Outline

- Introduction to ABC
- ABC Technologies
- Precast Decks
- SHRP2 ABC Toolkit
- Implementing ABC
- ABC Projects
What is ABC?
What is ABC?

Accelerated Bridge Construction (ABC)

ABC is bridge construction that uses innovative methods to reduce **mobility impacts** when replacing/rehabilitating existing bridges.

ABC is a platform for innovation.
Reasons for ABC include:

- Heavily traveled route (high ADT)
- Long or non-existent detours
- Stage construction is not a preferred option
ABC Advantages

- Reduces disruption to traffic/avoids congestion
- Safer; reduces exposure of workers and public to construction activities
- Better quality control due to prefabricated elements
- Reduced environmental impacts
ABC Elements and Methods

ACCELERATED BRIDGE CONSTRUCTION

- Prefabricated Elements & Systems (PBES)
- Structure Placement Methods
- Accelerated Geo-tech Work
- Rapid Demolition
Time Metrics for ABC – Mobility Impact Time

TRAFFIC IMPACTS WITHIN

*Tier 1* 24 hours

*Tier 2* 3 days

*Tier 3* 2 weeks

*Tier 4* 3 months

*Tier 5* > 3 months but overall project schedule significantly reduced
Prefabricated Elements and Systems (PBES)
Full Depth Precast Deck Panels
14 bridges in 10 weekends
• Build the entire bridge superstructures (where ROW is available) and then moving them into place in a few hours.

• Bridge movement technologies:
  – Self-Propelled Modular Transporters (SPMT)
  – Lateral Sliding
  – Launching/Skidding
  – Float-In
Bridge Movement – Self-Propelled Modular Transporters (SPMT)

Utah DOT
Caltrain Railroad Bridge replaced in a single weekend using SPMTs
- Sliding technique allows the new superstructure to be built alongside the exiting, reducing traffic impacts.
- Requires availability of ROW/space.
Bridge Movement – Roll-Out/Roll-In

New York City

- Bridge over I-678 – Van Wyck Expressway
Rapid Deck Replacement with Precast Concrete Deck Panels
Precast Deck System

- Advantages to Owners / Contractors
  
  • Crack free decks
  • Off site production
  • Accelerated on-site schedule
  • Reduced Maintenance
  • Lower Life Cycle costs
Barriers Prefabricated with Deck
Precast Deck Connections to Girders - Open and Hidden Shear Pockets
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

Strength Gain  
10 to 14 ksi usually in 48 hours

Stainless steel fibers in UHPC
Precast Deck Connections to Girders

- The design of the connectors attached to the girder shall be completed according to the provisions of AASHTO LRFD Bridge Design Specifications 5.8.4 and 6.10.10
Shear Connector Spacing

• In 2013 AASHTO approved a change to LRFD Article 5.8.4.2 to permit longitudinal spacing of studs up to 48 inches, but not greater than beam depth.
• However large spacing of blockouts will require a greater number of shear studs per pocket.
• Explore use of 1” or 1 ¼” shear studs to minimize number of studs per pocket.
Hidden Shear Pockets -- Rebars not Interrupted

Examples of minimum shear planes for horizontal shear transfer

A

B

C
Precast Panels with Hidden Pockets

Installation of Concrete Pre-cast Deck Panels at Morgan Avenue Viaduct in Brooklyn
Precast Deck Panel to Panel Connections

Panel to Panel Connection with Closure pours

Narrow Width
- UHPC

Intermediate Width
- Rapid Set Concrete

Larger Width
- Rapid Set Conc.
WV Turnpike Bridge Deck Replacement (Intermediate width -- U Bars)
NARROW WIDTH CLOSURE POUR: Ultra High Performance Concrete (UHPC)
Post-Tensioning with match cast shear keys has been used in precast deck slabs to transfer shear and some moments and to keep joints in compression.

- Prevents tension cracking under live load
- LRFD requires an effective prestress force not less than 250 psi.
Post Tensioned Connections of Panels
Deck Panel Handling: Crane-Based Erection

- Deck stress criteria for “no discernible cracking” should be followed during lifting.
Precast Deck Panel Erection with Gantries
Riding Surface Quality -- Deck Grinding

• Use diamond grinding or a deck overlay for a smooth deck
• Extra ½ inch for grinding for smooth riding surface
• Longitudinal grooving for skid resistance
Precast Deck After Grinding
1” Polyester Polymer Concrete Overlay (PPC)
Joint less Decks -- Link Slabs at Piers

- Spans are jointless but not continuous
- No moment transfer
- 0.05L of deck debonded (from girder) at each girder end – eliminate shear studs
- Allows end rotation
- Simple details at piers
UHPC Detail for Link Slab Connections

- **1' - 4" ± 1/"**
- **8" ± 1/2"**
- **8" ± 1/2"**
- **6" MIN.**
- **ULTRA HIGH PERFORMANCE CONCRETE**
- **8 1/2" DECK PANEL**

**Shear Connector Pocket**

**Haunch**
SHRP2 Project R04 – Making ABC Standard Practice
Project R04
Innovative Bridge Designs for Rapid Renewal
2008 – 2013
HNTB – Prime Contractor
Iowa State University
Genesis Structures
SHRP2 Project R04 – Goals

- Make accelerated bridge construction (ABC) standard practice nationally
- Develop standardized approaches to designing and constructing ABC projects
- Identify and overcome impediments to widespread ABC use
SHRP2 Project R04 – What Was Done?

- Identify obstacles to ABC Implementation
- Plan to overcome obstacles
- ABC Design Standards & Specifications
- ABC Toolkit
- ABC Training Course
- 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 and designs for ABC
• Challenges in getting industry support for ABC
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 with ABC.
• Contractors will be more willing to make equipment purchases if there are a greater number of projects to use the same equipment. Need a program 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.

ABC: ENGINEERS NEED TO – “THINK LIKE A CONTRACTOR”
SHRP2 ABC Toolkit
SHRP2 ABC Tool Kit was developed for PBES and Lateral slide

Focus on “workhorse” bridges

Standards will foster more widespread use of ABC

Make best use of program dollars by standardizing ABC design

ABC standards can be incrementally improved through repeated use
SHRP2 R04 ABC Toolkit

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

STANDARDIZATION OF DESIGNS

• SUPERSTRUCTURE
• SUBSTRUCTURE

CAN BE BUILT BY ANY BRIDGE CONTRACTOR

NO SPECIAL EQUIPMENT NEEDED
Prefabricated Decked Beam Elements

Deck Bulb Tees

Double Tees

Composite Steel System
ABC Standard Designs

- ABC designs for common bridge spans
- Simple / continuous spans from 40 ft to 130 ft.
- Plans are grouped in the following span ranges:
  - 40 ft to 70 ft
  - 70 ft to 100 ft
  - 100 ft to 130 ft.
- Plans for integral and semi-Integral abutments
- Plans for precast piers
- Plans for precast approach slabs
Recommended special requirements for ABC construction

**PROPOSED SECTION IN LRFD CONSTRUCTION SPECIFICATIONS**

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• Full moment transfer – no post tensioning required
• Only 6 inches wide—25 Ksi; low permeability

Longitudinal Joint
Grouted Splice Sleeve Couplers

Manufacturers of Splice Sleeve Coupler

- Splice Sleeve North American ("NMB Splice Sleeve").
- Dayton Superior ("Dayton Superior DB Grout Sleeve").
- ERICO United States ("Lenton Interlok").
Grouted Splice Sleeve Couplers
• Allows fast rate of erection
• Rides on existing bridge or new bridge
• Ideal for bridges with many spans, long viaducts
Erection Using Launched Temporary Bridges

- Sites with limited ground access
- Launched across to act as a “temporary bridge”
- Used to deliver the heavier modules without inducing large erection stresses.
Components of Slide-in Bridge Construction (SIBC) Design

*ABC Toolkit* provides guidance on:

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

Push/pull hydraulic jacks

Pulling with
• strand jacks
• power winch
Roller Bearings
Coefficient of Friction: 5% of Vertical Load

Teflon-Coated Neoprene Bearing Pads
Coefficient of Friction: 10% of Vertical Load
Implementing the SHRP2 ABC Toolkit
ABC and SHRP2 ABC Toolkit Training Courses

ABC Training Courses (One Day)
• PennDOT
• MIDOT
• MNDOT
• VTDOT
• National bridge conferences

National ABC Webinars
• FIU Webinars
• FHWA Webinars
Vermont Agency of Transportation
Using the SHRP2 ABC Toolkit for Hurricane Irene damaged bridges (17 bridges replaced)
Use of ABC Toolkit Concepts
Developed in SHRP2 R04
• Total prefabricated bridge
• 14 day closure
• 14 day ABC period
• Opened November 1, 2011
Keg Creek Bridge Rapid Replacement 2011

- 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

UHPC Joints
• Seven local bidders
• Contract letting: February 2011
• Contractor: Godbersen-Smith, Ida Grove, Iowa
• Low bid: $2.67 million
• Bridge cost = $231 / SF
• Incentive / disincentive = $22,000 / day during 14 day ABC period
• HFL funds $600,000; SHRP2 funds $250,000
Prefabrication Yard Adjacent to Bridge – Iowa Bridge Farm

- Bottom mat of deck reinforcing nearly complete
- Column sections cast and curing
- Rebar cage for next column section
- Abutment and wingwall components complete
Prefabrication of Abutments and Piers
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
• Pier caps: 168 kips
• Required two 110 ton cranes to lift into place
Erection of Superstructure Elements – Days 7 and 8

Span – 70 ft

112 K
Semi-Integral Abutment – Suspended Backwall – Days 7 and 8

- Allows superstructure expansion / contraction
- Easy fit up
- Well suited for **rapid construction**
• Full moment transfer
• No post-tensioning required
• Only 6 in. wide; low-permeability
• Hairpin bars or straight bars
• Weekend Replacement
• 20 Hr Closure
NY I-84 Bridges

- 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
• Slide-In replacement over two weekend nights
• Traffic disruption on I-84 reduced from two years to two Saturday nights (20 hour closures).
Superstructure Sections

- NEXT beams
- Precast approach slabs
- UHPC closure pour
New Straddle Bent Abutment – Modular Wingwalls

- T-Wall
- Cap Beam
- Drilled shafts supporting cap beam
Slide-In Replacement Concept

Temporary end span

Slide Surface

Modular walls

During Slide
End Diaphragm and Slide Shoe

Slide Shoe
Precast Approach Slabs – Temporary End Spans Carrying Traffic
7 hours to demolish existing bridge and slide in new bridge
Both Bridge Slides Completed 10 Months After NTP
ABC for Rehabilitation Projects
ABC for Bridge Rehabilitation

- Prefabricated elements provide
- Off-the-shelf ABC details and standards rarely work in a rehab situation.
- Modified standard ABC details or completely new details may be required.
- In a new bridge project, the designer has full control of all the dimensions from the ground up.
- In rehab, the accuracy and completeness of available bridge plans introduces added risks of proper fit-up
- There is increased risk of all elements fitting properly
- Field verify all dimensions -- Lidar surveys may be used
Project Description

• Concrete restoration
  – Repair abutments, piers, arch ribs

• Replace existing deck, cap beams, railings
  – ABC methods
  – Precast elements (Deck panels, cap beams, ornamental railings)
  – Address functional needs
  – Restore historic features

• Project Construction Cost: $43.1 million
Functional Needs

- Address non-motorized travel (Multi-Modal)
Structural Updates

- Repair arch ribs, pier walls and abutments
- New deck, cap beams, railings, overlooks
- Polyester Polymer Overlay
- Reduce the number of deck expansion joints
Historic Features – Railing / Overlook
ABC Preferred Option

- Staged construction not a viable option: Unbalanced arch loads and costly temporary supports
- Full closure was the least costly way
- Conventional construction would have taken two construction seasons.
- The bridge fully reopened to traffic Sept. 1, 2016 after being closed for only 16 weeks. (May 8 to Sept 1, 2016)
• Open to traffic 116 days after closure
Deck Panels Assembly

UHPC joints with polyester polymer overlay for added protection
Deck Panels Delivery Using Barges
Precast Cap Beams
Deck Panel UHPC Connections / Sliding Joint

- Ultra High Performance Concrete Closure Pour
- Precast Deck Panel, TYP
- Overlay Not Shown
- Deck Panel Reinforcement Not Shown
- 1/4" PTFE Sheet
- Recessed into and epoxy bonded to 3/8" Continuous S.S. Rod
- Embedded in Cap Beam
- 2 1-5/8" GAP
- 1/2" Cap Beam
- 8" Lap TYP
- 2-3/4" TYP
- 1/2" S.S. Rod, TYP
- 3/8" S.S. Rod, TYP
- Cap Beam Reinforcement Not Shown
- Cap Beam, 2-1/6"
Precast Ornamental Railing
Polyester Polymer Concrete Placement
PENNDOT State Route 30 over Bessemer Ave.

- Abutment Rehab / Superstructure replacement in 57 hours
Quick Facts

• Project was let on 11/5/2015
• Low bidder : $2,333,212.
• Pre-Cast Abutment Caps, steel beam modules with concrete deck/barrier, UHPC joints between the modules, pre- cast approach slabs, rapid set LMC overlay
• ADT is 21,798 (2015) with 4% trucks
• No available detour for weekday traffic
ABC Design Decisions

- Limited as-built Information for bridge
- Choice of ABC method that fits site constraints and 57 hour closure period
- Skew, curvature, super-elevation considerations for ABC design
- Removal and replacement of deteriorated portions of abutment walls
- Approach slab replacement
- ABC connections with accelerated cure UHPC
- Lidar Survey
LIDAR SURVEY: AS-BUILT BRIDGE MODEL
Weekend Closure (57 Hours) : Close Friday 9 PM

- Demolish superstructure, remove approach slabs and excavate backfill
- Saw-cut abutment along backface and remove sections
- Connect abutments caps with dowels
- Erect the six superstructure modules with cranes
- Erect precast sleeper slabs and approach slabs
- Place accelerated cure UHPC closure pours
- Reopen to traffic — Monday 6 AM
New Superstructure Cross Section

- 54’-0” Curved single Span
- Composite Steel Modular Superstructure
Superstructure Modules Assembly
Approach Slab Section
Thank You

Q & A