Accelerated Bridge Construction

Speeding the replacement of workhorse bridges to minimize traffic disruption and user costs
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Cover: Lake Champlain Bridge Replacement

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In October 2009, the Lake Champlain Bridge was unexpectedly closed due to irreparable pier cracking below the water level. The shutdown meant area residents would have to navigate an 85-mile detour to reach life-saving emergency services, jobs, childcare, shopping and loved ones.

The New York Department of Transportation and the Vermont Agency of Transportation, bi-state owners of the bridge, knew the closure would affect constituents’ lives. But, in the transportation world, safety trumps mobility.

“No one wants to make the decision to suddenly close a workhorse bridge,” said Rob Turton, HNTB bridge practice leader. “But with more than 600,000 bridges in the U.S. needing to be replaced, widened or rehabbed, more and more owners will need to do so.”

The economic and daily life burdens on the residents of Crown Point, New York, and Chimney Point, Vermont, are known as user costs — risks that did not exist when most bridges were built on new alignments 50 or 60 years ago. To tame those risks, owners need solutions that accelerate bridge repair and replacement.

And now they have them.
“ABC uses innovative methods of planning, design contracting and construction to dramatically reduce mobility impacts—bridge replacement projects that took years can be constructed in a matter of days!”

— Bala Sivakumar, PE  
Director of Special Bridge Projects, HNTB  
Author of ABC Toolkit

INDUSTRY BRINGS ABOUT CHANGE

The Transportation Research Board and the American Association of State Highway and Transportation Officials believed user costs could be reduced dramatically if bridges could be constructed faster. In 2009, they initiated the second Strategic Highway Research Program to evolve accelerated bridge construction from an isolated, one-and-done practice to a mainstream renewal method.

Working with TRB and AASHTO, HNTB and a team of subconsultants, including Iowa State University, embarked on a six-year program to develop a suite of standardized ABC products. They reviewed individual standards and specifications from pioneering states, identified best practices and eliminated obstacles.

In 2012, the Strategic Highway Research Program Report S2-R04-RR-2: Innovative Bridge Designs for Rapid Renewal: ABC Toolkit was published, changing the way the industry views bridge construction.

STANDARDIZING ABC FOR MAINSTREAM USE

The ABC Toolkit guides bridge owners through implementation. Users will find descriptions of standardized approaches to designing and constructing complete bridge systems for rapid renewals in addition to:

- Design standards and examples of completed prefabricated bridge systems for routine bridges with span lengths of 40 to 130 feet
- Sample specification language for ABC systems, which adheres to AASHTO’s LRFD Bridge Design and Construction Specifications
- Erection concepts for prefabricated bridge systems
- Slide-in construction concepts

“ABC uses innovative methods of planning, design contracting and construction to dramatically reduce mobility impacts—bridge replacement projects that took years can be constructed in a matter of days!” said Bala Sivakumar, PE, director of special bridge projects for HNTB and the author of the ABC Toolkit.

With ABC, activities are performed concurrently and in a controlled environment to quickly and efficiently design, procure, fabricate and erect replacement bridge systems. The result often is a faster construction schedule.

“That’s important,” Sivakumar said. “Although shorter project durations often are a common attribute of ABC, its mission is to minimize traffic disruption by moving construction away from traffic and building as much of the new bridge as possible offline.”

The toolkit groups ABC design concepts into five classes based on mobility impact duration:

TIER 1: Projects can be completed in 24 hours
TIER 2: Projects can be completed within three days
TIER 3: Projects can be completed within one to two weeks
TIER 4: Projects can be completed within three months
TIER 5: The overall project schedule is reduced from years to months

Each tier dictates the type of technology the owner will use. For example, a Tier 1 project would use a slide-in construction method, whereas a Tier 3 project would require on-site assembly of prefabricated bridge elements and systems.

“The toolkit takes a lot of the risk out,” Turton said. “There is nothing more reassuring to cash-strapped transportation agencies than to hear, ‘This method works, and here’s how to do it.’ It elevates ABC to a more reliable position.”
DEMO AT KEG CREEK
ELIMINATES SIX-MONTH CLOSURE

The ABC Toolkit was deployed on two demonstration projects. The first: Iowa’s U.S. 6 Bridge over Keg Creek. The 1953 structure, 20 miles outside of Council Bluffs, was due for replacement and had a size and span configuration typical of bridges needing replacement in Iowa. It was the perfect demonstration candidate.

The Iowa Department of Transportation prefabricated nearly 100 percent of the bridge components, including modular superstructure units with precast barriers and backwalls; precast concrete pier caps and columns; precast abutments and wingwalls; and precast concrete approach slabs. The prefabricated elements were delivered to the construction site over a period of one to two weeks and assembled like Legos®. The drilled-shaft foundations were the only components cast in place and were completed prior to closure.

Within a 14-day implementation, the Tier 3 ABC project delivered a new bridge from foundation to modular concrete-steel composite superstructure, eliminating a six-month bridge closure and a 14-mile detour.

According to Sivakumar, the construction cost alone was 25 percent higher than the DOT’s original estimate, but when you consider the savings in eliminating the temporary bridge and user delay costs, ABC was the lower cost option.

Iowa’s U.S. 6 Bridge over Keg Creek project eliminated a six-month bridge closure and a 14-mile detour. View a time-lapse video of the Keg Creek bridge replacement: www.youtube.com/watch?v=4E9VUsiZUwA.

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In late 2013, the New York State Department of Transportation implemented a Tier 1 demonstration project, replacing twin (east- and westbound), 135-foot-long, three-span, steel composite girder structures on Interstate 84 over Dingle Ridge Road. Using the toolkit’s guidance for lateral slide design and construction, each bridge was replaced in a single weekend night.

Expediency was paramount. The section of I-84, which connects New York and Connecticut, is heavily traveled, carrying approximately 75,000 vehicles a day.

“We had planned to replace the bridges conventionally in two nine-month construction seasons,” said Bill Gorton, NYSDOT regional director. “ABC cut the project length in half, reducing traffic impact dramatically.”

Using a precast replacement deck, the new bridges were constructed directly adjacent to the existing bridges. Crews slid the new structure into place using bridge movement technology specifically designed for overnight replacements. Only 10 months after the construction contract was awarded, the lateral slides for the I-84 bridges over Dingle Ridge Road were completed. The project for the two bridge slides only required two 20-hour weekend closures — one closure for each structure.

According to Gorton, NYSDOT paid a premium for the lateral slide technique compared with traditional costs. However, the department was able to reduce the contract’s duration, and by avoiding the cost of erecting a temporary bridge, the DOT saved taxpayers $2 million. The savings would have been substantially higher if user delay costs were recognized.

Bill Moreau, former chief engineer for the New York State Bridge Authority, said standardizing ABC approaches with the toolkit is worthwhile.

“It allows agencies to tailor the concepts to the job and specific needs,” Moreau said. “You don’t have to reinvent the wheel every time you do an overpass.”
Why are some owners hesitant?

Despite the compelling results, some owners are hesitant to use ABC techniques. Focus group meetings with representatives from more than 20 state departments of transportation identified four reasons for slow adoption:

1. **Initial cost is too high.** ABC’s higher implementation costs hamper widespread and sustained implementation. But as Sivakumar points out, "ABC can be the most cost-effective means of construction, especially when line item costs, such as right-of-way acquisition, project administration, maintenance of traffic, utility relocation or railroad flagging, are considered.”

   And, with ABC, there are no long-term work zones, which improves worker and motorist safety and helps reduce the 2,000 fatal work zone crashes that occur annually in the U.S.

   "Plus, productivity goes up," Sivakumar said. “Component fabrication and curing can continue year-round at ground level in a controlled environment, which improves worker productivity, safety and the quality of the finished product.”

   And, because ABC minimizes on-site construction time, it is a particularly effective tool for historical or environmentally sensitive areas or for statewide bridge replacement programs. Significant cost and time savings can be realized by clustering similar bridges into a single ABC contract.

2. **Greater risk.** ABC generally is perceived as raising the level of project risk. Therefore, designers are reluctant to suggest the approach. Plus, many procurement methods do not offer incentives for creativity.

   "However, alternative contracting mechanisms, such as best value awards, allow engineers and contractors to team up, present their best ideas and introduce innovative designs and construction technologies to projects,” Sivakumar said.

3. **Profitability.** Contractors have said large precast elements diminish profitability. Moreover, ABC involves new technology, and contractors prefer to keep their employees working instead of subcontracting to precasters.

   According to Sivakumar, owners either can counteract those attitudes by introducing the industry to precast technology and demonstrating its profitability, or they can borrow a page from Iowa’s playbook. The DOT emphasized constructability that could be mastered by local contractors and kept prefabricated elements within a 50-ton range — a weight that could be lifted by conventional equipment. It worked.

   Letting for SHRP 2 R04 attracted seven local bidders — an above-average number — for a typical DOT bridge project.

   Additionally, Iowa allowed the contractor to self-perform the precasting near the site, which kept crews busy and saved transportation costs.

   "Many states are allowing this as an option for fabricating non-prestressed components,” Sivakumar said. “It’s a win-win solution for the owner and the contractor.”

4. **Custom engineering.** Custom engineering every solution is another major impediment to ABC’s adoption. But as Sivakumar points out, pre-engineered modular systems — configured for traditional construction equipment — can reduce costs and encourage local contractors to bid on rapid replacement projects. Repetition makes precast components more economical and construction faster and more efficient.

   “Building this capability, however, requires working with local contractors over several projects,” he said. “Standardized ABC designs increase familiarity of this technology among owners, designers and contractors, and the ABC Toolkit has fostered greater use of ABC standards.”
The stage is set for ABC to become a common tactic for rapid bridge renewal. Accelerated bridge construction methods have increased traffic and worker safety, improved the overall quality and durability of bridges, minimized traffic disruptions and significantly reduced user costs. It’s how NYSDOT and VTrans completed the Lake Champlain Bridge in less than two years. The eight-story, 402-foot center arch span was floated out to the construction site and hoisted into place by four strand jacks.

As former NYSDOT Regional Director Mary Ivey said, “The project began as a crisis but resulted in an incredibly successful, collaborative effort progressed in unprecedented time frames.”

That’s what ABC is all about.

Making the shift to ABC

Some bridge owners may be eager to embrace ABC but are unsure of how to institute it. One key is to begin implementation early, using proper ABC planning and design activities:

- **Encourage collaborative strategy meetings among owners, designers, contractors and suppliers**
- **Acquire right of way**
- **Relocate utilities before advertising the project**
- **Secure early environmental clearance and permitting**
- **Prefabricate bridge components—or the entire bridge**
- **Complete geotechnical engineering enhancements, such as modular walls**

In addition to those efforts, below is a starter list of best practices that will help acclimate business models to the fast-paced world of accelerated bridge design and construction:

- **Seek outside resources to supplement staffing shortfalls.** A program manager or general engineering consultant can help develop best practices in ABC and/or alternative delivery, draft procurement documents, oversee construction according to specific delivery methods and augment staff where needed. Further, bridge designers might find cost estimating and scheduling assistance beneficial; ABC projects entail unique challenges not captured in historical bid prices.

- **Adopt new quality-control procedures that align with accelerated delivery.** Ongoing over-the-shoulder technical reviews, periodic check-ins and contractor reviews are necessary and becoming commonplace with newer delivery methods.

- **Consider alternative funding sources.** For example, with tolling, DOTs can deliver critically needed spans now as opposed to waiting 20 to 30 years.

- **Stress value, not lowest price.** A better design or construction solution may cost more initially, but it may be the best value over the facility’s lifetime.
ABC projects in 10 states

HNTB is working as designer or program manager/owner’s engineer on accelerated bridge construction projects in the following states:

1. **Louisiana:** U.S. 90 Bridges over L.A. 14, slide-in replacement
2. **Maine:** Western Avenue over I-95, rapid deck replacement
3. **Massachusetts:** Route 18 Bridge over MBTA Railroad, slide-in replacement
4. **Michigan:** Detroit I-94 Corridor Improvement, advanced bridge replacement
5. **Minnesota:** Minneapolis Franklin Avenue Arch Bridge, arch deck replacement
6. **New Jersey:** Ridge Road over Route 3 Bridge and the Park Avenue and Watchung Avenue bridges, superstructure replacement
7. **Pennsylvania:** Route 30 over Bessemer Avenue, weekend superstructure replacement
8. **West Virginia:** Bridge in Ghent on the West Virginia Turnpike, rapid deck replacement
9. **Georgia:** State Route 299 Bridge over I-24
10. **Mississippi:** Developing ABC guidelines
VTrans draws on ABC Toolkit to replace bridges damaged by Hurricane Irene

Precast elements, systems lead to successful, timely completion of 14 bridges

THE SITUATION
After Hurricane Irene damaged numerous bridges in 2011, the Vermont Agency of Transportation turned to the ABC Toolkit to help jump-start three replacement projects.

“We had to fast-track designs and plan development in order to obligate federal funds within one year of the flooding event,” said Kristin Higgins, accelerated bridge program senior project manager for VTrans. “The ABC Toolkit gave us the head start we needed.”

THE APPROACH
To gain economies of scale, VTrans designed two bridges together. By pulling details from the ABC Toolkit, modifying them to fit the agency’s geometrics and creating tables for information, VTrans reduced preliminary engineering costs of the two projects by 25 percent.

“The ABC Toolkit gave us the information and the incentive to create our own toolkit, and I think that’s how it should be used,” Higgins said.

Both projects were delivered to procurement in 11 months as scheduled and to construction on time.

“The kit was instrumental in helping us accelerate project delivery and reduce costs,” Higgins said. “Typically, our fast-track bridge projects are completed in approximately half the time of conventional construction, often in just one construction season.”

THE RESULTS
VTrans continued to develop and refine ABC details and has successfully replaced all 14 bridges damaged by Irene, with many using precast bridge elements and systems.

“We are developing projects now with an option for using precast concrete NEXT beams or precast decks on steel beams. We’ve allowed contractors to self-perform many of the precast details (those without prestressing),” Higgins said.

Most recently, the agency used the lateral slide method to replace two highway bridges over U.S. Route 5 on Interstate 91. Hydraulic jacks pushed the bridges in place, a first for Vermont. The Hartford Bridges project was completed this past September over two weekends, one weekend for each bridge.

Road closures on Interstate 91 were limited to two weekends. U.S. Route 5 remained open while the two bridges were moved into place. ■

Photos courtesy of VTrans.
"We had to fast-track designs and plan development in order to obligate federal funds within one year of the flooding event. The ABC Toolkit gave us the head start we needed."

— Kristin Higgins
Accelerated Bridge Program
Senior Project Manager
Vermont Agency of Transportation
Prefabrication, lift help SEPTA take bridge replacement from contract to completion in under 11 months

Superstructure, bearing seats replaced without interrupting rail service

THE SITUATION
When the Southeast Pennsylvania Transportation Authority retained HNTB in January 2009 to assess the condition of Bridge 20.25, an inspection revealed the need for full replacement of the superstructure, concrete bearing seats, bridge timbers and rail.

The bridge was a 1905 twin, two-girder, open-deck structure located on SEPTA’s busy Lansdale Regional Line. In addition to a deteriorating superstructure and concrete bearing seats, the aging bridge had substandard design features and an insufficient load rating. The bridge’s condition, coupled with immediately available federal stimulus funds, created an opportunity for SEPTA to address a significant need on its rail system.

SEPTA’s goal was to replace the structure and restore reliability and ride quality to the rail line with minimal disruptions to commuter rail service during construction. However, to achieve that goal, the project would have to overcome weighty, and sometimes unexpected, challenges:

• Delivering the final plans, specifications and estimates package in six weeks to receive federal stimulus funds
• Maintaining rail service with limited track outage work windows
• Minimizing the impact to overhead catenary systems
• Preserving the high-quality-designated stream below
• Working without existing bridge plans
• Limited site access
• An unexpected labor union strike
• Three unscheduled World Series baseball games

THE APPROACH
SEPTA retained HNTB as prime consultant for the replacement. In addition to bridge inspection, HNTB provided preliminary engineering, final design, permitting, staging and phasing, and construction support services for the rapid replacement of the bridge superstructure and concrete bearing seats.

HNTB delivered the final plans, specifications and estimates package within six weeks from SEPTA’s notice to proceed and final design in only three weeks. The new bridge would consist of welded, two-girder weathering steel bridge superstructures with an open timber deck.

To work around the overhead catenary system, HNTB used standard construction equipment in unconventional ways.

“The rail industry sometimes uses Caterpillar 583T pipe-laying equipment with side booms to put derailed locomotives back on the tracks,” said Rob Bistline, HNTB project manager.

If one 583T was positioned at each end, the equipment could lift bridges as well as locomotives.

“It’s like a double roll in, roll out,” Bistline said. “The bridges are rolled out/in on rail cars on the adjacent track. Then the 583Ts laterally roll the new structure into position.”

To ensure the 583Ts and new bridges would have adequate clearances with anticipated movements, HNTB used 3-D laser scanning technology to accurately locate overhead catenary systems and other aerial utilities.

“It’s like a double roll in, roll out. The bridges are rolled out/in on rail cars on the adjacent track. Then the 583Ts laterally roll the new structure into position.”

— Rob Bistline
Project Manager, HNTB
The complexity of maintaining rail service during construction was successfully resolved by having a single track on the dual bridge superstructure active throughout the two, four-day construction periods, with the exception of 12 a.m. to 5 a.m., when double track outages were permissible for major construction lifts. These operational constraints required a minute-by-minute work plan for each weekend outage.

THE RESULTS
The accelerated bridge design and construction tasks exceeded expectations. Through a shared philosophy on construction methodologies and working closely with the SEPTA project management team, the bridge replacement went from contract to completion in under 11 months. The contractor successfully removed the existing bridge structures, installed four new precast concrete bearing seats and set in place the two new, completely assembled bridge superstructures.

The maintenance of a single track provided uninterrupted train service with minimal delays for SEPTA passengers and, in two instances, saved the project schedule from being derailed. During the first scheduled weekend outage, an unexpected labor union strike and three unscheduled World Series games put additional burdens on the regional rail system. The strategy of maintaining a single track during peak travel times was crucial to accommodating the increase in passenger volumes.

Because there was no access to the site, the innovative approach eliminated the need for temporary falsework below the structure, which would have required time-consuming waterway permitting for the high-quality stream and jeopardized the overall project delivery schedule.

The project restored reliability and ride quality to a portion of the SEPTA Lansdale Regional Rail Line without interrupting rail service, disrupting the overhead catenary system or impacting the natural resources and aquatic life below the bridge structure.

In 2011, the Bridge 20.25 Lansdale Line replacement project received a Diamond Honor Award from the American Council of Engineering Companies of Pennsylvania.
New Jersey Transit will replace two bridges in two weekends

Self-propelled modular transports will minimize track outages, impact to operations and inconvenience to motorists

THE SITUATION
The Park and Watchung Avenue bridges are workhorses on the New Jersey Transit’s busy Raritan Valley commuter line. The historic bridges carry 27 trains and more than 20,000 passengers a day over two congested local streets in downtown Plainfield. But the bridges weren’t in good repair. Aging, with superstructures in poor condition and low underclearances prone to impacts, the pair of steel, through-girder bridges were the perfect candidates for New Jersey Transit’s ongoing capital program to bring all bridges on the rail system to a state of good repair.

However, high service levels on the Raritan Valley Line and their proximity to the city’s rail station necessitated the historic bridges be replaced quickly with minimal impact to rail operations, minimal track outages and minimal disruption to the surrounding urban business district.

THE SOLUTION
HNTB, the project’s engineer of record, recommended an accelerated bridge construction method using self-propelled modular transporters for two reasons. First, the use of a traditional lateral slide-in and slide-out on temporary bents in the roadway was not feasible. The proposed bridges could not be built and the existing bridges could not be accommodated side-by-side with the existing alignment in the congested downtown area without significant, lengthy impacts to local businesses and station access. Second, both bridges are directly adjacent to Plainfield Station, with one bridge at each end of the station platforms. Therefore, switching tracks between structure bays to stage construction was not a viable option, either.

According to HNTB Project Manager Phil Christian, the transit agency had used other ABC methods, but the Park and Watchung Avenue bridges will be the agency’s and New Jersey’s first project using SPMTs.

“The transit agency may have experimented with other accelerated bridge replacement methods, but this is their first superstructure to be built off-site and rolled in on SPMT,” Christian said. “In fact, this may be the first ABC roll-out/roll-in replacement using SPMT for a rail transit bridge in the Northeast.”

“Construction at the immediate bridge site will take place on weekends when there is less traffic in and out of downtown and fewer transit riders to be inconvenienced.”

— Phil Christian
Project Manager, HNTB
THE APPROACH
To complete the superstructure replacements, New Jersey Transit agreed to a single two-track weekend outage for each bridge. The Watchung Avenue Bridge’s superstructure is scheduled to be replaced fall 2015. Park Avenue will follow in spring 2016. Each 53-hour construction window will begin at 12:01 a.m. on a Saturday morning and end at 5 a.m. Monday morning.

“ABC will only succeed if you can plan out each construction task hour by hour for the final stage and get everything set up well in advance,” Christian said.

Each bridge has three spans: a main roadway span bordered on each side by sidewalk spans. After the existing rails and ties are removed by New Jersey Transit forces, the flanking sidewalk spans will be lifted out by crane and transported offsite by truck. Using SPMTs, the roadway main span then will be rolled out to the offsite staging area for demolition.

The SPMTs then will roll in the newly constructed main roadway span superstructure, built at the offsite staging area. Next, the previously assembled sidewalk spans will be lifted into place via crane. Finally, New Jersey Transit forces will reinstall the ties and rails before reopening the bridge to normal rail operations.

In addition to replacing the existing superstructures, the project also will increase the bridges’ underclearances without changing the profile of the tracks through a reduction in ballast depth and with the use of shallower floorbeams. Additionally, the agency will make substructure repairs at the abutments and piers.

THE RESULT
A traditional stick-build approach certainly would have taken longer, according to Christian. Getting the replacements done quickly using ABC methods saves the community and commuter passengers the headache of lengthy road and track closures. However, in this case, the traditional ABC method using temporary bents for construction and demolition adjacent to the existing bridges also would require lengthy road closures and would have significant impacts to nearby businesses. The SPMTs allowed for a majority of the construction of the replacement superstructures and the demolition activities for the existing superstructures to take place at a remote offsite staging location, away from the public.

“It would have been a really tough sell to the community to say we are going to take your downtown out for weeks at a time to replace the bridges,” he said. “Instead, construction at the immediate bridge site will take place on weekends when there is less traffic in and out of downtown and fewer transit riders to be inconvenienced.”

The historic Park and Watchung Avenue Bridges carry 27 trains and more than 20,000 passengers a day over congested local streets in downtown Plainfield.