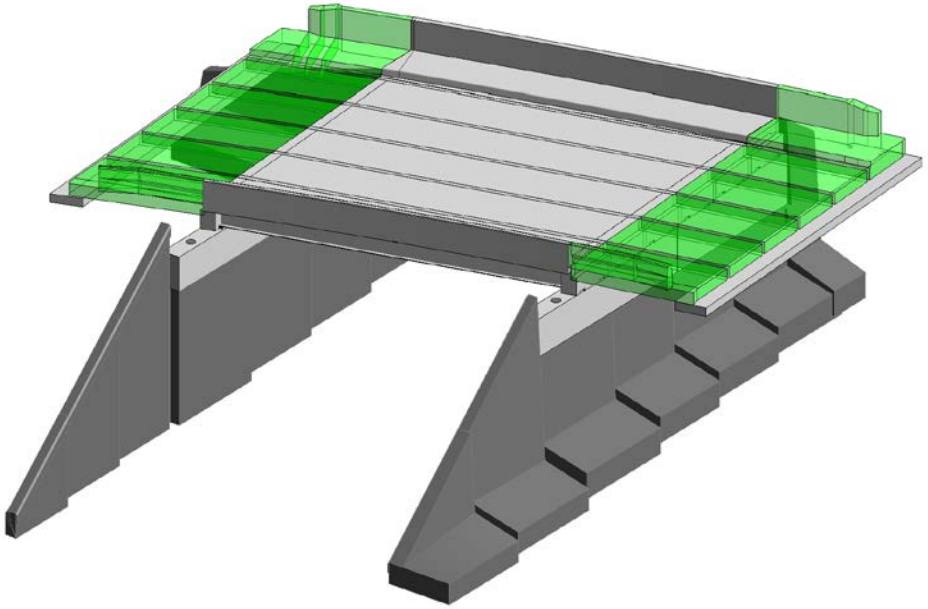
- 54 Hour closure
- Full superstructure and partial substructure replacement
- Limited bridge info
- Concerns about ensuring fit with prefab elements
- 3D design / Virtual fitup

PennDOT State Route 30 Bridge – Weekend Replacement



PennDOT SR-30 Weekend Replacement





West Virginia Turnpike – ABC Deck Replacement

- 3 span - 218’ total length on a 34 deg skew
- 43’ wide (two lanes)
- Full-Depth Composite Deck Panels
- 1 week deck replacement

Franklin Avenue Arch Rehabilitation

Minneapolis, MN

Franklin Avenue Arch Rehabilitation

Minneapolis, MN

ABC for Transit Bridges

NJ Transit Weekend Replacement with SPMT– October 31, 2015

PARK AND WATCHUNG

Accelerated Bridge Construction (ABC) Replacements

Plainfield, NJ

For the first time in the New York Metro region, NJ TRANSIT is replacing two railroad bridges using Self-Propelled Modular Transporters (SPMT). This ABC technique allows for the complete removal and replacement of *each bridge in one weekend*, with minimized service disruption. **You are invited to join us for a special technical workshop and site visit, where you will get to see the replacement in action.**

Shuttle to the site and refreshments will be provided.

Saturday, November 21, 2015

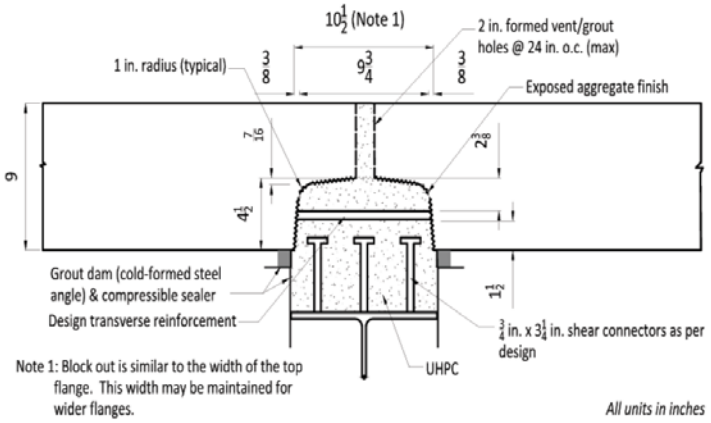
12pm	**Meet at the Hampton Inn - South Plainfield** *205 New World Way, South Plainfield, NJ, 07080*
2pm	**Roll-out of the existing bridge** *(approx. time)*
8pm	**Roll-in of the new bridge** *(approx. time)*

To RSVP Contact Phil Christian at pchristian@hntb.com

HNTB is pleased to provide attendance at this event at no cost to government officials and employees when permissible under applicable state and local laws and agency policies. Attendance by public officials at this event may constitute a reportable gift. HNTB will accept payment for any portion of this event to facilitate compliance with government ethics requirements.
Fair market value of attendance is $25.

ABC Applications in Major DB Projects

Kosciuszko Bridge - New York – New Precast Concrete Deck



SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

QUESTIONS

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO