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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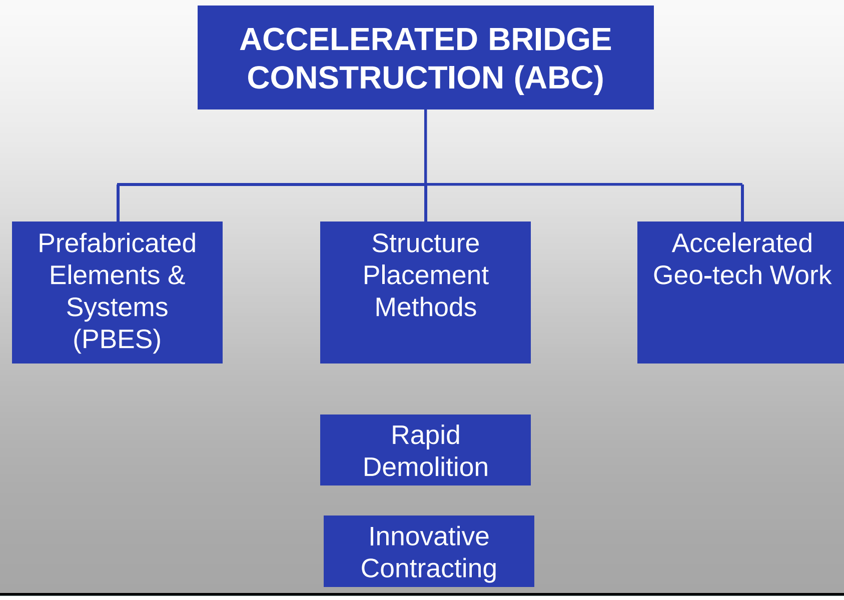
ABC Elements and Methods



SHRP2 Project R04 – Making ABC Standard Practice

Innovative Bridge Designs for Rapid Renewal

2007 – 2013

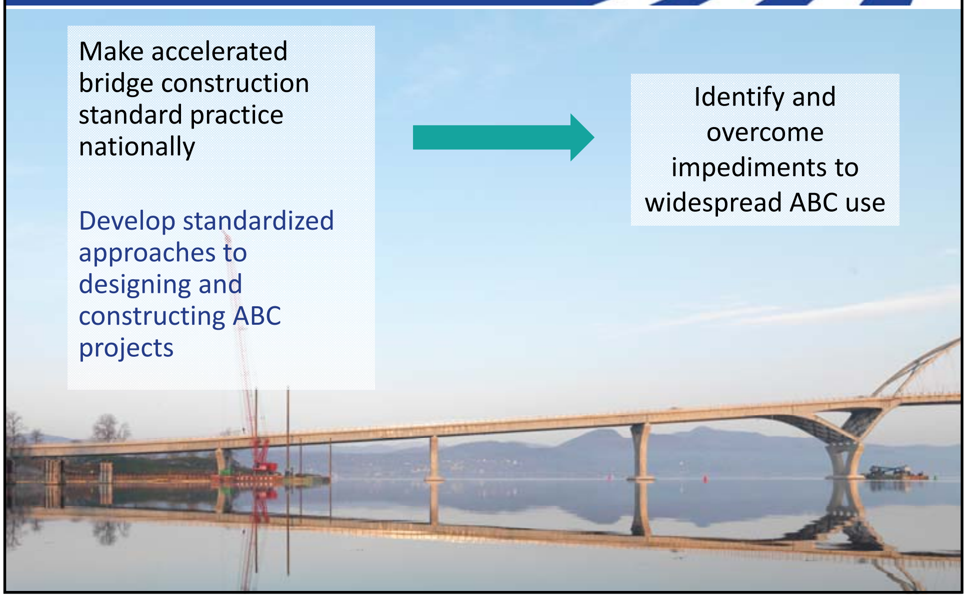
HNTB – Prime Contractor

Iowa State University

Genesis Structures

Structural Engineering Assoc.

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 was 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

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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

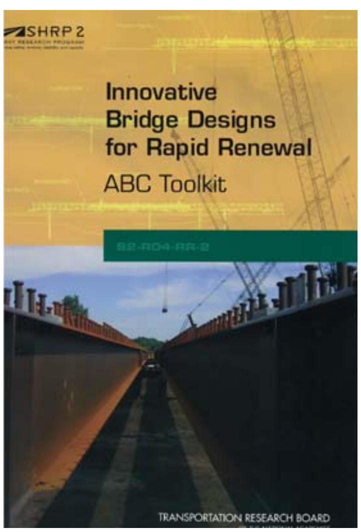
- ABC is perceived as raising the level of risk.
- Contractors concerns about the diminished profitability
- Greater outsourcing of work to precasters and specialty subcontractors.
- Contractors will be more willing to make equipment purchases if there are a greater number of projects to use the same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

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

ABC Toolkit – Benefits

ALLOWS STANDARDIZATION OF DESIGN SECTIONS

- Decks
- Superstructure
- Wingwalls
- Columns
- Footings

CAN BE BUILT BY ANY BRIDGE CONTRACTOR

- Increases competition
- Enables use of local contractors

NO SPECIAL EQUIPMENT NEEDED

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

Franklin Avenue Arch Rehabilitation
Minneapolis, MN

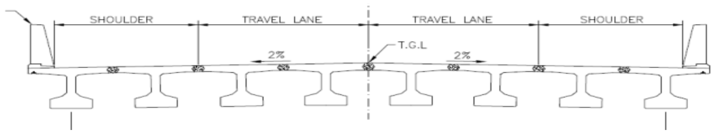
SELF-PERFORMING THE PRECASTING

Standard Design Concepts for PBES

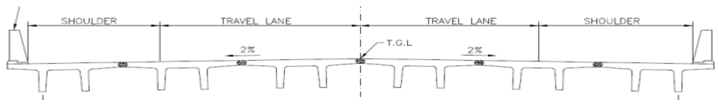
- Decked steel girders
- Decked concrete girders
- Precast abutments and wingwalls
- Precast piers
- Precast footings
- Precast approach slabs
- ABC connections

Prefabricated Decked Beam Elements

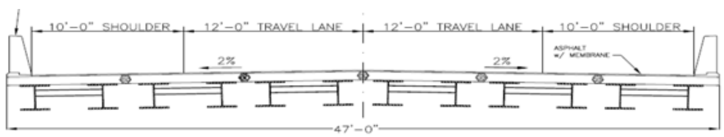
Deck Bulb Tees



Double Tees



Composite Steel System

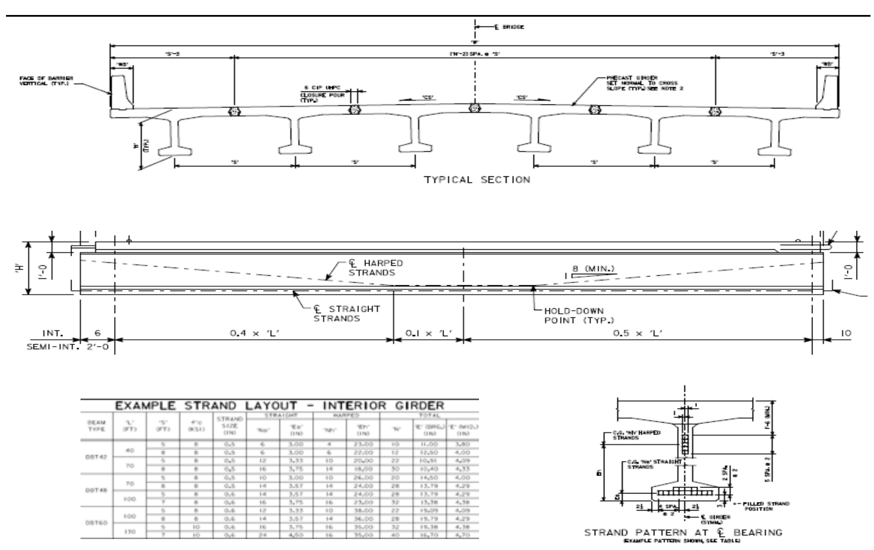


NJDOT Rte 18 Bridge
Weekend Replacement

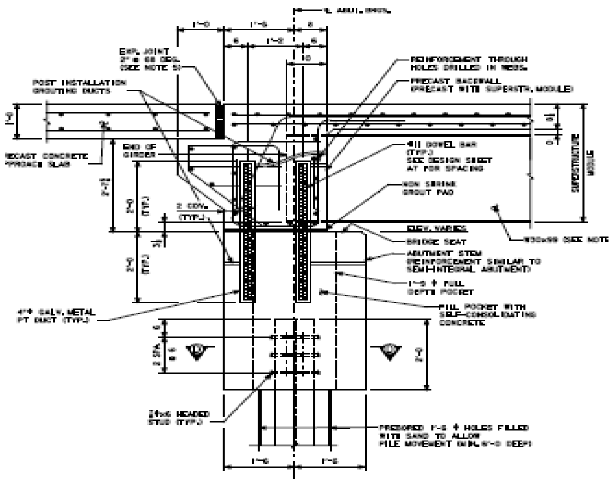
Superstructure ABC Design

- 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

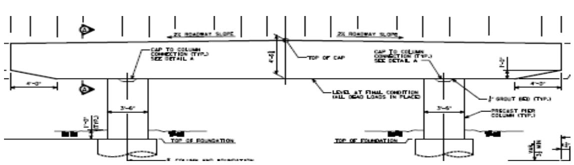


Integral Abutment

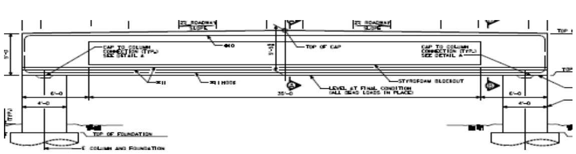


- Only one row of vertical piles
- Fast construction

Precast Piers



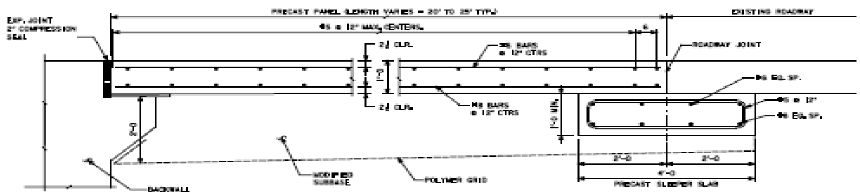
Conventional Pier



Straddle Bent

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

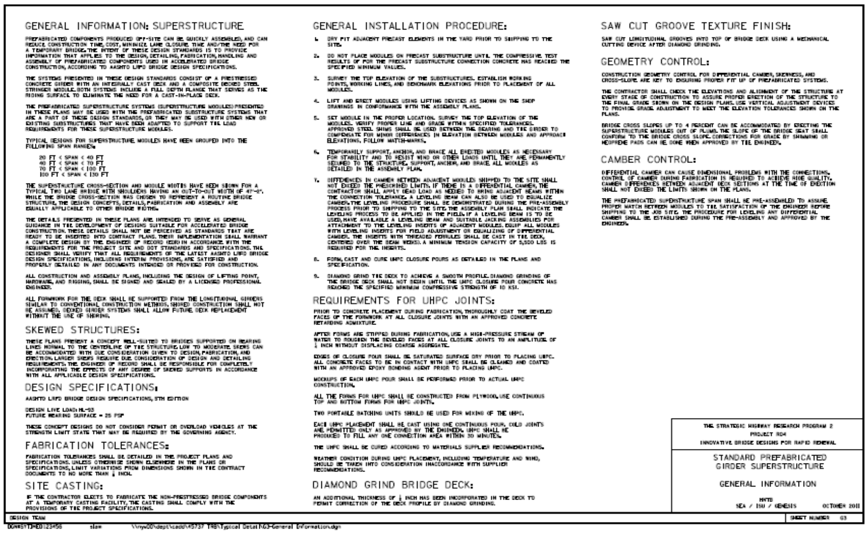
Precast Approach Slab



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

SKEWED STRUCTURES:

DESIGN SPECIFICATIONS:

FABRICATION TOLERANCES:

SITE CASTING:

GENERAL INSTALLATION PROCEDURE:

REQUIREMENTS FOR UHPC JOINTS:

DIAMOND GRIND BRIDGE DECK:

SAW CUT GROOVE TEXTURE FINISH:

GEOMETRY CONTROL:

CAMBER CONTROL:

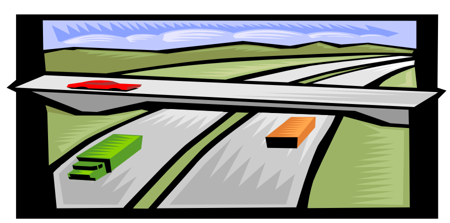
STANDARD PREFABRICATED GIRDER SUPERSTRUCTURE

GENERAL INFORMATION

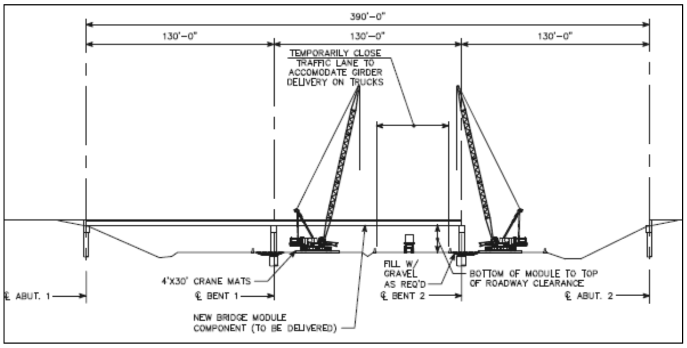
Erection Concepts for ABC

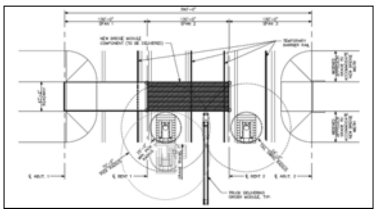
Erection methods in the *ABC Toolkit*:

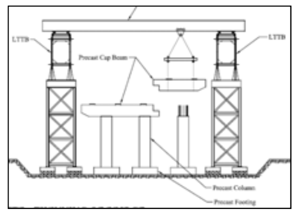
1. Erection using mobile cranes
2. Erection using gantry cranes / ABC construction technologies



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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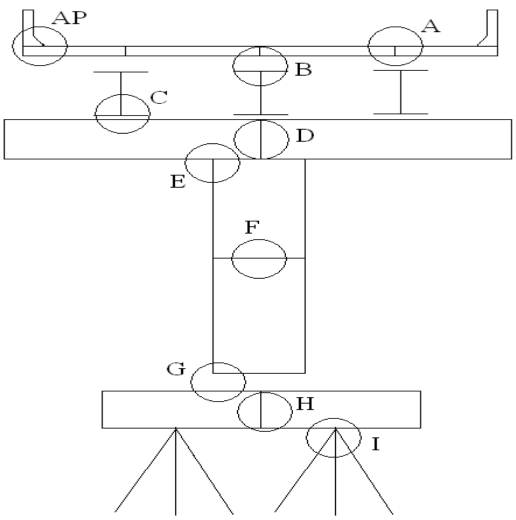
PBES Connections
ABC Toolkit / SHRP2 R04 Report



Ultra High Performance Concrete (UHPC)

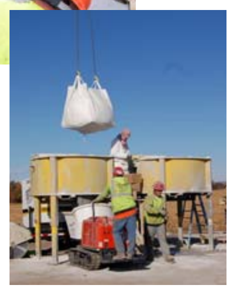
Compressive Strength:
20,000 to 32,000 psi

Flexural Strength:
3,000 to 7,000 psi

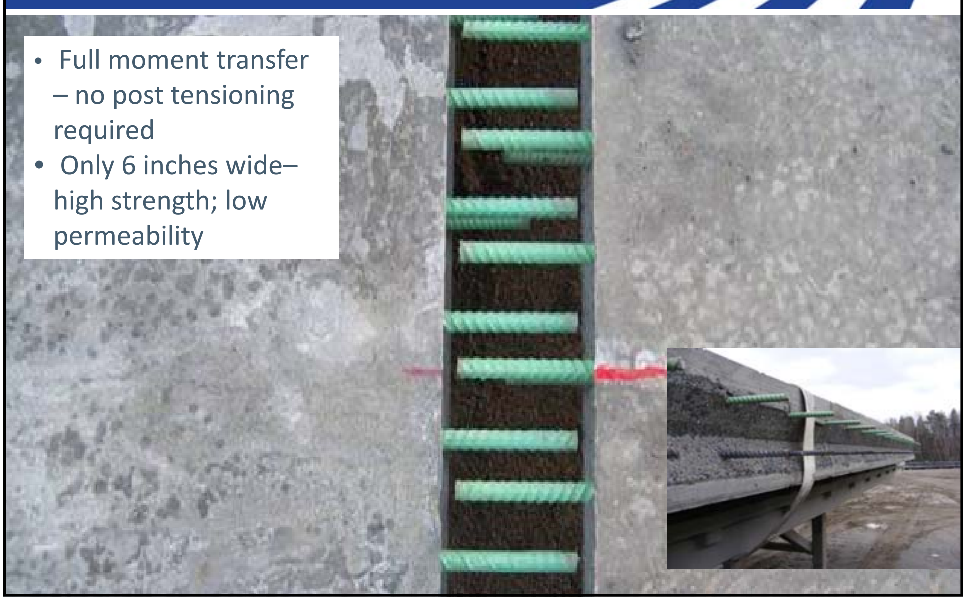
Ductility:
Greater capacity to deform and support flexural and tensile loads, even after initial cracking

Abrasion Resistance:
Similar to natural rock

Impermeability:
Almost no carbonation and penetration of chlorides



UHPC Joints in Bridge Deck

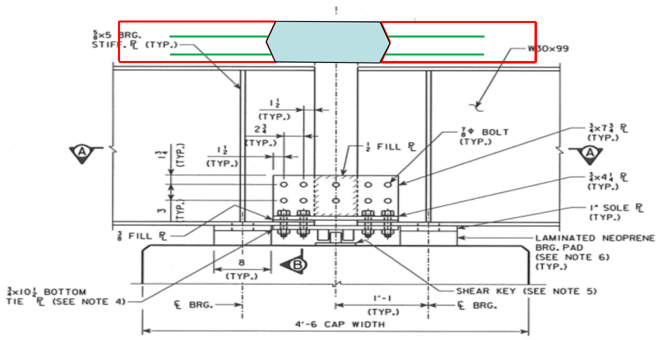


- Full moment transfer – no post tensioning required
- Only 6 inches wide– high strength; low permeability

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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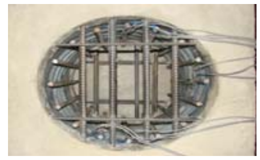
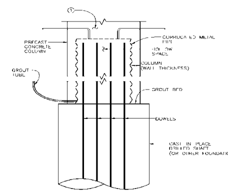
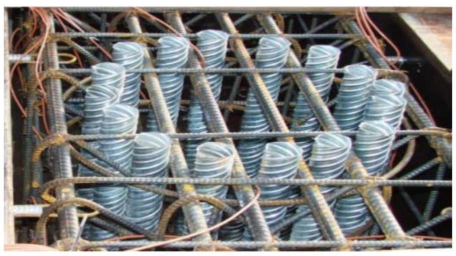
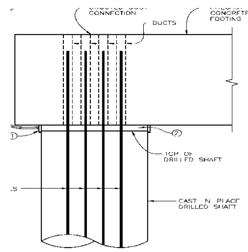
Cap Pockets & Grouted Ducts for Precast Piers

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)

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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.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

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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

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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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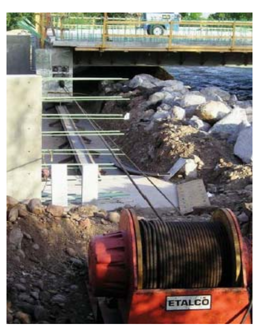
Movement Systems

Push/pull hydraulic jacks

Pulling with strand jacks/ power winch



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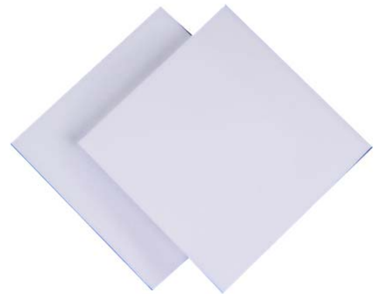
4. Slide Bearings

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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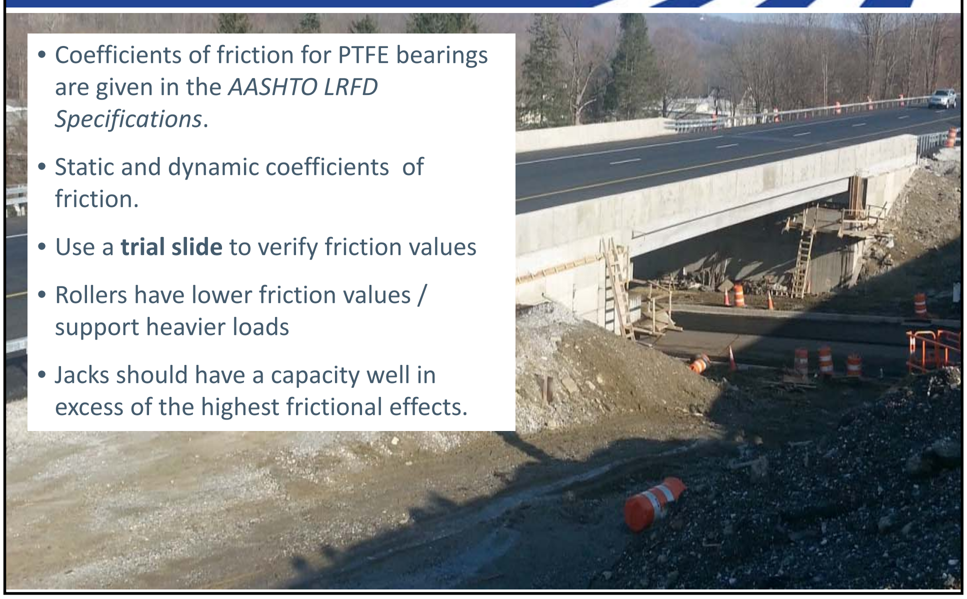
5. Sliding Forces

- 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)


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

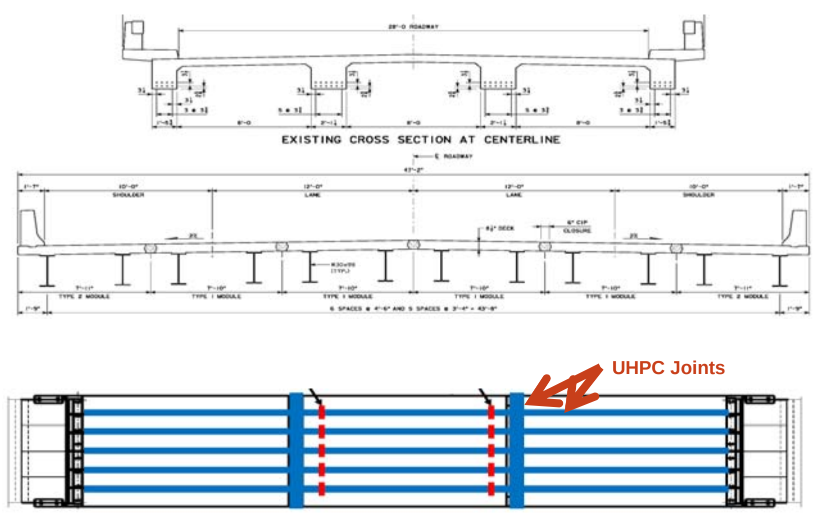
IowaDOT Design – Conventional Construction

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

Redesigned for ABC by HNTB

- Modular construction
- 14 day ABC period (Road closure)
- 3 span bridge
- 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

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

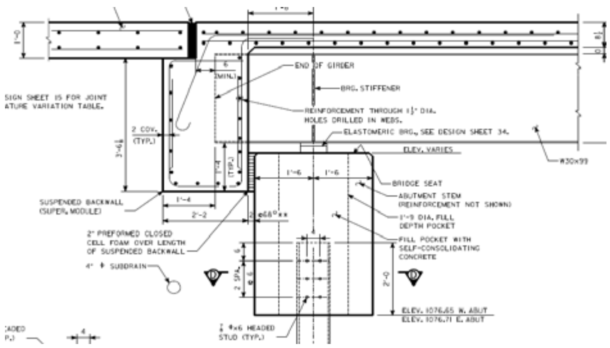
- Pier caps: 168 kips
- Required two 110 ton cranes to lift into place

Erection of Superstructure Elements Days 7 and 8

Erection of Superstructure Elements Days 7 and 8

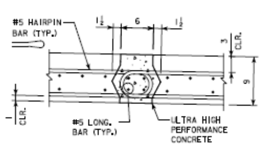
Semi-Integral Abutment – Suspended Backwall Days 7 and 8

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



UHPC Deck Closure Pours Day 10

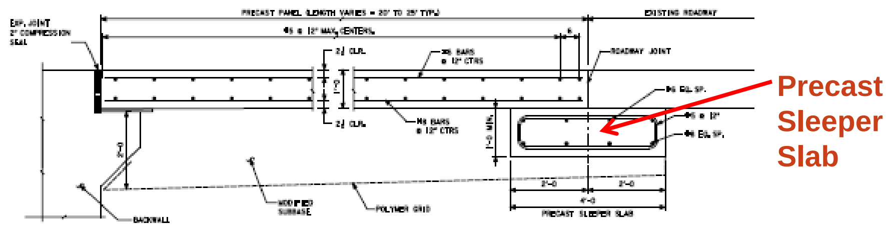
- Full moment transfer
- No post-tensioning required
- Only 6 in. wide; low-permeability
- Hairpin bars or straight bars



LONGITUDINAL CLOSURE POUR DETAIL

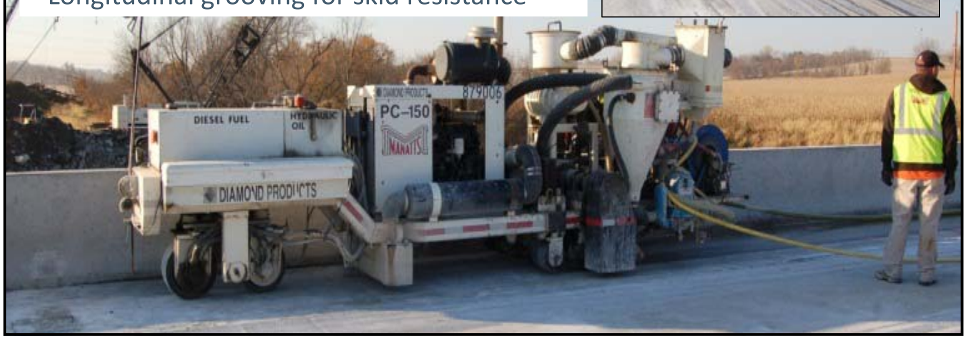
Longitudinal Joint

Precast Approach Slab — Day 10



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

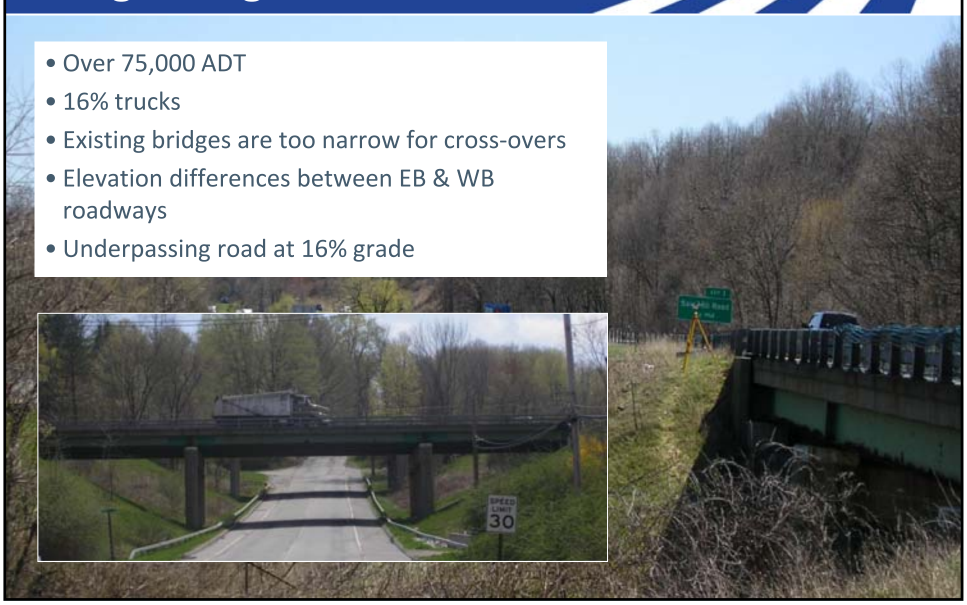


Second Demonstration Project
I-84 Bridges Slide-In Replacement — New York

- 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

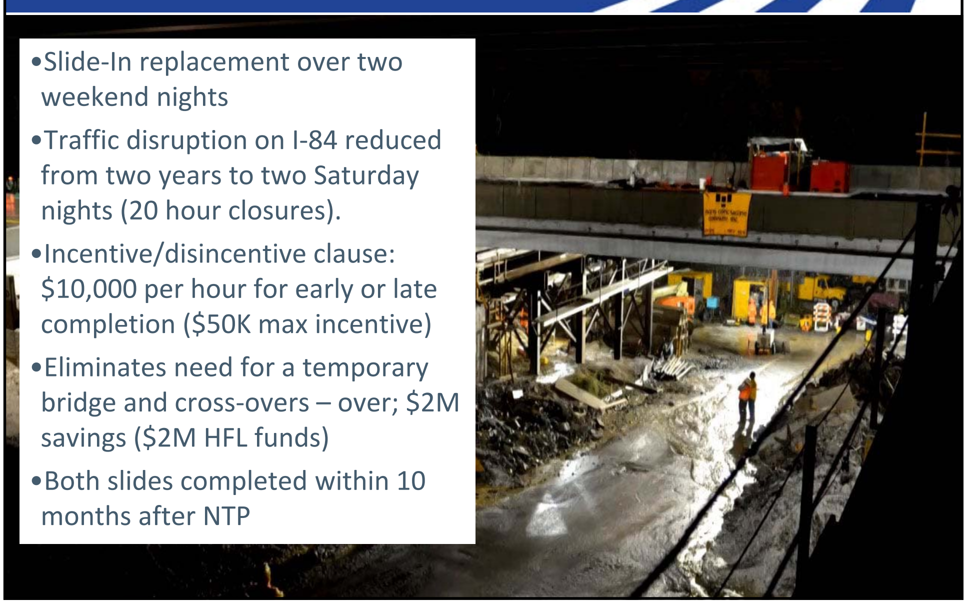


Original Plan

- 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

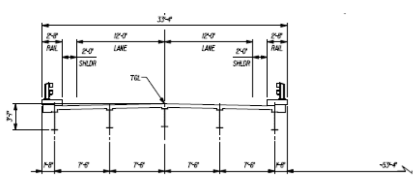
- Slide-In replacement over two weekend nights
- Traffic disruption on I-84 reduced from two years to two Saturday nights (20 hour closures).
- Incentive/disincentive clause: $10,000 per hour for early or late completion ($50K max incentive)
- Eliminates need for a temporary bridge and cross-overs –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

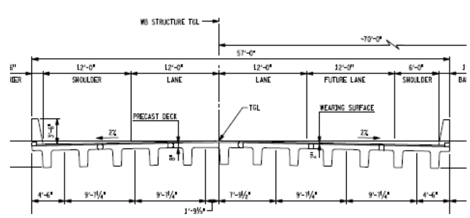


Slide-In Construction
NY I-84 Twin Bridges

Superstructure Sections

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

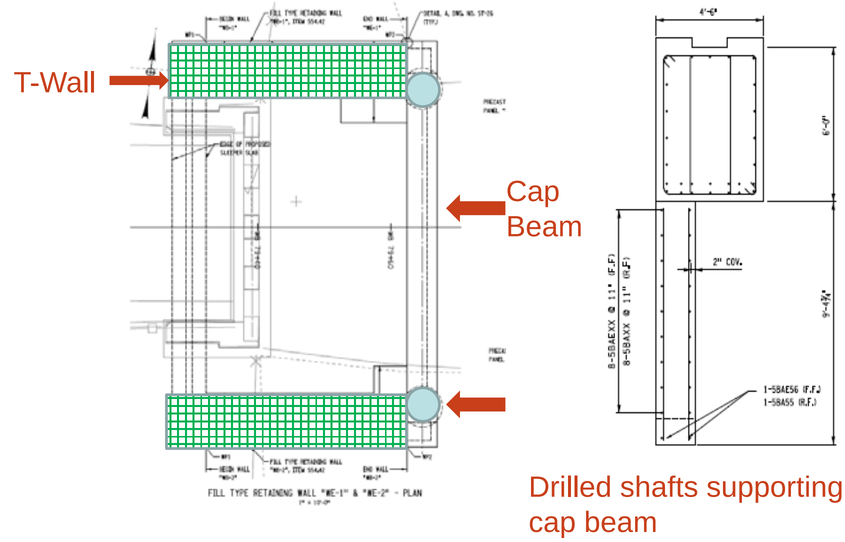




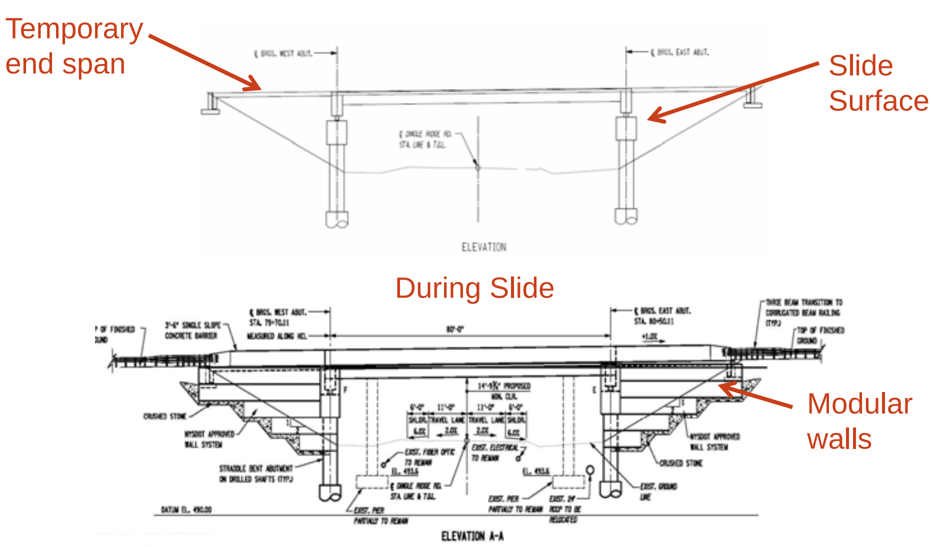
Abutment Construction -- Drilled Shafts Outside Existing Footprint

New Straddle Bent Abutment

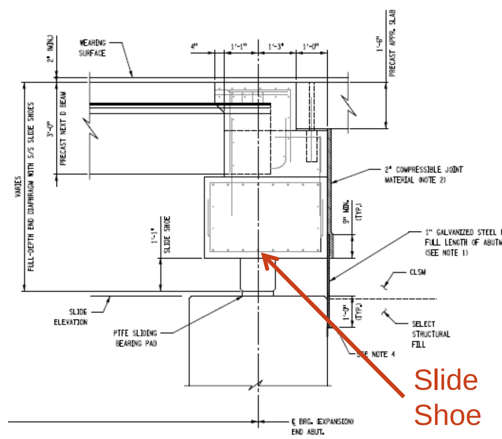
T-Wall Modular Wingwalls



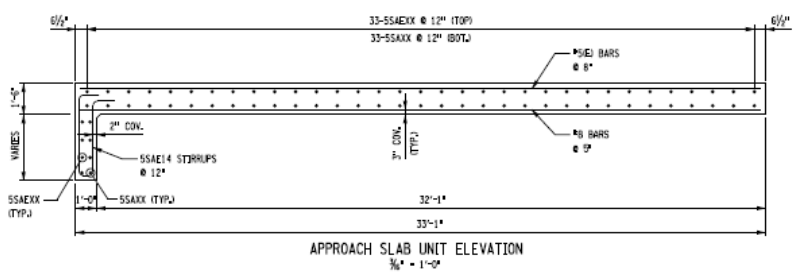
Slide-In Replacement Concept

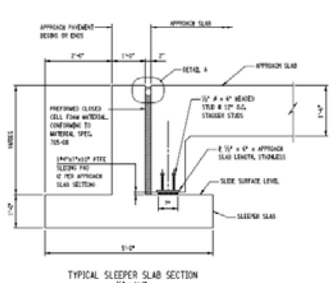


End Diaphragm and Slide Shoe



Precast Approach Slabs -- Temporary End Spans Carrying





Bridge Slide – October 21, 2013

Both Bridge Slides Completed 10 Months After NTP

PRESS

Thank You

Questions ?