A Renewal Project Brief

A Toolkit for Accelerated Bridge Construction

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Accelerated bridge construction (ABC) techniques have the potential to minimize traffic disruptions during bridge renewals, promote traffic and worker safety, and also improve the overall quality and durability of bridges. Typical construct-in-place processes—such as erecting beams, erecting formwork, tying deck reinforcing steel, placing deck concrete, and allowing concrete to cure—are time consuming; these and other sequential onsite construction activities can disrupt traffic and degrade highway safety. Because ABC entails prefabricating as many bridge components as feasible, it minimizes road closures and traffic disruptions, both goals of rapid renewal techniques.

ABC applications in the United States have developed two different approaches: accelerated construction of bridges in place using prefabricated systems, and the use of bridge movement technology to move completed bridges from an off-alignment location into the final position. Despite the gradual lowering of costs, transportation agencies are hesitant about using ABC techniques because of their perceived risks and higher initial costs. Rather than custom engineering every solution, pre-engineered modular systems configured for traditional construction equipment could promote more widespread use of ABC through reduced costs and increased familiarity with these systems among owners, contractors, and designers.

This document gives an overview of SHRP 2 Project R04: Innovative Bridge Designs for Rapid Renewal, which developed standardized approaches to designing and constructing complete bridge systems. This project created the SHRP 2 ABC Toolkit, which includes recommended design standards and design examples for complete prefabricated bridge systems for routine bridges with span lengths from 40 ft to 130 ft. The Toolkit also includes recommended specification language for ABC systems for future inclusion in the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design and Construction Specifications. The ABC design standards developed in this project were used in pilot projects in Iowa, New York, and Vermont.

Strategies for Accelerated Bridge Construction

For ABC to be successful, ABC designs should allow maximum opportunities for the general contractor to carry out prefabrication and erection. This project focused on three specific strategies for ABC systems:

1. Bridge should be as light as possible
    a. Sized to be manageable for transportation and installation
    b. Simplifies transportation and erection of bridge components
    c. Could improve the load rating of existing piers/foundations

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2. Bridge should be as simple as possible
    a. Fewer girders
    b. Fewer field splices
    c. Fewer bracing systems
    d. No temporary bracing to be removed
3. Bridge should be as simple to erect as possible
    a. Fewer workers on site
    b. Fewer cast-in-place operations
    c. No false-work structures required for prefabricated elements and systems
    d. Simpler geometry

This project classified ABC design concepts into five tiers, based on implementation duration:

- Tier 1: Traffic Impacts within 1 to 24 hours
- Tier 2: Traffic Impacts within 3 days
- Tier 3: Traffic Impacts within 2 weeks
- Tier 4: Traffic Impacts within 3 months
- Tier 5: Overall project schedule is significantly reduced by months to years

Modular bridge systems are particularly suited to be used as a Tier 2 concept for weekend bridge replacements or as a Tier 3 concept, in which the entire bridge may be scheduled to be replaced within one to two weeks using a detour to maintain traffic. Tier 1 concepts include preassembled superstructures, completed at an off-alignment location and then moved via various methods into the final location using techniques such as lateral sliding, rolling, and skidding; incremental launching; and movement and placement using self-propelled modular transporters. Tier 5 involves accelerating a statewide bridge renewal program by months or years through application of ABC technologies in the other tiers.

Standardized Designs

This project identified impediments and obstacles to greater use of ABC (through focus group meetings and surveys) and developed solutions to overcome them. Despite the gradual lowering of costs and the life-cycle cost savings, bridge owners are hesitant to use ABC techniques because of their higher initial costs and perceived risks. Another impediment to the rapid delivery of projects is the slow engineering process of custom engineering every solution. However, pre-engineered modular systems configured for conventional construction equipment could promote more widespread use of ABC through reduced costs and increased familiarity with these systems among owners, contractors, and designers.

Standardized designs geared for conventional crane-based erection would allow for repetitive use of modular superstructure systems, which could make contractors more willing to invest in equipment based on certain methods of erection to speed assembly. Repetitive use would allow contractors to amortize equipment costs over several projects, which is an important component to bring overall costs in line with cast-in-place construction. Where site condition makes crane-based erection difficult, overhead erection using ABC construction technologies provide an attractive alternative. Both of these options are addressed in the recommended ABC standards.

Typical ABC details for superstructure and substructure systems for routine bridges that are suitable for a range of spans are included in the Toolkit. Bridge designers are well versed in sizing beams and designing reinforcing steel for conventional construction for a specific site, and it would be appropriate for the engineer of record (EOR) to perform these functions for ABC projects as well. A single set of ABC designs for national use would not be practical as there are state-specific modifications to LRFD bridge design specifications, including loads, design permit vehicle for Strength II, and performance criteria for service limit states. The EOR, guided by the standard concepts and details and the accompanying set of ABC sample design calculations, would be able to easily complete an ABC design for a routine bridge replacement project. The standard concepts would need to be customized by the EOR to fit the specific site in terms of the bridge geometry, span configuration, member sizes, and foundations. The overall configurations of the modules, their assembly, connection, tolerances, and finishing would remain unchanged from site to site. The ABC designs should also be reviewed for compliance with state-specific LRFD design criteria.

The standard concepts provide substantially complete details pertaining to the ABC aspects of the project. Much of the remaining work in preparing design plans is not particularly related to ABC, but to bridge and site-specific customization. Specific instructions to designers are covered through general information sheets, plan notes, and instructions so that all the key design and construction issues in ABC projects are adequately addressed. The standard concepts, used in conjunction with the ABC sample design calculations and design specifications, will help designers become accustomed to ABC. More information about standardized designs is in the final report.

SHRP 2 ABC Toolkit Overview

This project developed pre-engineered designs to optimize modular construction and ABC. In addition to fostering more widespread use of ABC, standardizing ABC systems can result in greater familiarity with ABC technologies and concepts. The SHRP 2 ABC Toolkit includes the following components:

1. ABC standard concepts (as both PDF and CADD files),
2. ABC sample design calculations (as both PDF and mathcad files),

3. Recommended ABC design specifications (in LRFD format), and
4. Recommended ABC construction specifications (in LRFD format).

This Toolkit is not meant to be a comprehensive manual on all aspects of ABC. It is focused on the design and assembly of routine bridges using ABC techniques that would be of value to engineers, owners, and contractors new to ABC. It complements other publications on ABC, including the final report on this project, which should be consulted for more specific information on topics outside the scope of the Toolkit.

ABC Standard Concepts

Standard concepts were developed for the most useful technologies that can be deployed on a large scale in bridge replacement applications. They include complete prefabricated modular systems and construction technologies as outlined below:

- Precast modular abutment systems
  - Integral abutments
  - Semi-integral abutments
  - Precast approach slabs
- Precast complete pier systems
  - Conventional pier bents
  - Straddle pier bents
- Modular superstructure systems
  - Decked steel stringer system
  - Concrete deck bulb tees
  - Concrete deck double tees
- ABC bridge erection systems
  - Erection using cranes
  - Above-deck driven carriers
  - Launched temporary truss bridge

ABC Sample Design Calculations

Detailed sample design calculations provide step-by-step guidance on the overall structural design of the prefabricated bridge elements and systems for design engineers. The sample design calculations pertain to the same standard bridge configurations for steel and concrete used in the ABC standard concepts. The intent was to provide sample design calculations that could be used in conjunction with the ABC standard concepts so that practitioners new to ABC would get a comprehensive look at how ABC designs are carried out and translated into design drawings and details.

Recommended ABC Design Specifications

LRFD bridge design specifications do not deal explicitly with the unique aspects of large-scale prefabrication including issues such as element interconnection, system strength, and behavior of rapid deployment systems during construction. This project identified shortcomings in the current LRFD bridge design specifications that may be limiting their use for ABC designs and made recommendations for addressing these limitations. Recommended LRFD specifications for ABC bridge design are also included in the Toolkit. Users should note that these recommendations have not yet been formally adopted by AASHTO.

Iowa DOT/HNTB for SHRP 2

Keg Creek Bridge Project

Recommended ABC Construction Specifications

Recommended LRFD construction specifications for prefabricated elements and modular systems include best practices that are to be used in conjunction with the standard concepts for steel and concrete modular systems. As such, these specifications for rapid replacement focus heavily on means and methods requirements for rapid construction using prefabricated modular systems.

Keg Creek Bridge Project

In fall 2011, the designs and construction concepts developed as part of this research project were demonstrated during the replacement of a bridge located on US 6 over Keg Creek in Pottawattamie County, Iowa. The research agency for this project, in collaboration with the Iowa Department of Transportation (DOT), developed detailed bridge plans, details, and specifications that were incorporated into the construction of the replacement bridge. The replacement bridge, completed in 14 days, showcases the following innovative elements:

- Prefabricated superstructure module (precast concrete deck on steel stringers),
- Prefabricated substructure components (precast pier columns and caps and abutment stem and wing walls), and
- Prefabricated bridge approach (precast concrete panels and sleeper slab).

Wendell Davis/FEMA

One of the many bridges in Vermont destroyed by Tropical Storm Irene

To document this demonstration, three videos were produced: a 90-second time-lapse video of the construction, a 10-minute video overview of the project, and a 19-minute video that highlights the specific techniques used.

Iowa DOT's collaboration with SHRP 2 on this project won the America's Transportation Awards competition in the category of Best Use of Innovation award for a small project, which celebrates excellence in innovative management techniques and use of technology. The America's Transportation Awards competition—which is sponsored by AASHTO, AAA, and the U.S. Chamber of Commerce—recognizes the best transportation projects by state departments of transportation in three categories: Best Use of Innovation, Under Budget, and Ahead of Schedule.

Toolkit in Action

Following Iowa's success with the Keg Creek project, two other states made plans to use the SHRP 2 ABC Toolkit.

After Tropical Storm Irene washed out more than 2,000 roads and damaged hundreds of bridges in Vermont, the Vermont Department of Transportation (VTrans) looked to SHRP 2 for help. VTrans is using the SHRP 2 ABC Toolkit to replace 17 bridges. The projects are using precast NEXT beams on precast abutments on steel H-piles with precast approach slabs. Vtrans adapted the SHRP 2 ABC Toolkit to suit its practices. The first four bridges were the Hancock Bridge on VT 125, the Warrant and Jamaica bridges on VT 100, and the Brighton Bridge on VT 105. The additional bridges are in project development.

The New York State Department of Transportation is using the SHRP 2 ABC Toolkit to replace the eastbound and westbound I-84 bridges over Dingle Ridge Road using lateral slide technology. The existing structure is a 135 ft three-span steel girder superstructure. The replacement bridges will use modular double-tee NEXT beams joined with UHPC closure pours. This project is currently under construction and the lateral slide will be completed over two weekends in September 2013—one closure for each bridge. Whereas a conventional bridge replacement would have added two years to the timeframe and $2 million in additional costs, these innovative ABC techniques will eliminate the need for a temporary bridge, minimize traffic impact, improve safety, and minimize environmental impacts to the New York City watershed area.

Status

This project will be completed in December 2013. The videos from the Keg Creek Demonstration are available at www.TRB.org/SHRP2/KegCreek. The final report is available at http://www.trb.org/Main/Blurbs/167693.aspx and the Toolkit is available at http://www.trb.org/Main/Blurbs/168046.aspx. A supplement to the toolkit will be published based on the results of the Vermont and New York Pilots. Videos of those pilot projects will also be made available in late 2013.