SHRP2, R04
ACCELERATED BRIDGE CONSTRUCTION (ABC) IMPLEMENTATION

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Abstract:

The FHWA is in the process of mainstreaming the research from the recent SHRPR04 Accelerated Bridge Construction (ABC) project. The FHWA has selected seven different projects from across the nation to help introduce various parts of the R04 Tool Kit via construction projects and regional project showcases. The projects range from complete bridge replacements using all precast materials to complete precast piers including pile cap, columns, and cap. Various parts of the R04 Tool Kit are being used including suggested design details and construction specifications. This paper presents an update on the progress of the seven projects including lessons learned to this point. The projects will be under construction during the summer of 2014 and into 2015. The material presented will be of interest to those looking to get bridge replacement projects done quickly, efficiently and with the high quality obtained through the use of precast concrete products.

Keywords: ABC, SHRP2, Precast, Bridge, Accelerated Bridge Construction

INTRODUCTION

When much of our current highway system was constructed, it was on new alignments with little, if any, existing traffic to contend with. As the system has matured, the need to replace and update the existing bridges has led to extensive traffic issues during bridge reconstruction. The need to accelerate the bridge replacement process was recognized by bridge owners and the Federal Government and a research project was initiated through the second Strategic Highway Research Program (SHRP2, Ref. #1). The SHRP2 research project for Innovative Bridge Designs for Rapid Renewal was conducted with special emphasis in three areas. The first area studied was on the reluctance of transportation agencies to shift to accelerated methods of reconstruction for bridge replacements. Reluctance to change and the perception of higher costs associated with accelerated replacements was seen as the main points of resistance. The second area looked at by the research team was current best practices being used by several agencies to replace and rebuild bridges rapidly. Excellent information was available from lead states, such as Utah, on the subject of Accelerated Bridge Construction (ABC). Finally, the best methods were gathered into a final report and an ABC Toolkit. Much of the information presented in the Toolkit was used in practice to construct two demonstration ABC projects, as will be reviewed below.

Throughout the process, many lessons have been learned by the research team and those actively working to accelerate bridge construction. One of the more surprising discoveries was that accelerating bridge construction does not always cost more money. Indeed, there are several examples where the ABC approach has saved significant money to the owner agency directly, as will be detailed in the New York side slide project in this paper. Much of what has been learned during the past five years in the area of ABC can be summed up in a quote from an old bridge designer whom this author worked with years ago; “Look for what works and move that way”. What the designer was trying to say is do not be afraid of something that is different as it might be the next great thing to come along in the industry. In many situations, this is exactly the case for ABC. It is not a “one size fits all” solution, but should be given serious consideration during the project formation phase to see if all parties might benefit from getting in and out faster.

TWO BUILT SHRP2 IMPELEMENTATION PROJECTS

The SHRP2 research team wanted to test the various best practices that had been gathered from around the country in a real life, full scale bridge replacement project to make sure the final Toolkit was tested and worked well.

US 6 OVER KEG CREEK, IOWA:
Working closely with the Iowa Department of Transportation, a scheduled bridge replacement project at Keg Creek just east of Des Moines was chosen to be redesigned from a 4 to 6 month replacement project into a two week maximum total closure replacement.

The proposed project was for a standard, three span steel "I" girder bridge with cast-in-place concrete abutments and piers. The deck would also be cast-in-place, following standard Iowa DOT practices. This plan was redesigned by the SHRP2 team to follow the modular system approach being proposed in the Toolkit. The substructure was be supported by driven steel piling for the abutments. The piers were supported by drilled shafts placed outside of the existing bridge footprint in order to allow placement of the shafts before the existing bridge was demolished. The abutment bodies were precast with precast wings attached with a small closure pour. The piers had precast columns placed on top of the drilled shafts with a precast pier cap running between the two columns. The drilled shafts, columns and caps were attached to each other using grouted bar splicers. (See Figure 1) The use of bar splicers greatly reduced the lap length needed for the reinforcement and was a key lesson for the project and future ABC projects.

Figure 1 – Grouted Bar Splicers

Following the modular concept, the deck was cast on to the beams in modules of two beams, each module being one span long. These deck modules were set next to each other on all three spans. The deck modules were knitted together at the joints between them and over the piers using Ultra High Performance Concrete (UHPC). The intent was for the superstructure to be put in place over several days and cast together to form the ultimate riding surface. UHPC had been used in the past to attach superstructure modules together for simple span bridges, but this was the first use of the approach to make a multi-span continuous bridge. The beams were attached to each other at their bottom flange to create a true continuous bridge for live loads. (See Figure 2)

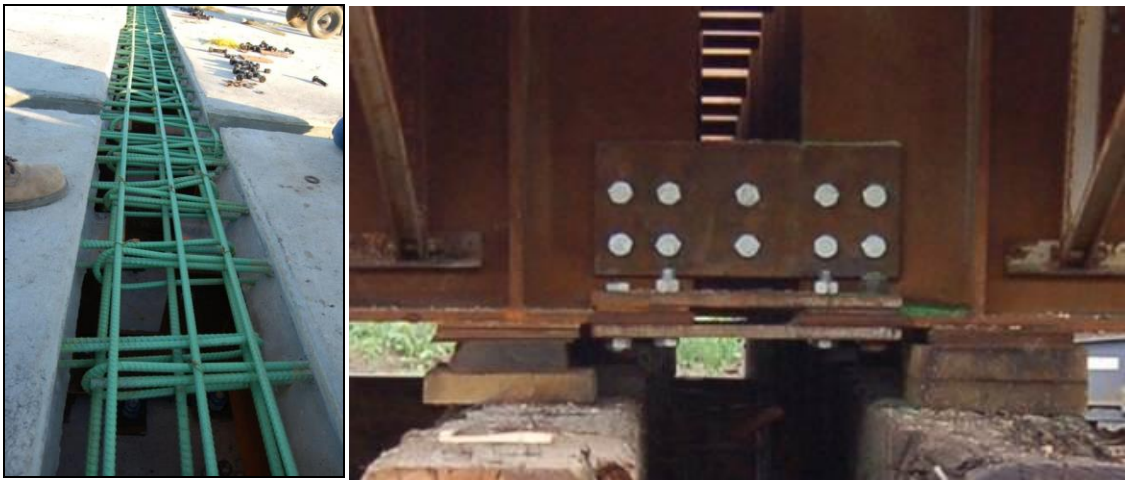

Figure 2 – Continuous Beam Modifications at Deck Top Reinforcement (Left) and Beam Bottom Flange (Right)

The project interrupted traffic for a total of 16 days, considerably shortening the standard closure time of 4 to 6 months. This demonstration project was successfully completed in 2011 and continues to function properly. A post project meeting was held with the owner, designer, and contractor. This meeting in itself was an excellent learning opportunity as the free exchange of what went well and not so well was useful in further refining the approach of the SHRP2 Toolkits. One of the important takeaways from the project was the need for the owner and designer to be open to suggested modifications to the ABC approach from the contractor, as long as all parties agreed that the quality of the final product would not be compromised.

I-84 OVER DINGLE RIDGE ROAD, NEW YORK**:**

The final piece of the SHRP2 research project on ABC included the side slide of an entire bridge superstructure into place with a very short closure period. The project chosen was Interstate 84 over Dingle Ridge Road just north of New York City in New York State. This project was a good candidate to test just how quickly the side slide method could be accomplished as I-84 has heavy traffic and a lengthy closure was not possible. After working closely with the NYDOT, the design team settled on a single span replacement structure built with Northeast Extreme Tee Beams (NEXT Beams). The current clearance at the Dingle Ridge Road overpass was substandard and the new single span NEXT Beams would be somewhat deeper than the exiting three-span steel beam superstructure. In order to accommodate modern clearance requirements, the grade line of I-84 would need to be raised approximately two feet during the bridge replacement project. This grade change would not normally be a challenge during "normal" bridge projects with extended closure periods, but turned out to be the controlling work item during this ABC project. Demolition of the existing bridge and sliding the new super structure into place ended up taking approximately 12 hours. The planned closure period was set at 20 hours for each bridge in order to have time to raise the mainline of the Interstate the required two feet and pave the new driving lanes. All this was accomplished within the projected 20 hour closure.

Figure 3 – Stage Side Layout

For the actual bridge construction, the new superstructure was built on falsework in the median for one side of the interstate and off of the road right-of-way to the side of the second set of lanes. There was a significant difference in elevation between the interstate lanes in this area, preventing the use of cross-over lanes and giving yet another reason for the ABC approach. Figure 3 shows a layout of the two staged side slides before the slides took place.

For this project, the approach slabs were also built ahead of time and slid into place along with the main span. This simplified some of the work during the actual closure period as the approaches came with the bridge, but it was felt afterwards that it might have been more efficient overall to have built the approaches with precast slabs placed after the slide, as sliding the approaches along with the bridge did add substantially to the slide operation. Figure 4 shows a computer rendering of how the approach slabs would look when slid with the main spans.

Figure 4 – Computer Rendering of Slide Operation

Figure 5 shows the first bridge slid into place during the first 20 hour closure period. Note the traffic continuing to flow on the open side while the new bridge is slid into place on the temporarily closed portion of the interstate.

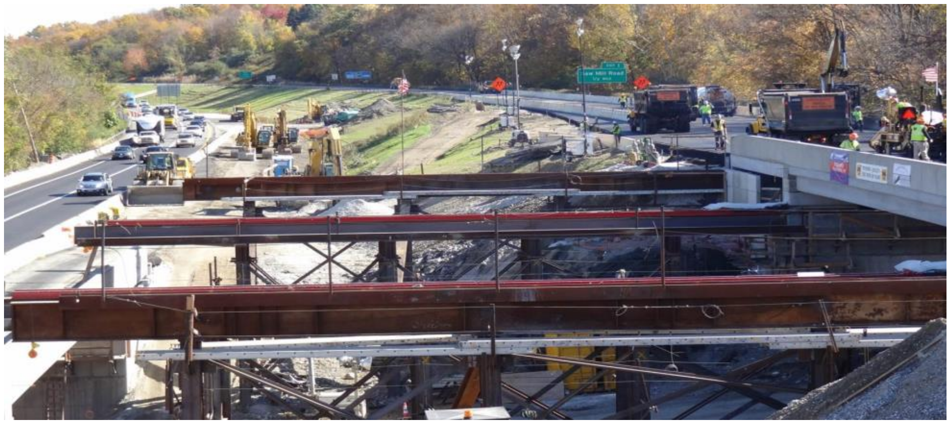

Figure #5 – First Bridge Moving Into Position

Figure #6 shows the second new bridge slid into place and completed with approaches and pavement. This bridge was done during the second 20 hour closure and is shown open to traffic. During these phased closures, Dingle Ridge Road was closed for a total of 5 days to allow for the accelerated bridge demolition. Keeping the interstate open as long as possible was the main goal of the project, but only having Dingle Ridge Road closed for 5 days was also a net gain for the local road users as well.

Figure #6 – Second Bridge Open to Traffic

Dingle Ridge Road was a successful ABC project for several reasons. First and utmost, it reduced the disruption of traffic on I-84 from the originally anticipated two years (two construction seasons) to just two 20 hour closures on two weekends. The savings to the traveling public from a user's cost standpoint was estimated in the millions, but not the main benefit behind the project cost savings. The real accomplishment lies in NOT needing to build cross-over lanes and a temporary road for each of the originally proposed construction stages. The total amount NYDOT saved from not building the cross-overs after the additional cost of the side slide move was calculated at over two million dollars. Dingle Ridge Road is an example of the DOT itself saving real construction dollars by using an innovative ABC method.

SEVEN PROPOSED NEXT GENERATION SHRP2 R04 IMPLEMENTATION PROJECTS

In a process to move the SHRP2 R04 ABC mentality from experimentation to production, the FHWA proposed a series of implementation projects be carried out around the country to showcase the R04 modular and side slide approach in different applications and site conditions. The FHWA requested proposals from any transportation agencies interested in trying this new approach to building quality bridges fast with limited disruption to the public. Over 40 proposals were received with seven of them receiving funding from the FHWA. These seven projects vary in application of R04, but all share with the original R04 mantra of “bread and butter” bridges as found across the country. The seven projects include both concrete and steel super structures, pile supported superstructures and Geosynthetic Reinforced Soil (GRS) abutments, along with a combination of simple and continuous spans.

The reasoning behind the need for speed (or precast elements) varies widely also. In several cases, the reasoning was the traditional reason to choose an accelerated a bridge replacement project; the need to limit the disruption to traffic for as minimal time as possible. What is interesting about several of the chosen projects is the push for precast elements had more to do with the remote location of the project, such as in northern California. The availability of ready mix concrete has caused significant quality issues for cast-in-place concrete in the past and the modular approach provided by the SHRP2 R04 method solves this deficiency while also shortening construction time in an area with a limited window for warm weather. This has been a well-known issue in Alaska and hence their common uses of decked bulb tee girder superstructures.

The following seven project descriptions will illustrate the variety of conditions both from a traffic and location point of view that make the ABC Toolkit approach desirable.

ROUTE 96 OVER FORT GOFF CREEK, CALIFORNIA**:**

The SHRP2 R04 implementation project underway in Northern California is over Fort Goff Creek in Siskiyou County. The location of the Goff Creek Bridge is more than 90 minutes from the nearest ready-mix plant along secondary roads. Delivering ready-mix concrete is a real challenge in this mountainous area. The use of precast bridge elements answers the challenge of building a quality bridge in this remote location. The plan is to build a single-span precast concrete voided superstructure to be placed on precast abutments. The abutments will be supported by cast in drilled piles (CIDP). As California is a high seismic region, the single span nature of the bridge minimizes the seismic concerns and the precast option will function well under the anticipated seismic loads. This bridge has several special aesthetic considerations through the use of form liners that are also well suited for the precast approach. The estimate cost of the prefabricated elements is $540,000 and the total project estimate is $1,770,000 million. Construction will take place in the summer of 2014.

GILA RIVER INDIAN RESERVATION, ARIZONA

Projects can not only vary in reason for construction, but in how they are delivered and administered as well. The Gila River Bridge is a Construction Manager, General Contractor (CMGC) project. In other words, the Gila River Indian Community DOT has contracted the design of the project with a consultant and has also contracted the construction of the project with a selected contractor. The three groups will work together in developing the project plans, specifications, and, ultimately, the overall cost. The CMGC method lends itself well to the ABC approach in that it allows the maximum benefit from the contractor's means and method to be worked directly in to the plans for the new bridge. This differs from the Design/Build approach in that the owner remains an integral part of the team throughout the process. The three groups (owner, designer, and contractor) have to form a true team in order for the CMGC approach to work and this project will be a good test of both means and methods of ABC.

Currently, the project is in the concept phase and a modular approach or side slide methods are still on the table. The expectation is the bridge will use precast abutments and piers. The expected closure time is approximately three weeks. One unique aspect of the bridge in either method will be the need to design and build one "abutment" as a future pier. The bridge is located in an area that experiences frequent flooding and the bridge will be designed to allow it to be lengthened at a later date if so desired. This approach has been used in other states with great success in the past.

The estimate of the precast elements is $840,000 and the total project cost is estimated at $2,584,000. The project is scheduled for construction during the late summer of 2014.

INTERSTATE ON-RAMP, RHODE ISLAND:

This project is more of a traditional ABC project since getting in and out as quickly as possible is the driving force. The bridge being replaced currently has timber bracing under its piers as it needs replacement in the near future. The bridge carries an on ramp to an interstate and cannot be out of service for an extended period of time. The total closure time is expected to be less than 30 days and the project carries significant incentives and disincentives for the contractor. The simple span replacement bridge will be built with precast elements for the substructure. Grouted splicers will be used to connect the substructure elements together. The superstructure will be erected using two modular units with the deck precast onto the support beams and a single closure pour used to knit the two units together. Crushed stone is also planned behind the abutments to speed the placement of backfill and further shorten the closure time of the ramp.

The estimated cost of the precast elements is $800,000 and the total construction estimate is $1.9 million. Figure 7 shows the advanced stages of deterioration of the existing bridge. The project will be constructed during the summer of 2014.

Figure 7 – Existing Bridge Conditions

STEWARTS CREEK BRIDGE, KENTUCKY:

The Stewarts Creek Bridge was originally going to be a standard bridge replacement project. With the assistance of the FHWA R04 Implementation funds, Kentucky Transportation Cabinet (KYTC) is not only using ABC techniques at Stewards Creek, but at a second bridge replacement location as well. KYTC used A + B bidding (cost plus time) to help limit the amount of time the bridge replacements will take. The winning bid will take an expected 38 days from start to finish with only three weeks of total road closure allowed. KYTC is furthering their effort to produce a high quality, long lasting bridge by not only using precast elements, but also using galvanized steel with a duplex coating for the support girders in the two bridges. The combination of galvanizing and then painting should produce a superstructure needing little, if any, maintenance for the girders during the expected bridge life. The bridges being replaced fit the expectations of the R04 bread and butter bridges normally found on our transportation system (See Figure 8). The superstructure will have the deck precast onto it and delivered to the job sites in two longitudinal sections. The two sections will be made into one with the placement of a closure pour. The bar steel in the deck will also be galvanized to ensure a long deck life.

The cost of the prefabricated elements is $400,000 and the total project construction cost is $700,000. This project will be under construction in June of 2014.

Figure 8 –KYTC Bridges Which Will Be Replaced With ABC Bridges

ROUTE 1 KITTERY OVERPASS, MAINE:

The Kittery Overpass Bridge is located on Route 1 in Kittery Maine and is a direct relief route for I-95. With the possibility of needing this bridge at any time as backup to I-95, the need for an ABC approach becomes clear. The goal is to replace this bridge as quickly as possible in order to limit the lack of backup to I-95. The ADT on the bridge is 7740 with 14% of this being truck traffic. The maximum allowed closure of the project is 30 days. This project will include an assortment of precast elements from the abutment walls that will be connected to a cast-in-place footing on bedrock, to the use of Northeast Extreme Tee Beams (See Figure 9 for cross section). The most unique part of this project is the use of carbon fiber prestressing cables in the NEXT beams. This should increase the longevity of the bridge by eliminating one more possible source of steel corrosion from the bridge. The performance of the carbon fiber cables will be of great interest to the bridge community as a whole.

This project has $1,350,000 in precast elements with a total estimated project cost of $2,560,000. The project is scheduled for construction in July/August of 2014.

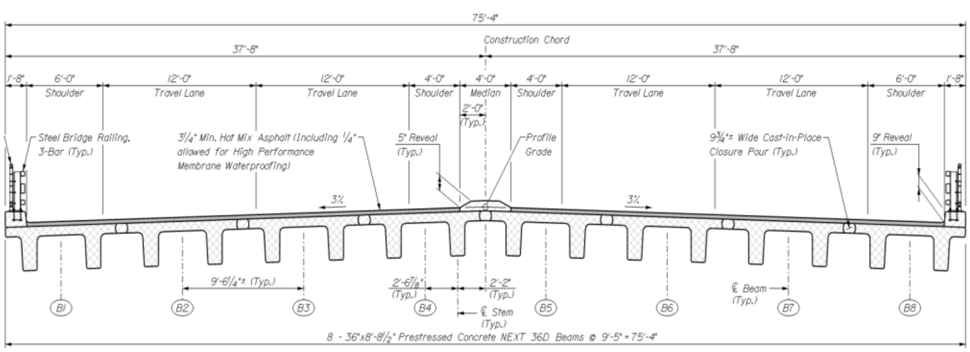

Figure 9 – Proposed Bridge Cross Section

MISSOURI:

This project will combine several ABC techniques. The project team is proposing to use precast/prestressed concrete box beams in combination with Geosynthetic Reinforced Soil (GRS) abutments. The box beams would rest directly on the GRS abutments, eliminating the need for an abutment (precast or cast-in-place) and also eliminate the need to an approach slab as the precast boxes would move with the roadway approach. This combination of systems and elements should produce not only a fast bridge replacement project, but a very economical one as well. The bridge is located in an urban area with high traffic both above and below with the complication of above and below ground utilities. Getting in and out quickly is a must and Missouri DOT (MoDOT) is currently planning on only a 1 to 2 week closure of the roads. A combination project showcase is being planned to involve both the ABC and GRS components of the project.

This project has $360,000 in prefabricated elements with a total project construction cost of $695,000. The project is scheduled for the fall of 2014.

ROAD OVER I-39/90, WISCONSIN:

This project differs from the other six in that the ABC application is to the piers only. A major rehabilitation of Interstate 39/90 between the Illinois border and Madison is planned starting in 2014 and continuing through 2019. Over one hundred bridges will be involved in the project. WisDOT is planning to precast the piers of five bridges under the current R04 Implementation project. The pier caps and columns will be precast and attached to cast-in-place footings through the use of bar splicers (See Picture 1). The push for ABC on the pier construction comes from the majority of the piers being located in the median of the interstate. The project will save an estimated three weeks per bridge by using the precast elements, but the real gain is seen as safety by reducing the amount of time the traveling public is exposed to the construction process and equally the amount of time the contractors' workers are exposed to the traveling public. This is another great demonstration of why the ABC process has so many benefits well beyond just saving time.

This project currently has $502,000 in prefabricated elements with a total construction estimate of $6,897,000. One bridge will be under construction in the fall of 2014 with four more to follow in the spring of 2015. Assuming this project goes well up to one hundred more bridges may be included in future construction on the I-39/90 corridor through 2019.

CONCLUSIONS

As can be seen from the modular bridge built in Iowa in 2011 and the side slide bridges constructed in New York in 2013, the R04 Project Toolkit offers a variety of different options to build quality bridges in an accelerated manner. (Additional information on Slide In Bridge Construction (SIBC) is available at www.fhwa.dot.gov/slide/). With over forty applications received for the current FHWA R04 Implementation projects, the interest in further developing the ABC approach by bridge owners is evident. The seven selected FHWA implementation projects further demonstrate just how varied the ABC world can be. The projects show the following different reasons for consideration of the ABC process.

1. Safety
    a. Of the public
    b. Of the contractor
2. Speed of construction
    a. Total project
    b. Closure to the public
3. Quality of product
    a. Precast
    b. Galvanized
4. Cost savings
    a. To the DOT
    b. To the road user
5. Innovative contracting
    a. A + B
    b. CMGC
6. Innovative materials
    a. UHPC, HPC, HPS
    b. Carbon fibers
    c. Rebar splicers
7. Innovative systems
    a. Modular construction
    b. Slide In Bridge Construction (SIBC)
    c. Geosynthetic Reinforced Soil (GRS) abutments

With all these advantages it is easy to see why the ABC process is becoming the norm in some states and catching on in others as the successful list of ABC projects continues to grow. Building bridges faster, with higher quality and the real possibility of cost savings is here now and being demonstrated by many innovative bridge projects across the county.

REFERENCE

#1. SHRP2. 2013. Innovative Bridge Designs for Rapid Renewal, ABC Toolkit. Transportation Research Board, Washington D.C.