Innovative Bridge Designs for Rapid Renewal

ABC Toolkit

Bala Sivakumar  HNTB Corp.

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Innovative Bridge Designs for Rapid Renewal
2007 – 2013
HNTB – Prime
Iowa State University
Genesis Structures
Structural Engineering Assoc.
<table>
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<th>Goals of SHRP2 R04</th>
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<td>Make accelerated bridge construction standard practice nationally</td>
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<td>Develop standardized approaches to designing and constructing ABC projects</td>
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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 concern 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”
Innovative Bridge Designs for Rapid Renewal

ABC Toolkit

Transportation Research Board

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  
<table>
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<tr>
<th>• Footings</th>
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| CAN BE BUILT BY ANY BRIDGE CONTRACTOR | • Self-perform precasting  
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<th>• Can be built by local contractors</th>
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| 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
Integral Abutment

- Only one row of vertical piles
- Fast construction
Precast Piers

Conventional Pier

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

Straddle Bent
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.
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
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
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

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 Toolkit

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
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

EXISTING CROSS SECTION AT CENTERLINE

UHPC Joints
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
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

112 K

Span – 70 ft
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
Full moment transfer
No post-tensioning required
Only 6 in. wide; low-permeability
Hairpin bars or straight bars
Precast Approach Slab — Day 10

Image of a construction site with workers installing precast approach slab.
• 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 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
• 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
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

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
7 hours to demolish existing bridge and slide in new bridge
Both Bridge Slides Completed
10 Months After NTP
OCTOBER 7, 2013 • A SUPPLEMENT TO ENGINEERING NEWS-RECORD

ENR New York
NEWS, DATA AND ANALYSIS FOR THE CONSTRUCTION INDUSTRY IN NEW YORK, NEW JERSEY AND CONNECTICUT

NEW YORK STATE PROGRAMS
FAST-TRACK BRIDGE REPAIRS

CREWS LAY PIPE IN OCCUPIED MULTIFAMILY HOUSING COMPLEX

TR News
JANUARY-FEBRUARY 2014
NUMBER 256

ABCs OF BRIDGE RENEWAL

Plus:
Clear and Safe Winter Roads
State Agency Innovations
Long Beach Megaproject
Energy Sector Road Impacts
Diluted Bitumen in Pipelines
Time Lapse
Assisting States with ABC Implementation
• 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 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
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
QUESTIONS