SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

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SHRP2 Innovative Bridge Designs for Rapid Renewal: Lessons Learned

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Abstract:

The implementation of the SHRP2 project, *Innovative Bridge Designs for Rapid Renewal* (R04), is coming to a successful close and has produced several positive outcomes and products that can be used by all transportation agencies. The design toolkit offers information on how a transportation agency might approach the process of replacing an existing bridge in a greatly accelerated manner. This process includes prefabricating most of the bridge off-site or in some cases sliding the bridge in from the side with a roadway closure of less than one day. Best practices from around the country were gathered in the toolkit and various methods were tested by eight "lead adopter" transportation agencies during 2014 and 2015. Three showcases were held by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the lead adopter states as well as three peer-to-peer exchanges covering all 50 states and the District of Columbia. The showcases gave the lead adopter states an opportunity to highlight their bridge projects and the many lessons learned when applying the *Innovative Bridge Designs* toolkit. The peer-to-peer exchanges also offered transportation agencies at the state, Federal, and local levels an opportunity to share and learn from each other's experiences.

This paper presents a compilation of the lessons learned during the SHRP2 *Innovative Bridge Designs for Rapid Renewal* project with an emphasis on the experiences and observations of the transportation agencies as they move into the accelerated bridge construction environment.

Key Words: Accelerated Bridge Construction, ABC, SHRP2, Lessons Learned

Introduction

With so many small- and medium-sized bridges needing replacement, Federal, state, and local departments of transportation (DOTs) need innovative design options deploying precast alternatives. As part of the second Strategic Highway Research Program (SHRP2), the *Innovative Bridge Designs for Rapid Renewal* (R04) product was developed to answer that need. At the core of the product is the *Innovative Bridge Designs for Rapid Renewal* toolkit. The toolkit includes standard design plans for foundation, substructure and superstructure systems, subsystems, and components that can be installed quickly with minimal traffic disruptions. It also provides detailed standards and design examples for complete prefabricated bridge systems (PBES), as well as flexible design concepts that can be adapted to most small- and medium-sized bridges. The toolkit and slide-in bridge addendum is available on-line at http://www.trb.org/Main/Blurbs/168046.aspx.

Under the SHRP2 Implementation Assistance Program, the *Innovative Bridge Designs for Rapid Renewal* toolkit has been successfully deployed on 10 state DOT projects including a variety of PBES bridge elements,

construction settings, and erection techniques. In addition, three national project showcases were held beginning in fall 2014, and the first of several regional peer-to-peer exchanges were held starting in late-spring 2015. Product deployment goals include providing simple design and construction planning tools to implement PBES options and sharing the latest Accelerated Bridge Construction (ABC) techniques with an emphasis on "states talking to states." During the various stages of product deployment, numerous lessons were compiled regarding ways to improve PBES designs, project acquisition, and ABC processes. The following is a compilation of these lessons with insights from national ABC experts who presented at the Sacramento SHRP2 Peer-to-Peer Exchange in May 2015.

Overview of the Sacramento Peer-to-Peer Exchange

During the two-day Sacramento Peer-to-Peer Exchange, public transportation agencies shared ideas and best practices about PBES design options, preferred contracting approaches, construction approaches, and the numerous challenges to successfully implementing PBES in an ABC environment. Representatives from each state presented their unique experiences and answered questions from their peers. As expected, the level of ABC experience varied greatly among the states.

The second day also included the participation of consultant designers, contractors, and academia, and featured several presentations from national ABC experts as well as open discussions on the challenges of integrating ABC into the mainstream of bridge design/construction. State participants generally agreed that the issues and challenges facing the implementation of ABC across the states are more alike than different. These observations are included in the following subsections and later in the summary of lessons learned.

State DOT Perspectives

Each attending state was asked to give a short presentation on its ABC activities. The presentations and follow-up discussions became the real heart of the two-day exchange. Below are the major points from the presentations (more details are included in the Lessons Learned section):

- ✓ DOTs are complex and a champion and real top-down support is needed to create effective change.
- ✓ All parties affected by the introduction of ABC must work closely together. They include:
  - o DOT design, permitting, acquisition, and construction groups
  - o Consultants
  - o Contractors
  - o Public
  - o Media

- ✓ ABC costs are complex. The big picture, including such things as traffic control, construction staffing, safety issues, and the needs of the traveling public, must be taken into account.
- ✓ Safety and quality will always be the leading drivers of change within a DOT – speed of construction, regardless of cost, drives the public.
- ✓ Having an ABC decision-making system (simple or complex) is required to clearly understand what project-specific factors drive the potential use of ABC.
- ✓ Environmental issues may dictate the need to consider ABC.
- ✓ The DOTs garner great public and political gain from successful ABC projects.

A large-group discussion among DOT participants drew particular interest in the various contracting practices and strategies for ABC projects. The traditional design-bid-build process works, but may constrain the designer and/or contractor from fully exploring the various ABC options. It was pointed out that some of the best ABC methods

have come from design-build projects where the designer and contractor work hand in hand. In the design-build process, time really is money and the push for speed is real. In the Construction Manager/ General Contractor (CMGC) method of contracting, the owner hires a contractor early in the design process to work side-by-side with the design team. These projects have generally been very successful, providing for equitable risk-sharing and encouraging collaborative innovation to align final designs with the contractor's best means and methods. The SHRP2 Gila River project in Sacaton, AZ (Figure 1) was designed and constructed under the CMGC method of contracting and all three parties -- owner, designer, and contractor -- were very pleased with the process and results. It was clear from all involved that the CMGC method should be added to the list of contracting methods for future use.

Figure 1. Highly successful CMGC bridge slide, February 2015, at the Gila River Indian Community, Sacaton, AZ.

Based on discussions with the DOT participants, ABC does generally cost more than traditional construction. These additional costs are related to perceived risks by the contractor about not completing the job in the tight window allotted for the ABC project. Penalties are real and contractors bid risk just like labor and materials. The need for speed needs to be carefully measured along with the inherent costs of speed. For example, weekend projects are helpful, but cost more than 14-day projects. Some of the more direct ABC issues or risks contractors consider are project disincentives, owner submittal review time, responsiveness of subcontractors, need for larger or specialized equipment, and other items the contractor sees as beyond his or her control during a short ABC window. All of these items add to a contractor's risk and hence the ultimate bid price. As a result, deciding just how fast a project "needs" to be completed is a critical step in the ABC process.

When figuring the actual owner cost of ABC, the cost of the bridge needs to be considered, but so do the potential savings in traffic control, construction management, and safety of shortening the impact to the public. User delay costs are real to the users and should be considered in some form when looking at the need for ABC. Detours cost users both time and money – not to mention the frustration they feel. Several states (Utah, Connecticut, Minnesota, Oregon, and others) have set up formal processes to evaluate the impact of ABC on bridge construction projects and determine whether an ABC approach should be considered or implemented. Although these figures can be difficult to calculate, simply calculating the basic square footage cost of the structures does not always represent the full picture. Stepping back and looking at the total project cost can be an eye opener to those watching the budgets.

Contractor Perspectives

Contractors price three main items – labor/equipment, materials and risk (e.g., schedule, site conditions, weather, environmental impact). In traditional design-bid-build, they understand these well and price them accordingly.

When the project construction process is accelerated, the risk factors increase. If additional subcontractors (precasters) are added, the risk increases again as another step is added beyond the direct control of the prime contractor. It was pointed out during the peer-to-peer exchange that much of this risk can be either mitigated or at least assigned to a specific entity in the CMGC process. When the owner, designer, and contractor work together in a collaborative way, risks can be defined and assigned to the party best suited to handle the risk. This may indeed be the owner, but if the project price is positively affected by this approach, the risks may be worth the potential money savings. Fitting the proposed construction process to the contractors' means and methods also reduces the risks, thereby lowering the price. The contractors in attendance liked the CMGC process and would like to see this contracting tool used more often in the future.

National Expert Perspectives

Three different speakers talked about ABC from a national perspective. One of the recurring themes was to "keep it simple." Complex solutions rarely work out well in the field and always cost more money. Trying to use simple details that allow contractors to use equipment they already own and understand leads to the best combination of quality and price. Precast elements are generally of higher quality than cast-in-place concrete and add value to the final constructed project. Care must be taken to ensure the element joints are detailed well so they will be both long lasting and fit together well when assembled in the field.

One of the ABC issues brought up was expansion deck joints. Experts noted that expansion joints have been problematic over the years so they are generally avoided. Sound deck joints between precast elements need to be part of any proposed ABC solutions in order to be at least as good as the cast-in-place option the ABC method is replacing. SHRP2's *Service Life State Design* initiative fully supports the elimination of expansion-type deck joints to the fullest extent possible.

Experts also discussed the positive impact ABC has on work zone safety. In 2010, 576 fatalities occurred in construction zones. ABC dramatically improves work zone safety by minimizing worker exposure to oncoming traffic and traveler exposure to construction zone hazards. This is a real benefit of ABC and one that is challenging to quantify, but needs to be considered.

Experts noted that Slide-In Bridge Construction (SIBC) is a nice combination of speed and cost. Self-Propelled Modular Transporters (SPMT) can be fast, but can be costly to bring on site. Assembling numerous precast bridge components piece-by-piece will save money, but may take several weeks to complete. All three of these methods have a place in the ABC world. Site conditions and the need to build more quickly will normally lead the project team to the best solution. The experts stressed the importance of considering the bigger picture when assessing whether or not to use an ABC solution.

Lessons Learned

The following "lessons learned", grouped by general category, have been compiled from DOT, contractor, and national expert participants at recent SHRP2 showcases and peer-to-peer exchanges. Some of the items may seem obvious but bear repeating. Others are less obvious and should be considered when looking at building an ABC project.

Cost of ABC

1. As with the introduction of most new technologies, some states are seeing a decline in ABC costs with similarly designed, repetitive ABC projects, and increased acceptance by contractors.
2. ABC is showing up on many design/build contracts. ABC can be an effective tool to assist the contractor in expediting the project and may be cost effective in the bigger picture.
3. Owners need to step back and look at the big picture when it comes to project costs and consider:

a. Cost of traffic control (how long in place).
b. Cost of staff (construction management).
c. Other items such as safety to the public which are harder to quantify, but present a real public benefit.

4. Standardization of ABC approaches saves money.
5. Simple details lower costs. Complex details cost more money. Think simple!
6. Precast fabrication tolerances have a real effect on project costs. Keep tolerances realistic and attainable, giving due consideration to the issues impacting fit-up on the job site.
7. Using an ABC process that aligns with the local contractor's equipment can help control costs.
8. Engaging all design and construction parties involved early in the project through construction phase ensures that unforeseen issues, onerous specifications, submittal review issues, or other issues do not impact the accelerated aspects of the project.

Speed of ABC

1. In some areas, the length of the detour is a real driving factor behind using ABC.
2. ABC is not just about building the bridge more quickly, but also mitigating traffic, safety, and environmental impacts.
3. Self-Propelled Modular Transporters (SPMT) work well, but are expensive. If speed is the main goal, however, SPMT may be the right solution.
4. Slide-In Bridge Construction (SIBC) can be a cost-efficient form of fast ABC if the site is appropriate for this approach.
5. The use of precast is common in the ABC world although occasionally some elements can be cast-in-place as fast as precast elements and should be an allowed option for the contractor.

Policy-Related Issues

1. Many ABC resources are now available, including the FHWA website along with Utah and other states that have published manuals and best practices: http://www.fhwa.dot.gov/goshrp2/Solutions/Renewal/R04/Innovative_Bridge_Designs_for_Rapid_Renewal
2. Several states (Minnesota, Oregon, Utah, Connecticut, and others) have developed several different ways to decide if an ABC approach is appropriate for projects during the scoping phase.
3. In assessing whether or not to use ABC, consider the real goal of the project. Is it ensuring the least disruption to the traveling public or lowest cost to the owner agency? This question needs to be asked and answered early in the process.
4. States need to look at opportunities to allow the prime contractor to cast elements without the precast certification requirement. This would make it more attractive to bid ABC projects since the contractor would retain more of the work. (This concept does not include precasting prestressed elements.)
5. ABC is not the right approach for every project. The specifications of the project and the local conditions need to be considered carefully when exploring an ABC approach.
6. Several states now have a chapter in their Bridge Manual devoted to ABC. At this time, 44 states consider ABC during project development with 6 states operating dedicated ABC programs.
7. Projects should be scoped according to the goals for the project, not just cost.
8. Environmental issues can be a strong driver for ABC. For example, an ABC project was built in upper Michigan in the middle of the winter with precast elements. The main driver was the sensitive marsh land

in a wildlife preserve. With the marsh frozen, minimal effects were seen from the construction activities and the project was completed before the spring thaw.

9. Length of construction season can be a strong driver for ABC. Projects that in the past took more than one season can now be competed in one, preventing the construction site from being exposed to harsh winter conditions.

Owner-Related Issues

1. DOTs need to innovate if they want to meet user demands related to structure capacity, availability, and durability.
2. By exercising good engineering judgment supported with proven technology (such as the SHRP2 PBES toolkit), risks in "trying something new" can be avoided.
3. Durable connections between precast elements are a must to gain acceptance with owners.
4. Changing the "we have always done it this way" paradigm is not easy. Top-down support and a team approach is needed to effectively change the current environment to promote ABC.
5. DOTs can gain tremendous political capital by employing ABC on their projects (Figure 2).
6. In 2010, 576 fatalities occurred in work zones. ABC can improve work zone safety by reducing the exposure of the public to the contractors' operations (and vice versa).
7. Using precast elements on an ABC project improves the quality of the final bridge. Better concrete mixes and more controlled curing lead to these durability improvements.

Figure 2. Local media interviewing Wisconsin DOT ABC Project Manager about accelerated construction activities along the USH 29 corridor near Green Bay, WI.

Technical Issues

1. Geotechnical issues can be a major concern on ABC projects. The method of structure support must be closely considered since it directly affects the project's progress in many cases. Spread footings are fast and inexpensive, if applicable.
2. Post tensioning in an ABC world tends to take extra time.
3. Simplicity is important and overcomplicated designs may not be successful. Meeting with contractors before bidding is critical when new ABC methods are being rolled out.
4. Ultra High Performance Concrete (UHPC) is a useful tool but needs to be used only when needed since it is expensive. (States are developing their own generic versions of UHPC at this time.)

5. Geosynthetic Reinforced Soil (GRS) is a fast and simple way to build abutments and/or approaches. Scour remains a concern when they are used for water crossings.
6. The shop plan review process require close attention. This is important and well worth the effort in order to prevent field issues.
7. Bridge deck overlays can help with minor deck vertical alignment issues.
8. The weight of precast elements need to be closely monitored. Having to mobilize and use big cranes can be costly.
9. Precast spread footings, when applicable, promote fast construction.
10. ABC can help solve some weather-related issues, such as cold temperatures or rain.
11. Avoiding expansion deck joints reduces future maintenance costs. Reduced joints need to be part of most ABC methods.
12. Grouted reinforcing splice couplers are well suited for ABC projects. Tests have shown they have good seismic properties. Check bar clearances in locations of bar couplers.
13. Durability of joints is not an issue if quality details are used. Keep joint details simple and, if desired, have the precast elements fitted to each other in the precast yard to guarantee a good fit in the field.

Contractor-Related Issues

1. Contractors prefer to retain as much of the work within their company and direct control as possible.
2. Working closely with the contractor before, during, and after the project is key to long-term success of ABC. A debriefing meeting after the project is complete can yield many good lessons learned to bring forward to the next ABC project.
3. Contractors bid risk along with labor and materials. Risk tends to lower with each completed ABC project.
4. Contractors like CMGC contracts because these work to their strengths.

Contracting with ABC

1. CMGC contracts can work very well as long as all parties (owner, designer, and contractor) truly buy in. (Several good examples of CMGC projects were cited during the exchange.)
2. Contractors know how to build bridges so their suggestions for improving the ABC process may bring value to the project.
3. Most ABC projects go well, due to the emphasis on good communication between all the involved parties. Good communication equals good projects!
4. Owners like the direct input and better control they receive under a CMGC contract than the less controlled design/build process.
5. How tight an ABC schedule is set dictates risk and costs to the contractor. Pick your timeline carefully and consider what the project “really” needs. An extremely fast timeline can be costly.
6. CMGC contracts often come down to each party (owner, designer, contractor) being willing to accept the input of others to find a good solution. Be open to suggestions.
7. CMGC contracts are all about trust. Build trust and the rest is simple.

8. Assignment of risk during the CMGC process can help reduce the overall project costs.
9. Incentives/disincentives need to be carefully used in contracts. Too little and they are meaningless. Too much and the disincentives lead to big risks for the contractor and costs to the owner.

General ABC Topics

1. The owner, designer and contractor need to dedicate their best people to the proposed ABC project to make sure it is successful as these are dynamic, fast moving projects with little extra time allowed for idle talk.
2. At some time in the not-too-distant future, we will call these methods BC (Bridge Construction) and not ABC because this approach will become the norm.
3. Not every project needs an ABC solution, but some really benefit from the approach (Figure 3). Identify the projects that could most benefit from an ABC solution and boldly move forward!

Figure 3. Superstructure ready to be picked up and swung into place on Warren Avenue project, Providence, RI.

Summary

The SHRP2 showcases and subsequent peer-to-peer exchanges have been a success. Owners had the opportunity to hear what the ABC-related issues were in other states and many realized they were facing similar issues and concerns. Designers had the chance to hear the issues and concerns owners are experiencing with ABC and how they would like to see them addressed on future projects. Contractors had the opportunity to share their concerns about the ABC method of construction directly with owners and designers. It's clear from the discussion that contractors not only factor in labor and materials into the price, but also the potential risk of the project.

As the ABC methods mature, all parties involved in the process will become better informed about the costs and benefits of building bridges with an accelerated approach. Prefabricated bridge elements and systems as presented in the *Innovative Bridge Designs for Rapid Renewal* Toolkit are good examples of how the bridge building industry can reduce user delays and improve quality and safety of the constructed project. These peer-to-peer exchanges have, as one attendee noted, "Lit the fuse of the ABC world" so we can all see the benefits of this growing methodology.

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