Using the SHRP2 ABC Toolkit

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HNTB Corp.
INNOVATIVE BRIDGE DESIGNS FOR RAPID RENEWAL
2007 -- 2013

HNTB (Prime)
Iowa State University
Structural Engineering Assoc.
Genesis Structures, Inc.
SHRP2  Project R04

Goal

To develop standardized approaches to designing and constructing complete bridge systems that address rapid renewal needs

Make Accelerated Bridge Construction Standard Practice
SHRP2 ABC TOOLKIT

- Published by TRB in 2012
  - ABC concepts for PBES
- Addendum in 2014 to cover Slide-In Bridge Construction
Innovative Bridge Designs for Rapid Renewal Toolkit

TRB's second Strategic Highway Research Program (SHRP 2) SHRP 2 Report S2-R04-RR-2: Innovative Bridge Designs for Rapid Renewal. ABC Toolkit describes standardized approaches to design and construct bridges for rapid renewal. The report includes design standards and design examples for complete precast concrete bridge systems, and proposes specification language for accelerated bridge construction systems, which adhere to Resistance Factor Design (LRFD) Bridge Design and Construction Specifications.


An e-book version of the report is available for purchase at Amazon, Google, and iTunes.

The R04 MathCAD files for the SHRP 2 Report S2-R04-RR-2 are available to help illustrate the sample accelerated bridge construction (ABC) design calculations. The sample design calculations serve as an example of how to apply ABC concepts to real-world projects.

A demonstration project on US 6 over the Keg Creek near Council Bluffs, Iowa, used the accelerated bridge construction standards developed as part of Renewal Project R04.

The following three videos were produced related to the Keg Creek project:
- ABC for Everyday Bridges (18:39) highlights the specific techniques used to deliver a new bridge with a 10-day closure.
- Time-Lapse Video (8:30) shows ABC techniques being used by a local contractor with standard equipment to replace the Keg Creek three-span bridge.

A second demonstration project on I-84 in New York also used the ABC Toolkit in applying bridge slide technologies, which were used over two weekend nights to save millions of dollars and two years.

A case study on I-84 bridge project is also available.

The R04 Renewal project also developed a half- and full-day presentations to help facilitate training on the accelerated bridge process to interested parties.

In June 2013, SHRP 2 produced a Project Brief on the project that developed the ABC Toolkit.

Project: Project Information
Project Number: R04

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Expected Outcome: The designer, guided by the sample drawings, and ABC design examples will be able to easily complete an ABC design.
14 Day Bridge Replacement
PBES Demonstration Project
Keg Creek Bridge, Iowa

Total prefabricated bridge

- 14 day ABC period
- Opened Nov 1, 2011
ABC Current Projects Nationwide

Ongoing/recent ABC projects
ABC Design of the Franklin Avenue Arch Rehabilitation

Minneapolis, MN
Weekend Superstructure Replacement
Standard Design Concepts For PBES

- DECKED STEEL GIRDER
- DECKED CONCRETE GIRDER
- PRECAST ABUTMENTS & WINGWALS
- PRECAST PIERS
- PRECAST FOOTINGS
- PRECAST APPROACH SLABS
- ABC CONNECTIONS
Prefabricated Decked Beam Elements

- Deck Bulb Tees
- Double Tees
- Composite Steel System
Pre-decked Modular Steel Beams

- Not proprietary
- Contractor can self-perform precasting of deck onsite
- Adaptable to any geometry
Precaast Decked Girders

- Deck Bulb Tee
- Span lengths from 40 ft to 130 ft
- UT, WA, ID among states with DBT standards

- Double Tee -- PCI NEXT beam
- Spans to 90 ft
- Low depth alternative
UHPC Joints in Bridge Deck

- Full moment transfer. No post tensioning required
- Only 6 in wide. High strength; low permeability
Integral Abutment

- Only one row of vertical piles
- Precast backwall - dowelled
- Fast construction
Semi-Integral Abutment
Suspended Backwall

- H piles or spread footings
- Fill pile pockets with SCC
- Easy fit-up in the field
Precast Piers

- Non-prestressed so contractor can self-perform precasting
- Fast erection using grouted splice couplers
- Deep foundation may be outside existing footprint
Grouted Splice Sleeve Couplers
Precast Approach Slab

- Flooded backfill
- Flowable fill under slab
- Exp joint can be moved to sleeper slab
Erection Concept Drawings

1. Erection using conventional cranes.

2. Erection using ABC construction technologies adapted from long span construction
Erection Using Mobile Cranes

Short Single Span over Stream
Cranes selected for 90 Kip pick

Longer Span over Roadway
Weight up to 200 kips
Erection Using Mobile Cranes

Factors to Consider

- Weight of Module
- Pick Radius
- Crane Set Up Locations
- Ground Access / Barge / Causeway / Work Trestle
- Truck Access for Delivery
Erection with ABC Construction Technologies

• Use ABC construction technologies where ground access for cranes below the bridge may be limited.

• ABC technologies that allow construction from above:
  – Above Deck Driven Carriers
  – Launched Temporary Bridge
  – Transverse Gantry Frames
  – Longitudinal Gantry Frames
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.**
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)
Proposed LRFD Specs for ABC

- LRFD formatted design and construction specifications
- Address impediments in LRFD Specs to ABC implementation:
  - Loads and Load combinations
  - Construction load cases, Erection stresses
  - Design of connections
  - Design responsibility --- EOR / Contractor’s engineer
  - Prefabrication tolerances, quality, rideability
  - Assembly plans
Traffic impacts within:

Tier 1: 24 hours
Tier 2: 3 days
ABC Toolkit: Components of Slide-In Construction Bridge Design

1. Permanent Bridge Design
2. Temporary Support System
3. Push / Pull System
4. Sliding Bearings
5. Sliding Forces
1. Permanent Bridge Design

- Permanent bridge design must consider how the new bridge will be slid into place.
- Strengthen local areas where the push/pull system will be attached (end diaphragms)
- Consider flexural, shear effects on substructure from moving vertical load
2. Temp Support System (falsework)

- Design must consider 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
- Attach the temp support to the permanent structure
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

Pulling with strand jacks / Power winch

Push/Pull hydraulic jacks
4. Sliding Bearings

- Steel rollers or PTFE (teflon) sliding bearings can be used.
- PTFE bearings could be designed to remain as part of the permanent structure.
- PTFE also allows the use of an unguided system.
- Rollers are more costly than PTFE pads and are often used on bridge projects with larger load requirements.
Slide Bearings

Roller Bearings

PTFE Pads
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
- Jacks with capacity well in excess of friction.

<table>
<thead>
<tr>
<th>Slide Mechanism</th>
<th>Coefficient of Friction</th>
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<tbody>
<tr>
<td>Teflon coated neoprene bearing pads</td>
<td>10% of Vertical Load</td>
</tr>
<tr>
<td>Hillman Rollers</td>
<td>5% of Vertical Load</td>
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</tbody>
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Lateral Slide Demonstration Project

NY I-84 Twin Bridges

- 20 Hr closure
- Two weekend nights
- Sept 21, 2013
- Oct 19, 2013
20 Hr Lateral Slide
NY I-84 Twin Bridges
Substantial completion in 10 months