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| 16. Abstract <p>Accelerated bridge construction (ABC) is a solution for upgrading substandard bridges that reduces construction and closure times and minimizes exposure of the traveling public and road workers to construction activities. To take full advantage of the benefits of ABC, agencies should decide which projects are appropriate for ABC and how to bid these projects given the unique attributes of ABC methods.</p> <p>The research team compiled information on decision matrices for identifying ABC projects and outlined bidding processes for projects that utilized ABC. Four ABC projects in three states (Georgia, Indiana, and Minnesota) were then investigated in detail. Note that this project coincides with a partner project that contained similar information collection efforts for project delivery methods (Delivery Methods for Accelerated Bridge Construction Projects: Case Studies and Consensus Building [ABC-UTC-2016-C1-ISU01]). The research team reached out to personnel involved in the projects to discuss bid items, contracting methods, and lessons learned. The results of this effort are included in this report and also in four standalone case study summaries.</p> <p>The case studies suggest that, when bids allow for flexibility, innovation is often incorporated into the project, which results in financial savings for the agency and/or time savings for the traveling public. After a project is completed, the agency can benefit from reviewing the lessons learned and successful aspects of the project and applying these to future projects.</p> | | | | | |
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Bidding of Accelerated Bridge Construction Projects: Case Studies and Consensus Building

Final Report
March 2020

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Accelerated Bridge Construction University Transportation Center



ACCELERATED BRIDGE CONSTRUCTION
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INTRODUCTION

Accelerated bridge construction (ABC) is a solution for upgrading substandard bridges when closure times are of critical importance, as well as one for repairing existing individual bridge elements. ABC provides several benefits, such as reduced construction times and less exposure to construction activities for the traveling public and roadway workers.

However, ABC has received a reputation for being more expensive than conventional construction. This reputation is not always earned, and it is often found that ABC has good value and can compete cost-wise with conventional bridge construction, especially when user costs are taken into account. In addition to concerns with the cost of ABC projects, there is also hesitancy to incorporate ABC due to questions regarding optimal project delivery methods, contracting and procurement, and the determination of bid items that result in competitive bidding.

To address these concerns, this work documented a select number of past ABC projects with a particular focus on the project delivery methods and bid items that were used and the lessons learned from each project. The research plan included a detailed review of literature related to how the decision is made to use ABC on a project and how the delivery methods and bid items are selected. The research team also reviewed research related to procuring and contracting ABC projects. Note that the information collection efforts for this project were done simultaneously with those needed for the partner project, *Contracting Methods for Accelerated Bridge Construction Projects: Case Studies and Consensus Building [ABC-UTC-2016-C1-ISU01]*.

After the literature review was complete, several ABC projects were identified as candidates for further investigation via detailed case studies to obtain case-specific information and the lessons learned from each project. The ABC projects were identified by using the ABC-UTC database that can be found on the ABC-UTC website (<http://utcdb.fiu.edu/>). To narrow the pool of projects, the research team focused on ABC projects completed within the last five years. The research team conducted interviews with agency staff and, when possible, the contractor to gather as much information about each project as possible. Representatives from the following states were interviewed as part of this project: Georgia, Indiana, Minnesota, and Tennessee.

INFORMATION COLLECTION

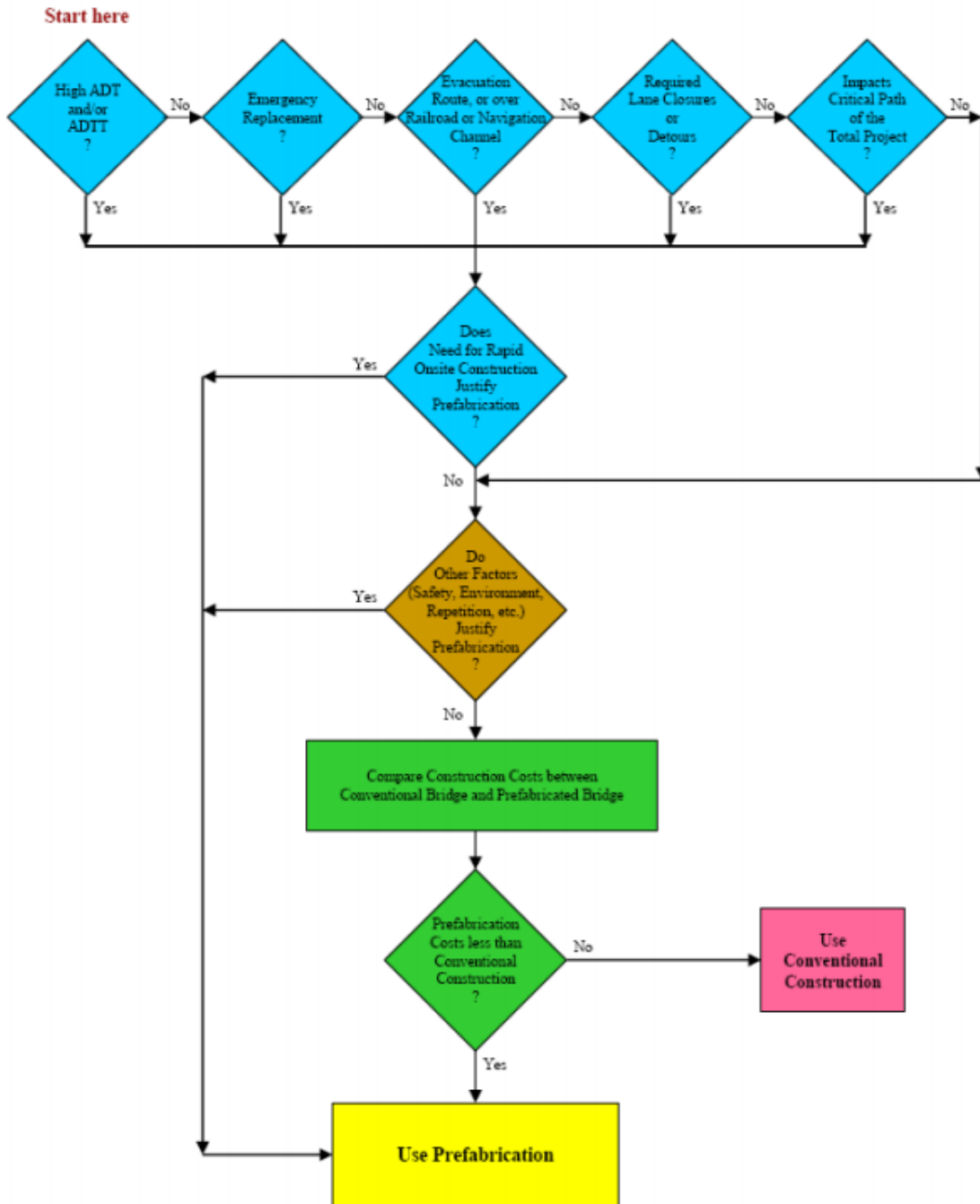
Current Practices: ABC Decision Matrix

Using ABC has many advantages, such as reducing the exposure of the public and construction workers to work zones, accelerating the construction process, and reducing environmental impacts. However, ABC might not be the best choice for every project because not all projects demand accelerated schedules and many can be completed using conventional construction practices. As such, several decision guidelines and processes have been developed to ensure that ABC is only used when warranted. This multiplicity of decision-making frameworks reflects the different values and systems that are used in the various federal and state transportation agencies.

During the course of this research project, the research team looked into the means and methods that are used to decide whether ABC will be used for a project. This involved reviewing transportation agencies' manuals, as well as examining the models that have been developed by the Federal Highway Administration (FHWA). The means and methods for deciding whether ABC will be used on a project will herein be referred to as the ABC decision matrix. Understanding the decision-making process for selecting ABC helps to understand possible areas of the project that would benefit from certain bidding methods.

There are two types of ABC decision matrices: qualitative and quantitative. The qualitative decision matrices ask yes/no questions to assist in the decision-making process, often through the use of flowcharts. The quantitative decision matrices involve assigning a numerical score in response to each question. At the end of the matrix, the total score is compared against a numerical criterion. If the score is above the criterion number, the project is likely a good fit for using ABC.

The FHWA has developed frameworks and guidelines that can be used for deciding whether to use ABC for individual projects. These guidelines fall into the qualitative ABC decision matrix category. An example of a flowchart that was developed by the FHWA is shown in Figure 1.



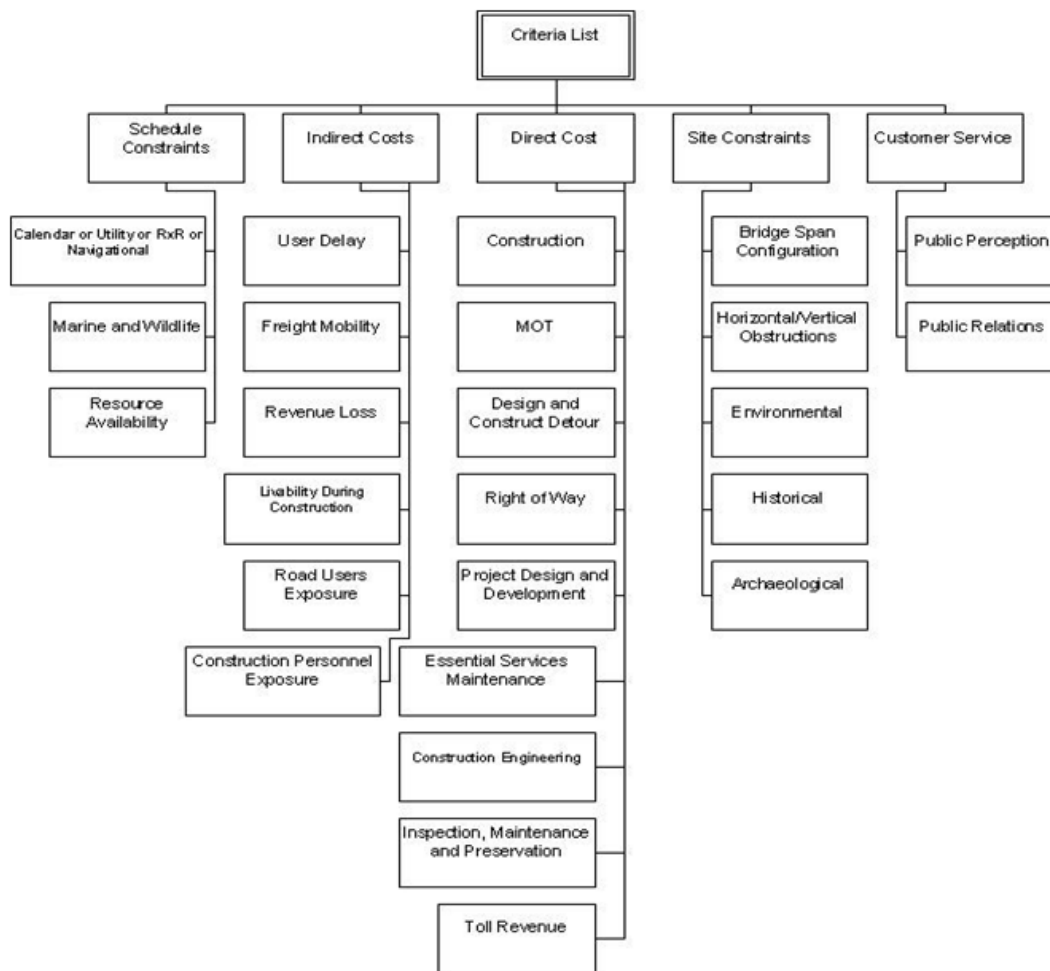
FHWA 2005

Figure 1. Example of FHWA decision matrix

The flowchart shown in Figure 1 is used to decide whether to use prefabricated bridge elements and systems (PBES) on a project. The flowchart asks several questions about aspects of the project that might warrant using ABC. The FHWA also developed a checklist of questions that are answered yes, no, or maybe. After going through the checklist, if a majority of the answers are yes, the project should use PBES. If a majority of the answers are no, PBES should not be

used on the project. The FHWA’s considerations for whether to use ABC can be divided into three categories: rapid onsite construction, costs, and other factors. The costs are further divided into traffic costs, contractor costs, and owner costs. The other factors that need to be considered are safety issues, site issues, standardization issues, and environmental issues.

Many states, however, use a quantitative approach to decide which projects would most benefit from ABC. One of the tools used for this approach is an analytical hierarchy process (AHP) tool. AHP tools find the best alternative by using pair-wise comparison based on the decision-maker’s goals, using various criteria and sub-criteria, on a scale from 1 to 9. One state that uses an AHP tool is Oregon. Oregon’s AHP tool uses five main criteria: direct cost, indirect cost, schedule constraints, site constraints, and customer service. Each of these five criteria have several sub-criteria, which are shown in Figure 2.



Oregon State University 2012

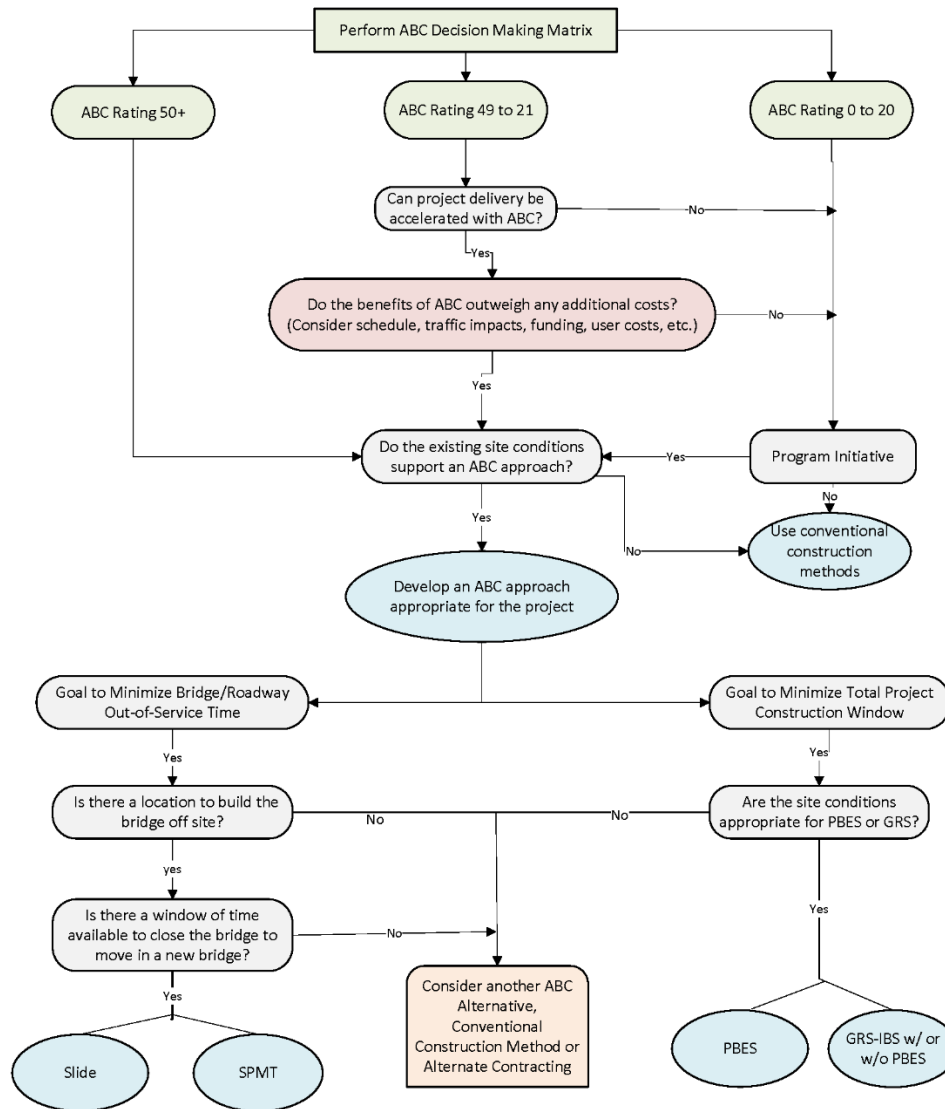
Figure 2. Oregon AHP criteria list

Some of the sub-criteria are public perception, construction costs, user delay, and resource availability. The tool operates by having the user select the criteria to compare and results in a cost-weighted analysis.

Another state that uses an AHP tool is Michigan, which calls its tool MiABCD. MiABCD uses six criteria: site and structure, cost, work zone mobility, technical feasibility and risk, environmental considerations, and seasonal constraints and project schedule. The criteria can be divided into anywhere from 26 to 36 sub-criteria.

Some states have adopted a two-step process for deciding whether ABC is appropriate for a bridge replacement project. Three such states are Arizona, Iowa, and Wisconsin. Wisconsin uses a matrix and flowchart approach. The matrix is used to assign a rating to the project, which is then put into the flowchart to determine whether ABC should be used and which specific strategy should be used. The matrix has eight categories: disruptions, urgency, user cost and delays, construction times, environment, cost, risk management, and other factors such as economy of scale, weather limitations for conventional construction, and complexity. Each of the categories has a pre-set weight. Disruptions on the bridge are 17% of the score, urgency is 8%, user cost is 23%, construction time is 14%, environmental concerns are 5%, cost is 3%, risk management (which includes the safety of the workers and the traveling public) is 18%, and the last 12% is other issues. After the matrix has been filled out, the score falls into one of three categories: scores between 0 and 20, scores from 21 to 49, and scores over 50. If the project is in the first category, it is not considered for ABC unless it is a part of a program initiative. If the project falls into the second category, then using ABC needs to both accelerate the schedule and result in benefits that outweigh the additional costs. If the project is in the third category, it is considered for ABC as long as the site conditions allow for ABC (WisDOT 2018). More detailed information regarding the methods used by the Wisconsin DOT (WisDOT) can be found here: <https://wisconsin.gov/dtsdManuals/strct/manuals/bridge/ch7.pdf>.

The Arizona Department of Transportation (DOT) ABC decision matrix includes the categories of railroad, construction impacts, project duration, environment, safety, economy of scale, and risk management (ADOT n.d.). Each category is composed of one to eight decision-making items. The highest weighted category is construction impacts (45 of 100 points), with the highest weighted decision-making items being average daily traffic (ADT) (10 points) and “Is Phased Construction with Widening an Option” (8 points). Project duration is the second highest weighted category (22 points), with “Restricted Construction Time” (10 points) and “Impacts Critical Path of the Project” (8 points) as the highest weighted decision-making items in the category. Also highly weighted is the safety category (16 points), which is evenly split between “Worker Concerns” and “Traveling Public Concerns.” The decision matrix is completed during the scoping phase by the project team. Once the matrix is completed, the project team uses the results in its ABC decision flowchart, which is shown in Figure 3. The results are documented in a separate initial bridge study.



ADOT n.d.

Figure 3. Arizona ABC decision flowchart

As part of its two-step process, the Iowa DOT typically assembles a project concept team that consists of personnel from the district, the Bridges and Structures Bureau, and the Location and Environment Bureau.

The first stage is where the project concept team assigns the project an ABC rating score. The score is between 0 and 100 and is based on average annual daily traffic (AADT), out-of-distance travel, user costs, and economy of scale. AADT, out-of-distance travel, and user costs are scored on a scale from zero to five, and the scores are multiplied by ten. Economy of scale is scored on a scale from zero to three, and the score is multiplied by a factor of five. If the ABC rating score is 50 or greater, the site conditions and project delivery methods are examined to determine whether they support ABC. There are two conditions that immediately generate scores of 50. The first is if the out-of-distance travel is equal to or greater than 30 miles. The second is if the bridge

is on an Interstate. If the score for the bridge project is less than 50, it is slated for conventional construction, unless the district requests further review.

If the site conditions and project delivery system support using ABC, then the project concept team decides whether the project should be further evaluated for ABC. If the team decides not to go forward with further review, then traditional construction is used. If the team decides to conduct further review, then the project proceeds to the second stage, where AHP analysis takes place. The AHP tool has five categories: direct costs, indirect costs, schedule constraints, site constraints, and customer service. The direct costs include construction, maintenance of traffic, design and construction detours, right of way acquisition, project design and development, essential service maintenance, construction engineering, and inspection. The indirect costs include user delay, freight mobility, revenue loss, and road user and construction personnel exposure. The information that is accumulated from the AHP tool is then used to help the concept team decide whether to proceed with creating an ABC concept for the project (Iowa DOT 2018). The director of the Project Delivery Division and the advisory team from the Bridges and Structures Bureau approve any ABC candidates before a concept is developed for the project.

Overview of Procurement and Bidding

ABC Procurement and Bidding Processes

ABC projects are most often designed to reduce the amount of time that it takes for a bridge to be constructed. This typically results in a procurement system that differs from the typical low-bid process. The procurement systems identified as part of this research include different types of best value procurement that emphasize the project schedule and/or the contractor's technical expertise.

The predominant procurement system that was identified for the ABC projects included in this research is best value procurement. Best value procurement takes into account both the technical expertise of the bidders and the bid price. Best value procurement can be a single-step or two-step process. For two-step best value procurements, the process starts with the owner issuing a request for qualifications (RFQ). After the responses have been received, the owner shortlists candidates, typically three to five contractors, who receive the request for proposals (RFP). The RFPs are evaluated on the merit of their technical proposal and their costs according to a formula laid out by the owner before the start of the process.

The advantages of best value procurement are that it allows for innovation, the project schedule, and the contractor's safety record to be a part of the bid. A challenge of using best value procurement is that it is typically associated with alternative delivery methods such as design-build (DB) and construction manager/general contractor (CMGC). However, some contractors feel that such delivery methods lead to a non-competitive procurement process that results in certain contractors gaining more contracts. Additionally, some states do not have much experience with these delivery methods, with some states not able to use alternative delivery methods at all due to legislative restrictions. However, alternative delivery methods may work

well for ABC projects because they emphasize the teaming of the owner, designer, and the contractor.

Beyond the typical best value procurement process, which considers project cost and the contractor’s technical expertise, some of the case study projects specifically focus on bringing project schedule into the procurement process. The first schedule-focused best value procurement system that was identified is A+B bidding. A+B has two components. The first is the bid based on the unit prices of all costs associated with the project in order to meet the specified schedule given with their bid. . The second component is the number of days that are needed by the contractor to complete the project. The basic formula for finding the total bid is

$$\text{Total Bid} = A + (B \times \text{Road User Cost per Day})$$

with A being the bid amount and B being the number of days. The Road User Cost per Day corresponds to the additional cost that motorists and the general community must bear as a result of the work zone.

The following is a simple example, based on the information in Table 1, of how A+B bidding works.

Table 1. A+B bidding example

| Contractor | Bid Amount (\$) | # Days | Road User Cost (per day) (\$) | Total Bid (\$) |
|-------------------|------------------------|---------------|--------------------------------------|-----------------------|
| A | 4,300,000 | 130 | 12,000 | 5,860,000 |
| B | 4,900,000 | 110 | 12,000 | 6,220,000 |
| C | 4,450,000 | 115 | 12,000 | 5,830,000 |

In this example, Contractor A has the lowest bid for component A. However, when the road user cost is taken into account, Contractor C has the lowest total bid because this contractor requires 15 fewer days to complete the project than Contractor A. If the owner decides to award the project to Contractor C, the owner’s cost would be higher, but the overall cost of constructing the bridge would be lower because the general community would not be as affected by the construction.

The second schedule-focused best value procurement system that was identified is A+B+C bidding. This approach is rather similar to A+B bidding, but it has an added component. There is no hard rule for what the third component must be, though it is often milestone timeframes or a quality/warranty component. The C component could be a cost that would only accrue during a portion of the project rather than the entire project. In Louisiana and Montana, A+B+C bidding is used as an opportunity to incorporate life-cycle costs into paving projects (Scott and Klei 2006). The C component of the bid adjusts for maintenance costs associated with concrete vs. asphalt pavements. As this example illustrates, A+B+C allows for creative and case-specific opportunities to incorporate another element of importance to a bid.

Another option that is used in the procurement of ABC projects is to include an incentive/disincentive (I/D) clause in the contract. An incentive or disincentive clause gives contractors the financial motivation to finish the job as fast as they can. In these clauses, the contractor usually receives a certain amount of money for every day, week, or sometimes month that the job is finished early. Alternatively, the contractor may be required to pay money if the project ends up behind schedule and finishes late (usually referred to as liquidated damages).

Adding clauses such as these to the contracts is very effective for most projects, but especially so for ABC, since construction time is a significant factor in choosing this method. In most cases, the incentive dollar amount offered is large enough to motivate the contractor to at least finish the project on time. In a study published by Arditi et al. (1997), 93.3% of the I/D contracts that were undertaken by the Illinois DOT during the five-year period from 1989 through 1993 were completed on time or sooner. This demonstrates that I/D clauses usually ensure that projects get done by the expected dates.

An advantage of using best value procurement with alternative delivery methods is that it changes where the incentive comes into the contract. Instead of the owner awarding additional money to the contractor for finishing a project early, the contractor has an incentive to propose as short of an initial schedule as possible in order to win the project.

ABC Bid Items

While the above bidding and procurement information applies to construction projects of all types, bid items and bidding processes specifically for ABC projects can pose unique challenges. When an agency is just getting started with ABC or trying a specific ABC method for the first time, well-defined bid items become critical to obtaining economical bids. When a bid item comes back with a wide range of values from multiple contractors, this often indicates that the bid item was not well understood by the contractors. For example, Table 2 shows several bid items that appeared in a previous ABC project and their corresponding bids from three contractors, along with the engineer’s estimate.

Table 2. Wide range of bid item values example

| Bid Item | Unit Price | | | |
|----------------------------------|-----------------------|--------------|--------------|--------------|
| | Dept. Estimate | Bid A | Bid B | Bid C |
| Construct Closure Pours | \$750 | \$875 | \$900 | \$334 |
| Prefabricated Deck Unit | \$125,000 | \$128,300 | \$158,000 | \$177,976 |
| Prefabricated Approach Slab | \$4,500 | \$3,500 | \$12,000 | \$15,523 |
| Prefabricated Moment Slab | \$2,600 | \$2,200 | \$7,000 | \$9,294 |
| Prefabricated Abutment Cheekwall | \$1,250 | \$1,500 | \$5,000 | \$4,153 |

Source: ADOT at <http://utcdb.fiu.edu/2017-10-2717:07:20.pdf>

As the table shows, the four bid sources proposed a wide range of values for all of the bid items. However, it is important to note that a wide range of values does not always indicate a lack of

understanding of bid items. Contractors may lump other components into a particular bid item, leading to a higher bid price for the item in question, but possibly a lower price for another. It is also possible that some contractors have available equipment or experience that better position them to complete certain bid items, resulting in significantly lower costs for particular tasks.

While many agencies have faced challenges in identifying and defining bid items for ABC projects when new methods are being used, these difficulties are often project-specific and cannot be broadly applied to all projects. However, in an effort to better define these challenges in general, several interviews were conducted with state agency representatives. These interviews will also be further discussed later in this report with respect to project delivery methods and individual case studies. In an effort to further explore the issues associated with bid items, contractors were also interviewed to gain an alternative point of view. During this information collection effort, the following bid items were identified as challenging from an estimating and bidding standpoint:

- **Bridge Installation:** Float in, roll in, slide in, or other methods specific to ABC can be difficult to bid on because they differ substantially from conventional construction.
- **Engineering of Temporary Structures:** The design of temporary shoring or other engineered devices/processes is challenging from the contractor's perspective.
- **Acquisition and Installation of Specialty Moving Equipment:** This item includes self-propelled modular transport (SPMT) or gantries.
- **Staging or Preparatory Work for Assembly:** This item includes temporary docks or bulkheads.
- **Other Operations:** Operations that must be performed at a high rate of production are especially crucial. For instance, demolition that must be completed within a specifically allotted time during a weekend closure requires a conservative cost estimate to ensure that the contractor can include more resources to cover worst case scenarios.

In general, the approach taken by contractors when bidding on something new to them is to break down the operation into smaller and smaller components until an individual task is identified that is familiar or has been done before. There are very few operations that, when broken down finely enough, are entirely dissimilar to operations on previously completed projects. This breakdown process is a consistent feature of bidding, so the clearer the plan set is, the better for the contractor to accurately (and efficiently) bid.

CASE STUDIES

Methodology

Several ABC projects listed in the ABC-UTC database on the ABC-UTC website (<http://utcdb.fiu.edu/>) were identified as candidates for case studies. The research team targeted ABC projects that had been completed in the last five years (2013–2018).

The research team then reached out to relevant personnel who had been involved in the projects, including agency staff and, when possible, the contractor, to discuss the bid items, contracting methods used, and lessons learned about the design and construction of the bridges. The research team ultimately conducted interviews with people in three states (Georgia, Indiana, and Minnesota) that covered four projects.

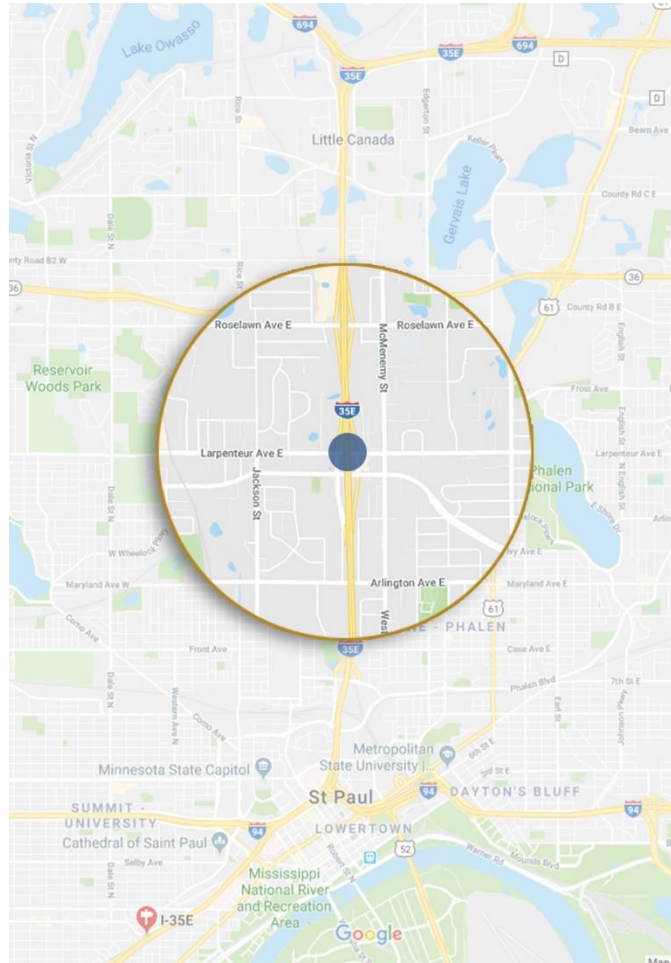
The results of this information collection are included in this report, as well as in four standalone case study summaries that can be found on the ABC-UTC website at the following hyperlinks:

- [Larpenteur Avenue – Minnesota ABC Case Study](#)
- [Keller Lake, Minnesota, ABC Case Study](#)
- [Indiana ABC Case Study](#)
- [Atlanta, Georgia, Courtland Street ABC Case Study](#)

Case Study 1

Project Description

The Larpenteur Avenue bridge over I-35E north of downtown St. Paul, Minnesota was replaced as part of MnDOT's I-35E MnPASS Express Lane project.



Map data © 2019 Google, <https://www.google.com/maps/search/Larpenteur+Avenue+bridge+over+I-35E/@44.9784196,-93.1075428,14z>

Figure 4. Location of the Larpenteur Avenue bridge over I-35E, north of downtown St. Paul and I-94 in Minnesota

The I-35E MnPASS project was designed to add capacity to I-35E, and to reconstruct nine bridges throughout the corridor, between Maryland Avenue on the south and Little Canada Road on the north.

Why ABC

Unlike most ABC projects, the Larpenteur Avenue bridge was not identified as an ABC project by the DOT. Instead, it was proposed by the contractor during the bidding process.

The proposal of an ABC solution to the bridge replacement had the benefit of reduced closure time for Larpenteur Avenue, perhaps giving the contractor an advantage on a project with a heavy focus on maintenance of traffic. This serves as a great example of innovative solutions that can come from the flexibility allowed in the proposal process.



MnDOT

Figure 5. Construction of the Larpenteur Avenue bridge

Design and Estimating

The project delivery system was DB. This resulted in the design builder being responsible for the design and estimating for the project, including the design of the slide-in mechanism.

ABC Procurement

The project was procured using a best-value procurement for the selection. One of the criteria for the technical proposal was the closure time for Larpenteur Avenue. As previously mentioned, the ABC component that was proposed by the selected contractor provided reduced closure times, thus making their proposal more attractive.

The winning bid involved closing Larpenteur Avenue for 47 days, while the estimate for conventional construction was closer to 100 days. The slide-in technique required closing I-35E for two nights as the bridge was moved over the interstate.



MnDOT

Figure 6. Nighttime work on the Larpenteur Avenue bridge over I-35E

Contracting

The contract did not have any incentives or disincentives. However, there were penalties for the contractor if more days were needed than the contracted amount.

In Minnesota, most projects are DBB, although, on occasion, the state will utilize alternative contracting methods such as design-build or CMGC when deemed advantageous for the project.

Design-build was authorized by the Minnesota legislature in 2001 and was used for this project. Another alternative delivery method, CMGC, was authorized by the legislature in 2012 on a test basis. The legislation allowed MnDOT to have 10 CMGC projects total, while there can only be four CMGC projects per calendar year.

ABC Construction

The contractor utilized steel pile bents to hold the new permanent superstructure in the temporary position. Traffic was allowed to continue using the old Larpenteur Avenue bridge, while the contractor constructed the steel pile bents and the new superstructure.

Since the new bridge was on the exact same alignment and location as the existing bridge, the existing bridge had to be closed to build the new substructure. Demolition began on the old superstructure and substructure. Once demolition was complete, the new substructure was constructed.

After the superstructure and substructure were completed, the superstructure was slid onto the new substructure. During the slide effort, there were issues with the bridge moving laterally and difficulty overcoming the friction of the slide system. These complications, among other factors, resulted in the contractor needing to close I-35E an additional night to complete the slide.

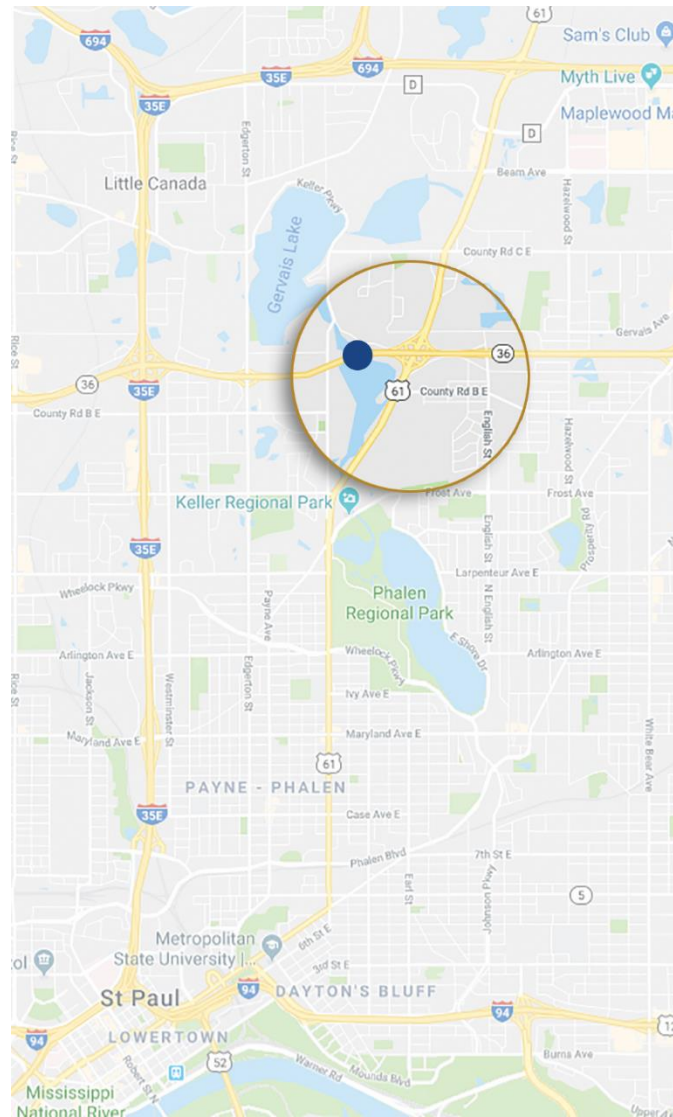
Key Takeaways

- For construction, it is recommended to have multiple contingency plans.
- Contractors might propose ABC if it makes their proposal more attractive.

Case Study 2

Project Description

The second case study for MnDOT was the replacement of two side-by-side bridges on Minnesota Trunk Highway (TH) 36 over Keller Lake, in Maplewood, Minnesota, north of Saint Paul.



Map data © 2019 Google, <https://www.google.com/maps/@45.0111804,-93.0685791,2014m/data=!3m1!1e3>

Figure 7. Location of the Keller Lake bridges on TH 36, in Maplewood, Minnesota, north of Saint Paul

MnDOT utilized ABC techniques. The project was used as a trial for MnDOT to test several innovative technologies, including precast bridge elements and an inverted T-beam system. The inverted T-beam technology had been identified for possible ABC by the former state bridge

engineer on a scanning tour and had been undergoing non-accelerated trial installations since 2005.



MnDOT

Figure 8. Completed Keller Lake bridge on TH 36 in Maplewood, Minnesota

Why ABC

The project was chosen for ABC because the construction season was limited for these bridges, and TH 36 in this area is a high-volume route and re-alignment of the route for off-line bridge construction was not an option. This was combined with the fact that MnDOT was planning to replace two bridges in the area at the same time, leading to dense construction activity. In addition, there was a bald eagle nest in the vicinity of the project that limited construction activities between August 1 and January 15 to avoid unwanted impact to the nest.

ABC Procurement and Bidding

The project was completed using DBB. MnDOT detailed several precast elements as part of this project, including precast substructures and an inverted-T superstructure. In using all precast

elements, the precast pick weights and corresponding crane reach were investigated in an attempt to balance the equipment needs to complete construction.

All precast elements were required to be cast in a Precast/Prestressed Concrete Institute-certified (PCI-certified) plant because of the tight tolerances. After the job was completed, the contractors also noted that they would have been reluctant to self-perform precasting due to increased risk should MnDOT reject the product or impose penalties on the project with such a tight schedule.

Contracting

The contract that was awarded included disincentives of \$7,500 per calendar day. The bridge construction cost was approximately \$2.1 million for 10,615 square feet, which translates to roughly \$195 per square foot. In comparison, conventional precast beam bridges with cast-in-place (CIP) substructures in 2013 were averaging between \$110 and \$130 per square foot without the time constraints. Typical bridge construction duration for three-span slab spans without time constraints is between 3.5 and 5 months.

ABC Construction

Several innovative technologies were utilized in this trial project. The project utilized substantial precast elements: precast piles, precast pile bent caps, precast stub abutments, and precast inverted T-beams, which serve as a permanent form for a CIP deck with a single layer of reinforcing steel.



MnDOT

Figure 9. Keller Lake precast concrete bridge construction including inverted-T geometry (top)

The inverted T-beam is a prestressed beam that fully forms the underside soffit and eliminates the need for significant forming over water. Precast piles were utilized in this project because of both aesthetics and the perception that pile driving noise would be minimized to avoid disturbance of the nearby eagle nest.

This project was completed using staged construction. The prestressed concrete piles for the abutments and piers were driven, followed by setting precast abutments and pier caps on temporary brackets to establish the bearing seat grade. The piles extended into the precast substructure through full-depth openings and were grouted with a conventional substructure concrete mix with smaller aggregate.



MnDOT

Figure 10. Precast abutment setting over piles with projecting, hooked, reinforcing steel bars

After grouting the substructure units, the inverted T-beams were placed for the three-span bridge using a crane. The beams were set on narrow elastomeric pads that extended the full length of the substructure.

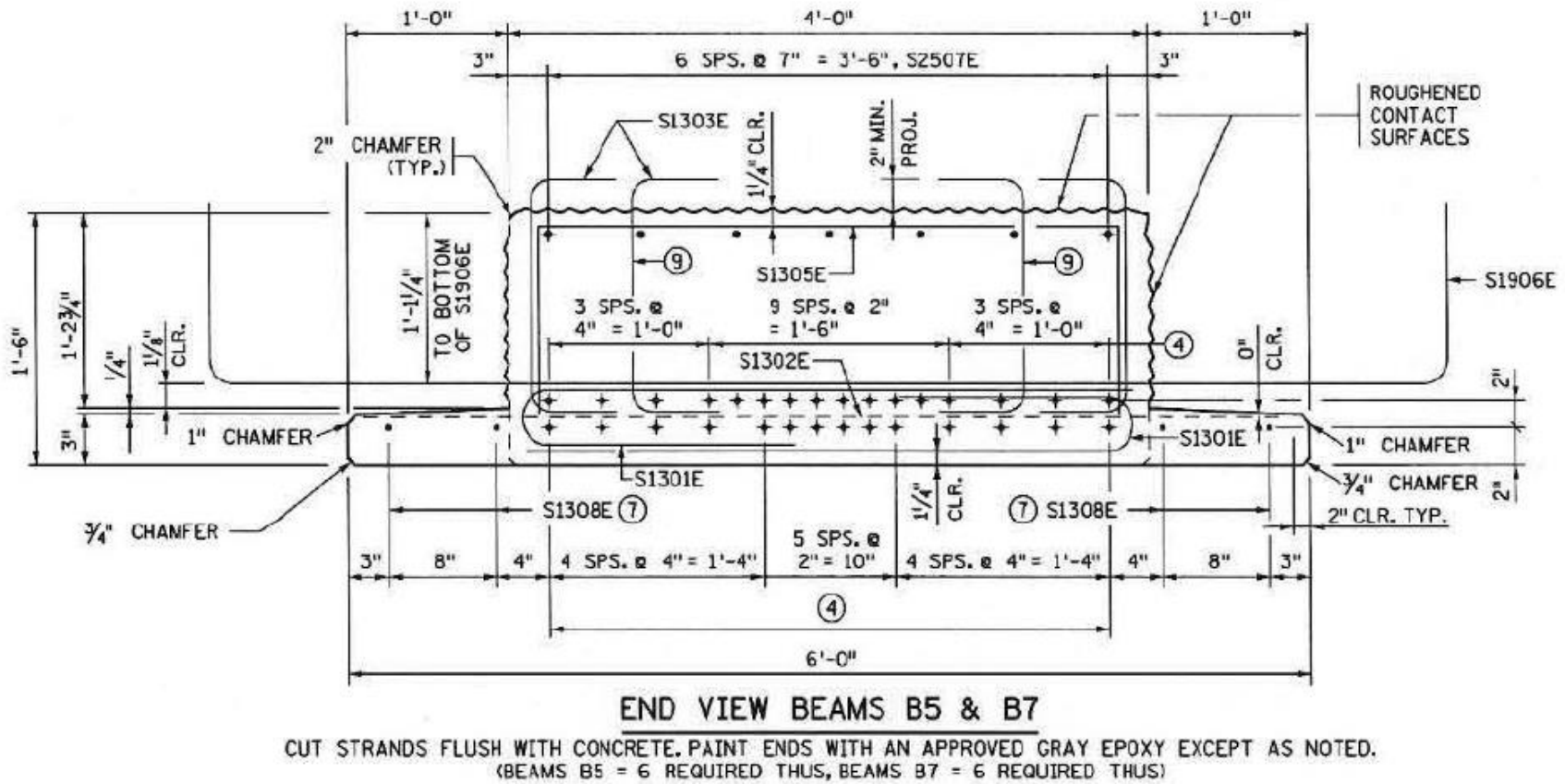


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Figure 11. Precast abutment set showing pile grout pockets with wingwalls that consisted of a permanent sheetpile wall with a CIP facing and top coping

At the piers and abutments, dowels extended up into the coped areas of the flanges to tie the superstructure to the substructure. These dowels were isolated from the superstructure by using pipe insulation. The isolation of the dowels frees up local restraints to permit superstructure thermal expansion, free of significant substructure restraint.

The abutment configuration was therefore a hybrid of the semi-integral abutments that MnDOT uses elsewhere, with integral abutment behavior acting when the dowels become engaged.



MnDOT

Figure 12. Interior inverted T-beam details showing flanges are coped over supports to enable substructure connectivity

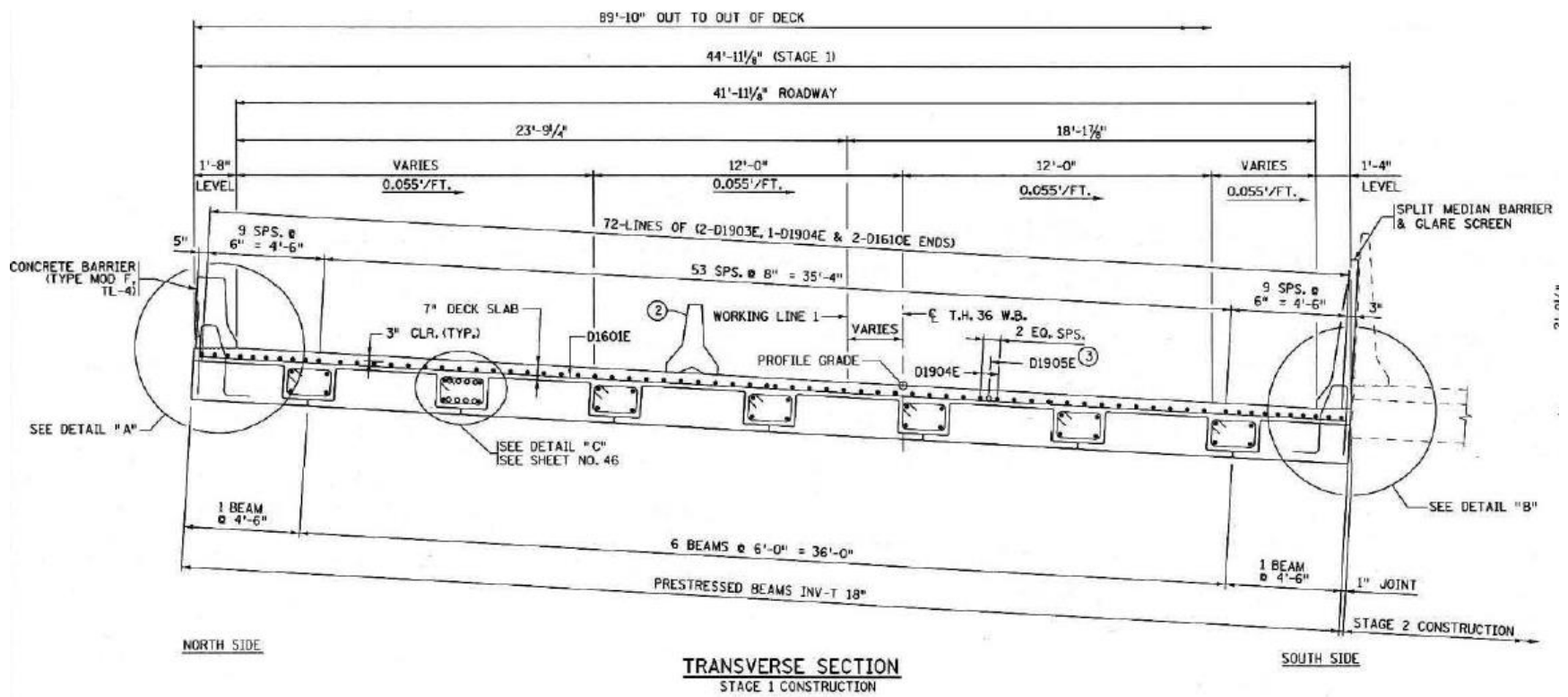
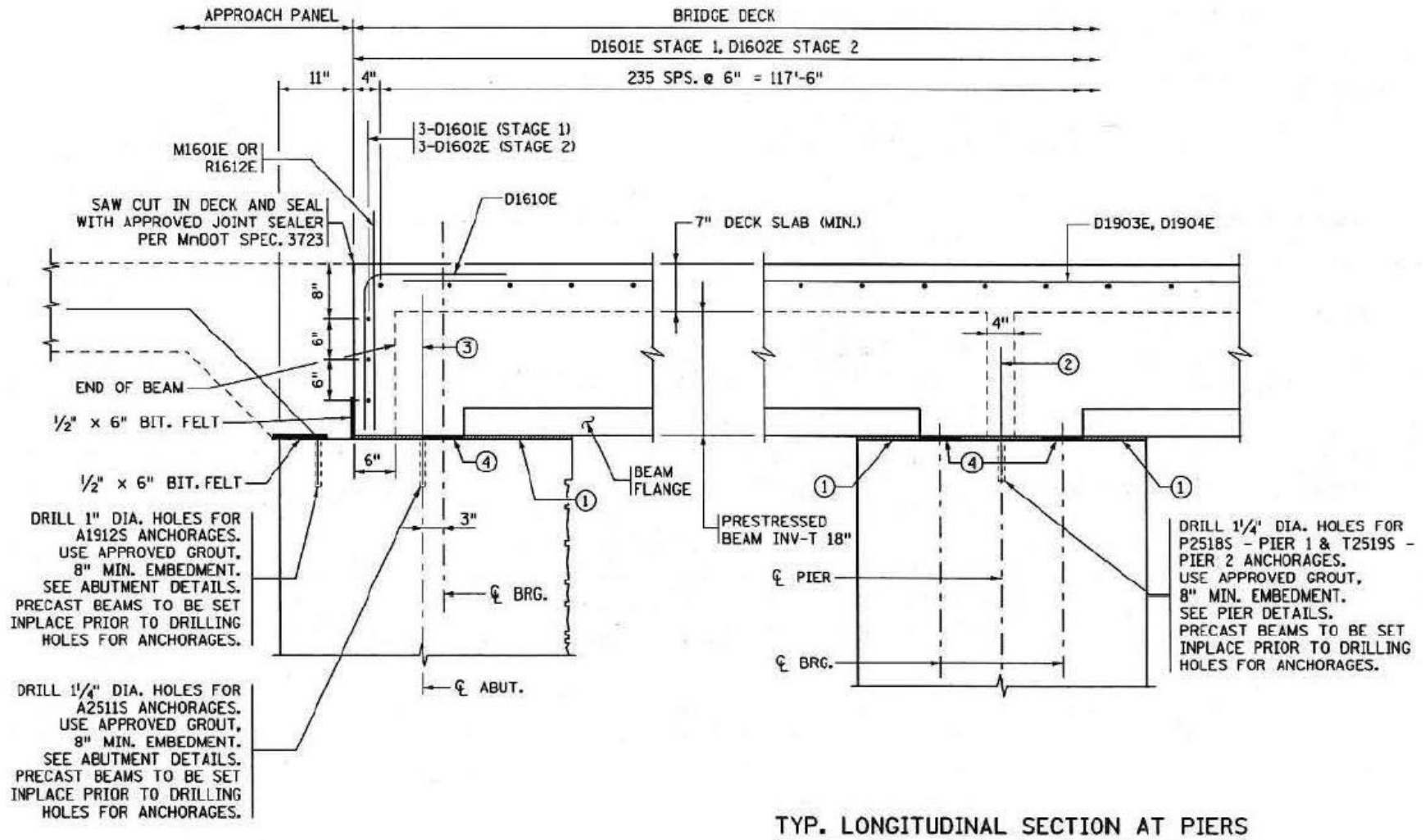


Figure 14. Superstructure cross-section with deck reinforcement and interconnecting diaphragm reinforcement



MnDOT

Figure 15. Longitudinal section showing bearings (Circle 4), anchoring dowels (Circle 3), and single layer of deck reinforcement

The inverted T-beam system had been through five iterations of design and detailing changes, with the first bridge trials starting in 2005. Each construction implementation resulted in various degrees of deck cracking over time. It was believed that the cracking was due to a combination of thermal restraint, creep and shrinkage restraint moment, and deck shrinkage restraint over the large webs with longitudinal troughs of diaphragms.

In response, small details and deck reinforcing were changed in each bridge design, including modifications to the precast shape to soften stress concentrations. After several studies and years of mapping crack patterns, the major deck cracking factors were determined instead to be mix design related, with substructure fixity detailing and reinforcement detailing contributing to a lesser degree.

The Keller Lake bridge was not only the highest volume inverted T-beam bridge built at the time, but it was also built in two stages with separate superstructures. This configuration afforded the opportunity to introduce nonmetallic fibers as a means to control deck cracking alongside a control superstructure with identical detailing. MnDOT included 7.5 pounds per cubic yard of micro-macro fibers into the eastbound structure.

A year after opening to traffic, the westbound control deck was showing high levels of cracking, which was treated by the addition of a 3/8-inch thick polymer wearing course. The eastbound deck with fibers did not show cracking levels of any concern over three years of detailed crack-mapping.

To date, it remains a good performer in terms of deck cracking levels. The success of fibers in this inverted T-beam construction, where all prior T-beam bridges were resulting in deck cracking, was responsible for MnDOT moving to include fiber requirements in all bridge deck mixes starting in 2017.

Summary

This bridge replacement was accomplished rapidly with the westbound structure taking 29 days to complete and the eastbound structure taking 36 days to complete. The overall response was that the precast piers, piles, and deck panels worked well and helped to accelerate the schedule. It is believed, however, that the precast stub abutments did not provide much value in accelerating the schedule and were the heaviest elements to pick and set.

MnDOT is looking to expand the use of the inverted T-beam system in the future where acceleration for a slab span-type superstructure would be beneficial. In all inverted T-beams, a moderate dosage of fibers is recommended to mitigate deck cracking.



MnDOT

Figure 16. Keller Lake Bridge view from trail under bridge

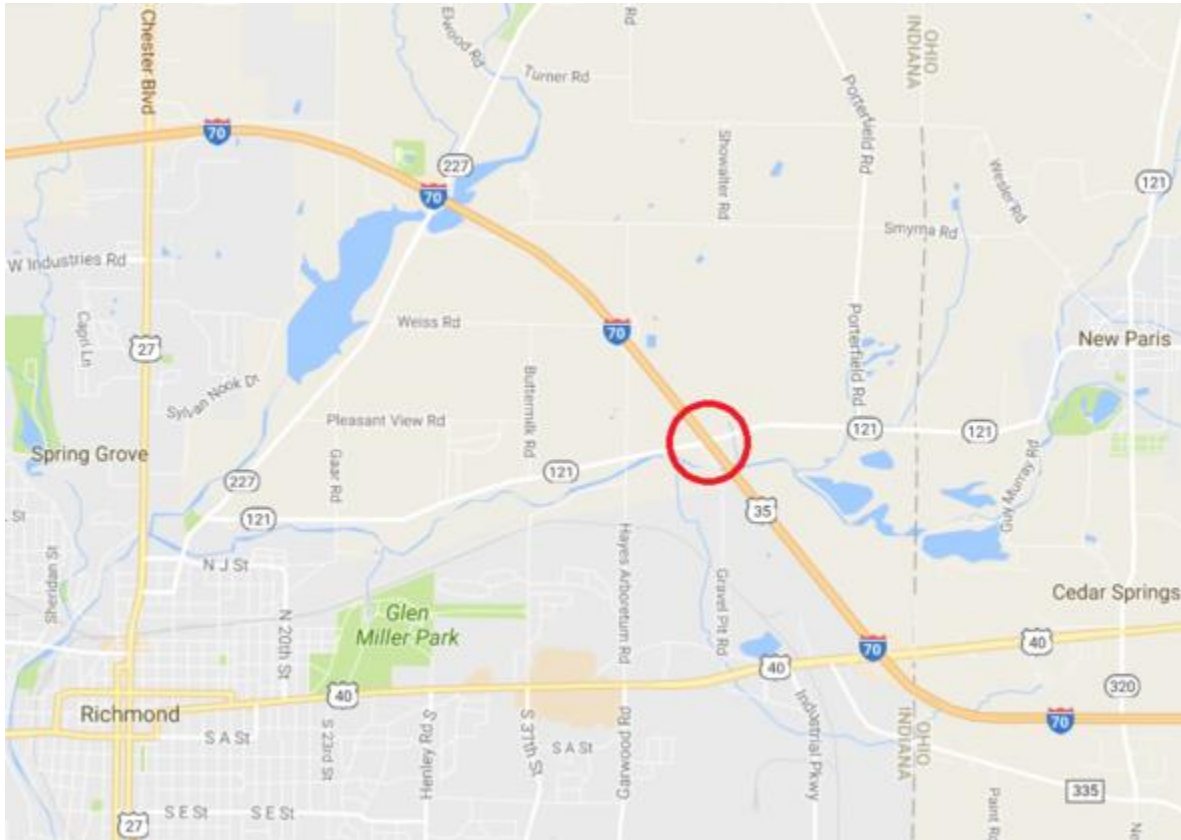
Key Takeaways

- Contractors would prefer CIP elements over precast elements for heavy substructure components. Precast stub abutments weren't found to add much acceleration value.
- Precast substructure elements can lead to higher bids for the work, or fewer bids if it is a limiting factor for contractors.
- Shifting risk to contractors during the bidding process tends to increase bid dollar amounts.
- The most successful component of the bridge was the inverted T-beam system in combination with non-metallic fibers.
- Non-metallic fibers resulted in reduced deck cracking and are now used in most deck placements statewide in Minnesota.

Case Study 3

Project Description

This case study was an ABC project for twin bridges over State Road (SR) 121, carrying both east and westbound I-70 in Wayne County, Indiana.



© 2016 Google, <https://www.in.gov/indot/images/I70%20at%20SR%20121.png>

Figure 17. Location of the I-70 bridge over SR 121 in east central Indiana

The project was originally slated to be constructed using conventional means of project delivery, and the Indiana DOT (INDOT) initially procured a designer for the conventional design. However, once a field visit was conducted, it became apparent that this project was a candidate for accelerated bridge construction.

The agency began developing plans for two types of ABC: slide-in and self-propelled modular transport (SPMT). The plan for construction was to maintain traffic on the existing bridge while the substructure was created for the replacement bridge. Once the substructure was completed, traffic over the existing bridge was closed, and the contractor had eight days to move in the new bridge superstructure and reopen the roadway to traffic. The project delivery system was design-bid-build utilizing the A+B bid method.



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Figure 18. I-70 over SR 121 in Wayne County, Indiana

Why ABC

The project was identified as an ABC candidate primarily because of the presence of an available staging area next to the bridge site. The staging area allowed for either SPMT or slide-in construction. In addition, INDOT designated the project as an ABC candidate in order to develop experience with this type of construction within the agency.

Design and Cost Estimating

The schedule for the project was developed using the critical path method and discussions with INDOT construction staff. The cost estimate for the project was developed using the ABC-UTC webpage, which at the time of planning was up to date with bid tabs that allowed INDOT staff to evaluate and compare projects that were relevant to the INDOT project. The risk that was included in the estimate was included in the slide-in unit bid.

Input provided by INDOT's Traffic Section stated that closures on Fridays should be avoided due to the high traffic volumes during the afternoon peak. The Traffic Section also recommended avoiding closures during the summer months.

ABC Procurement

In Indiana, most projects are DBB and are procured using low-bid procurement, although some projects are DB.

The design consultant for the project was procured via an RFQ. The contractor was procured using A+B bidding. A+B bidding is a cost-plus-time bidding procedure.

The A component of the bid is similar to low-bid, representing the unit prices for the contract. The B component is the number of days that the contractor expects the work to take. The A component is then added to the B component to generate the contractor's final bid. The bidder with the lowest final bid (both components) is awarded the contract, for the amount specified in the A component of the bid.

In this case, the A component included the typical low-bid unit prices used for state construction projects, such as concrete per cubic yard and reinforcing steel bar per pound. The B component included an estimation of the cost to road users of construction on the roadway. The A+B bidding method was used to allow for closure time to be considered, instead of only the low-bid procurement amount.

INDOT took the unusual step of developing two plan sets for this project, one for slide-in bridge construction and the other for SPMT. INDOT requested the two plan sets to gauge contractors' interest in both types of ABC. Contractors had to select one option in their bid. Bids were only received for the slide-in plan set. The SPMT option was not bid due to the high cost of the equipment, along with contractor concerns of constructability due to the small stroke of the SPMT equipment.

Contracting

The contract included incentives and disincentives based on the cost to road users of construction. The road user costs used to develop the incentives and disincentives were developed and adjusted by INDOT construction staff.

The incentives were capped at \$170,000 for both the eastbound and westbound lanes of the bridge, and the incentives on SR 121 were capped at an additional \$50,000. The contract also provided incentives to encourage the contractor to avoid construction on Fridays. The disincentives kicked in if the closures for the new bridge exceeded the eight days specified in the contract.

ABC Construction

The project was constructed using the slide-in technique, with both replacement bridges constructed next to the original bridges. The original bridges were then demolished, and the new superstructures were slid into place. During construction, a tolerance system was used by the contractor to ensure the final bridge location would be correct. During the slide-in, the tolerances were found to be too strict. A more relaxed tolerance system was needed to facilitate the slide-in.

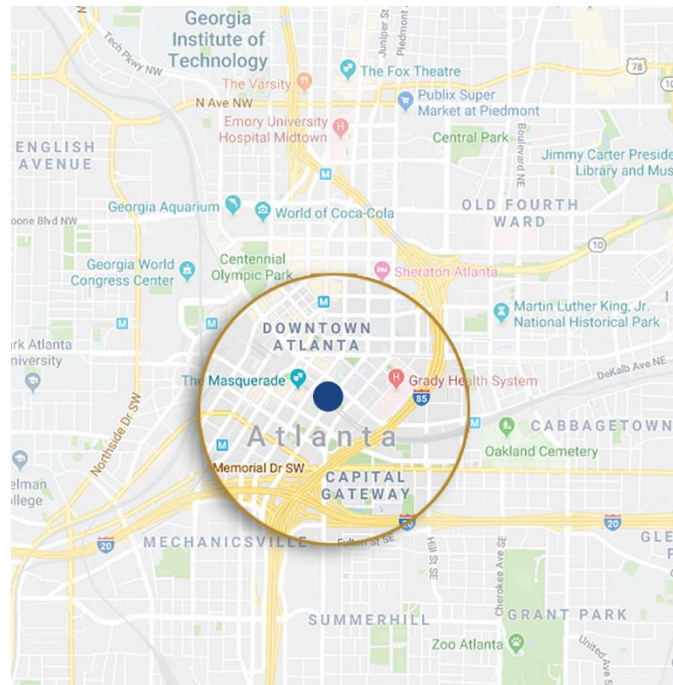
Key Takeaways

- With a slide-in bridge, the most focus is typically placed on the slide itself. For this project, the slide went well, but in hindsight, the design of the substructure could have been of greater focus. During this process, the initial substructure design was not feasible; thus, the design work had to be repeated. A cost-effective solution to the substructure design was difficult to find.
- A mock-up was performed to ensure all equipment worked and that personnel were trained prior to the official slide. This ensured there were no surprises during the slide, and worked well for the contractor.
- The slide-in engineering that had to be done by the contractor was subcontracted out and was stamped by the engineer only after the engineer of record (EOR) for the bridge approved the plans.
- In terms of the bidding, the sliding component of the project was less expensive than expected.

Case Study 4

Project Description

This ABC project was to reconstruct the 110-year-old Courtland Street Bridge from Martin Luther King, Jr. Drive to Gilmer Street in downtown Atlanta, Georgia. The project was in close vicinity to Georgia State University and the Georgia State capitol building.



Map data ©2019 Google

Figure 19. Location of the Courtland Street Bridge between MLK, Jr. Drive and Gilmer Street in downtown Atlanta, Georgia

The project delivery system for this bridge reconstruction in downtown Atlanta was DB. This Courtland Street ABC project followed the Georgia State Route (SR) 299 bridge replacement over I-24, which was a weekend closure that involved replacing two bridges. Many of the lessons learned from the SR 299 over I-24 project were directly applied to the Courtland Street Bridge project, helping to make this project such a success.

Previous Lessons Learned

The preceding SR 299 bridge over I-24 project was near the border of Tennessee and Georgia; as such, the project resulted in detour routes that were burdensome to the traveling public. The Georgia DOT (GDOT) constructed the new bridge north of the existing one.

Once construction of the replacement bridge was completed, the old bridge was demolished in phases. As this demolition occurred, traffic was moved onto the lanes that were not directly underneath the bridge work. Once the first bridge section was completed, traffic was moved to the other side of the road underneath the newly constructed bridge segment. After traffic was moved, the second section of the old bridge was demolished and replaced.

Although the project was ultimately successful and did not have any traffic accidents, the project had a closure time of 81 hours, instead of the planned 56 hours. The lessons learned from this project were documented, and, thus, available for the Courtland Street bridge replacement project. Lessons learned on the SR 299 project included the following:

- Providing the contractor with information that accurately conveys the condition of the existing bridge facilitate safer and faster demolition
- Coordination and communication between the DB team and the DOT is critical to project success
- Dedicated DOT staff should be on-site for the entirety of the project
- Consider the ABC timeframe based on the complexity of the project
- Overestimate the closure times prior to and during the ABC period for public outreach efforts to ensure realistic expectations for all parties
- Design can be improved when the engineer of record and the contractor work closely together

Why ABC

The project was originally programmed to be a conventional DBB construction project. However, as planning progressed, it became clear in the constructability review phase that because the bridge was located in a highly complex urban environment, and the bridge was in the middle of a major university, it was not feasible to have a two-year closure. As such, the decision was made to switch the project to design-build delivery and to incorporate ABC methods.

ABC Procurement

The project was procured using GDOT's Innovative Delivery office, using a best value procurement method. The best value was divided fifty-fifty between technical value and cost.

Contracting

The contract was awarded based on a best value selection. The contract did not include any incentives for completing the bridge early, because it was already a part of the bid to get the bridge open early. Disincentives and penalties were in place in case the project went over the amount of time that was bid. The contract made it the responsibility of the design-builder to communicate with the stakeholders.

ABC Construction

Construction on the bridge began with the substructure, as the new bridge foundation was constructed beneath the existing bridge prior to any closures. The existing bridge was then closed, and the contractor began to deconstruct the superstructure, with deconstruction occurring along longitudinal halves of the bridge. Once half of the bridge was removed, the contractor replaced it using precast concrete beams, steel diaphragms, and high early strength concrete.



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<https://mailchi.mp/88a11bc823ca/courtland-street-bridge-replacement-newsletter-may-issue>

Figure 20. Staged deconstruction of the existing bridge in downtown Atlanta

After the first half of the bridge was constructed, the other half of the bridge was demolished and replaced using the same techniques. The bridge was originally scheduled to be closed for two years; however, through ABC and DB, the closure time was reduced to 180 days.

During the course of construction, the bridge office made a dedicated reviewer available for the project. The project was ultimately successful in part due to the increased collaboration that existed between the design-builder and the DOT.

The DB team and DOT also rolled out an effective and far-reaching public information plan that included flyers, public outreach meetings, a website dedicated to the project, as well as hiring students from Georgia State University to assist in updating students on construction progress and critical closure times.

Key Takeaways

- The bridge office made a dedicated reviewer available to answer questions for the project.
- Documenting and utilizing lessons learned on each project allows for continuous improvement and makes construction much smoother.

Summary of Case Study Findings and Recommendations

ABC projects are effective at accelerating the construction of bridge projects and minimizing the closure time experienced by the traveling public. ABC can be successfully implemented using any of the three delivery methods detailed in the previous chapter: DB, DBB, and CMGC. Key takeaways from the case studies that have broad applicability include the following:

- Communication and collaboration between the contractor (regardless of project delivery method) and the DOT will result in a better project outcome.
- When flexibility is allowed in the bids (i.e., presenting multiple construction method options or using alternative delivery methods), innovation is often incorporated into the project and results in savings to the DOT, either in terms of financial savings or time savings for the traveling public.
- After completion of a project, discussions regarding lessons learned and successful project components are beneficial from the agency's perspective because these can be applied to future projects.
- Effectively communicating with the public during ABC projects is important and can be done by either the agency or the contractor.

CONCLUSIONS

ABC projects are used to reduce bridge closure time and to increase the safety of both construction workers and the traveling public. ABC is useful for testing new technologies and fostering innovation in new projects. With this in mind, ABC projects need to be bid in such a manner that the contractor is focused on closing the roadway for the least amount of time.

Using A+B bidding or alternative delivery methods can often allow for streamlined bidding and project timelines while also often introducing incentives to the contractor for efficient, limited closure periods. However, ABC can be successful with several delivery systems, including traditional DBB. Each individual project has unique challenges and site attributes that may make it well suited for particular bidding, contracting, or project delivery methods.

While many agencies and contractors were interviewed as a part of this project, more information could still be garnered through additional case studies that may be useful for state agencies. Many ABC projects differ greatly from location to location due to site-specific challenges. As such, capturing broadly applicable patterns in ABC projects with respect to bidding, contracting, and project delivery methods can be challenging. It is important to keep these limitations in mind when applying the findings and recommendations that were presented in the previous chapter.

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