Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
ABC-UTC-2016-C1-ISU01-Final		

4. Title and Subtitle	5. Report Date
Delivery Methods for Accelerated Bridge Construction Projects: Case Studies and Consensus Building	March 2020
	6. Performing Organization Code
7. Author(s)	**8. Performing Organization Report No.**
Katelyn Freeseman (orcid.org/0000-0003-0546-3760), Jennifer Shane (orcid.org/0000-0002-2612-4269), and Michael Volk (orcid.org/0000-0001-6927-6249)	
9. Performing Organization Name and Address	**10. Work Unit No. (TRAIS)**
Bridge Engineering Center and Institute for Transportation Iowa State University 2711 South Loop Drive, Suite 4700 Ames, IA 50010-8664	**11. Contract or Grant No.** 69A3551747121
12. Sponsoring Organization Name and Address	**13. Type of Report and Period Covered**
Accelerated Bridge Construction University Transportation Center Florida International University 10555 W. Flagler Street, EC 3680 Miami, FL 33174 US Department of Transportation Office of the Assistant Secretary for Research and Technology and Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC 201590	Final Report (January 2018–September 2019) **14. Sponsoring Agency Code**

15. Supplementary Notes

Visit www.abc-utc.fiu.edu for other ABC reports.

16. Abstract

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 which procurement and project delivery methods to use.

The research team compiled information on decision matrices for identifying ABC projects, alternative delivery methods, and the procurement methods used for ABC projects. 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 bidding of ABC projects (Bidding of Accelerated Bridge Construction Projects: Case Studies and Consensus Building [ABC-UTC-2016-C1-ISU02]). 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 also included in four standalone case study summaries.

The case studies suggest that ABC can be successfully implemented using any of the delivery methods explored in this study: design-build, design-bid-build, or construction manager/general contractor. Regardless of the project delivery method, communication and collaboration between the contractor and agency results in a better project outcome. Effective communication with the public is also important during ABC projects and can be done by either the agency or the contractor. 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.

17. Key Words	18. Distribution Statement
accelerated bridge construction—ABC bidding—ABC case studies—ABC construction—ABC contracting—ABC procurement—ABC project delivery	No restrictions.

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified.	Unclassified.	70	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

(this page is intentionally left blank)

Delivery Methods for Accelerated Bridge Construction Projects: Case Studies and Consensus Building

Final Report
March 2020

Principal Investigator: Katelyn Freeseman
Bridge Engineering Center, Institute for Transportation
Iowa State University

Co-Principal Investigator: Jennifer Shane
Construction Management and Technology Program**,** Institute for Transportation
Iowa State University

Authors
Katelyn Freeseman, Jennifer Shane, and Michael Volk

Sponsored by
Accelerated Bridge Construction University Transportation Center

A report from
Bridge Engineering Center and Institute for Transportation
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103 / Fax: 515-294-0467
www.intrans.iastate.edu

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by a grant from the U.S. Department of Transportation's University Transportation Program. However, the U.S. Government assumes no liability for the contents or use thereof.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

These two related projects, Contracting Methods for and Bidding of Accelerated Bridge Construction Projects: Case Studies and Consensus Building, were supported by the Accelerated Bridge Construction University Transportation Center (ABC-UTC at https://abc-utc.fiu.edu/) at Florida International University (FIU) as the lead institution, with Iowa State University, the University of Nevada-Reno, the University of Oklahoma, and the University of Washington as partner institutions. The authors would like to acknowledge the support of the ABC-UTC.

The research team would like to extend special appreciation to the ABC-UTC and the U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology for funding these projects.

These projects were also made possible by match funds from Kiewit Infrastructure Co. through related work for Iowa State University's Institute for Transportation. Special thanks for Kiewit's financial support, and for their participation in interview and case study efforts to provide valuable contractor perspectives on ABC projects.

Thanks should also be given to the many state agency representatives who provided feedback and case study information, and who participated in phone interviews to help provide the content presented in this report.

INTRODUCTION

Accelerated bridge construction (ABC) is a solution for upgrading substandard bridges when closure times are of critical importance. 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 past ABC projects with a particular focus on the project delivery method that was 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 are selected. The research team also reviewed research related to procuring and contracting ABC projects.

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 on the selection of project delivery and procurement methods 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

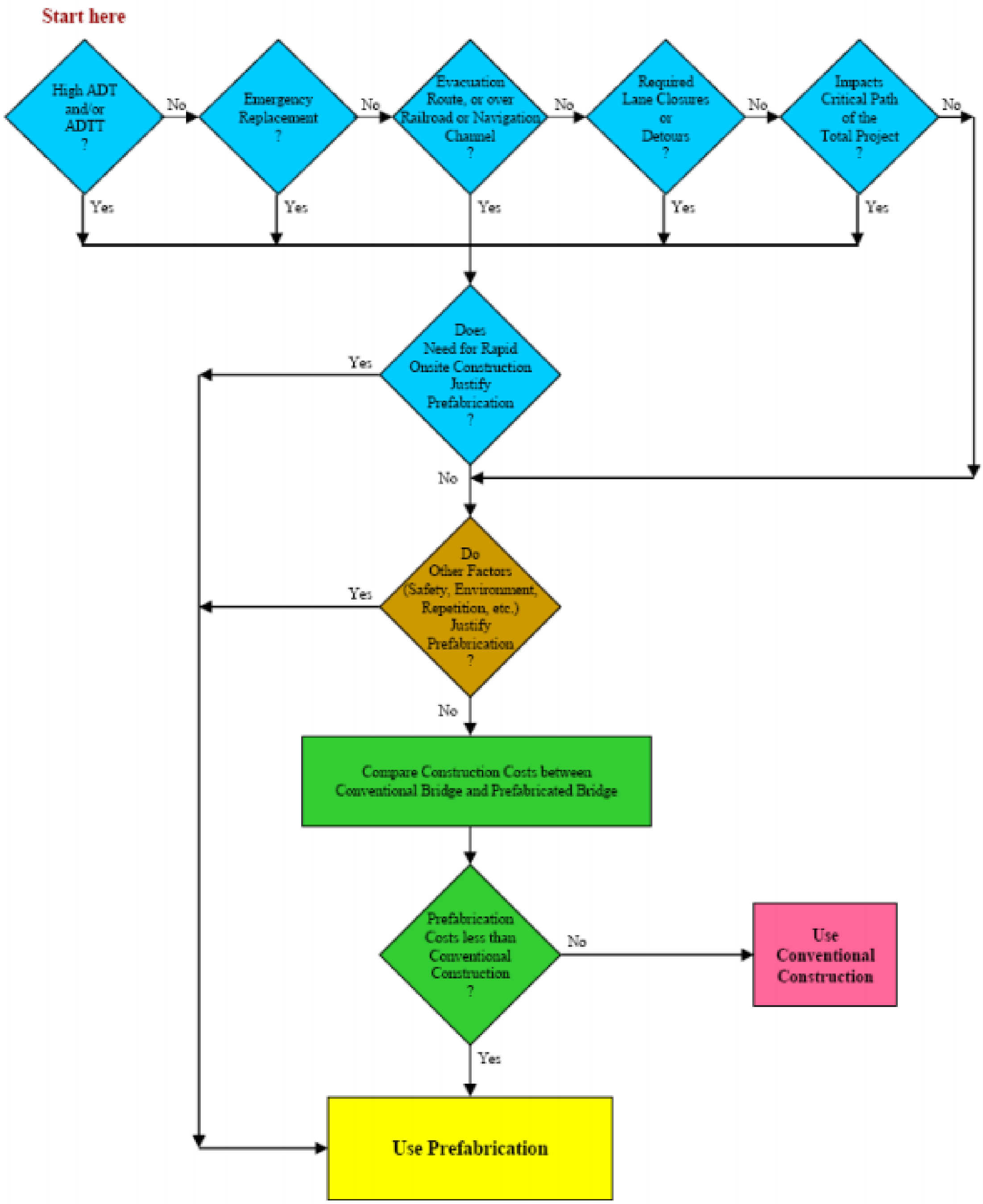
Current Practices: ABC Decision Matrix

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 the 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.

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.

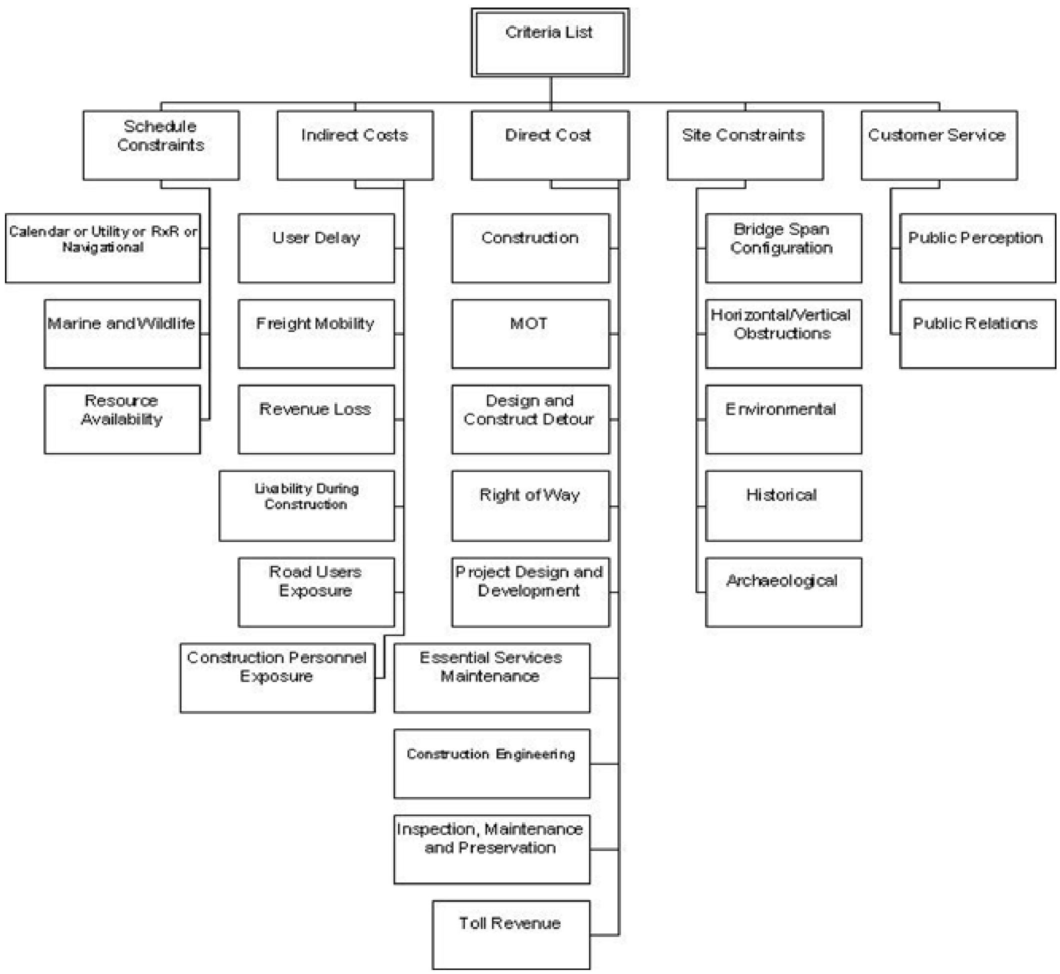


FHWA 2005

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

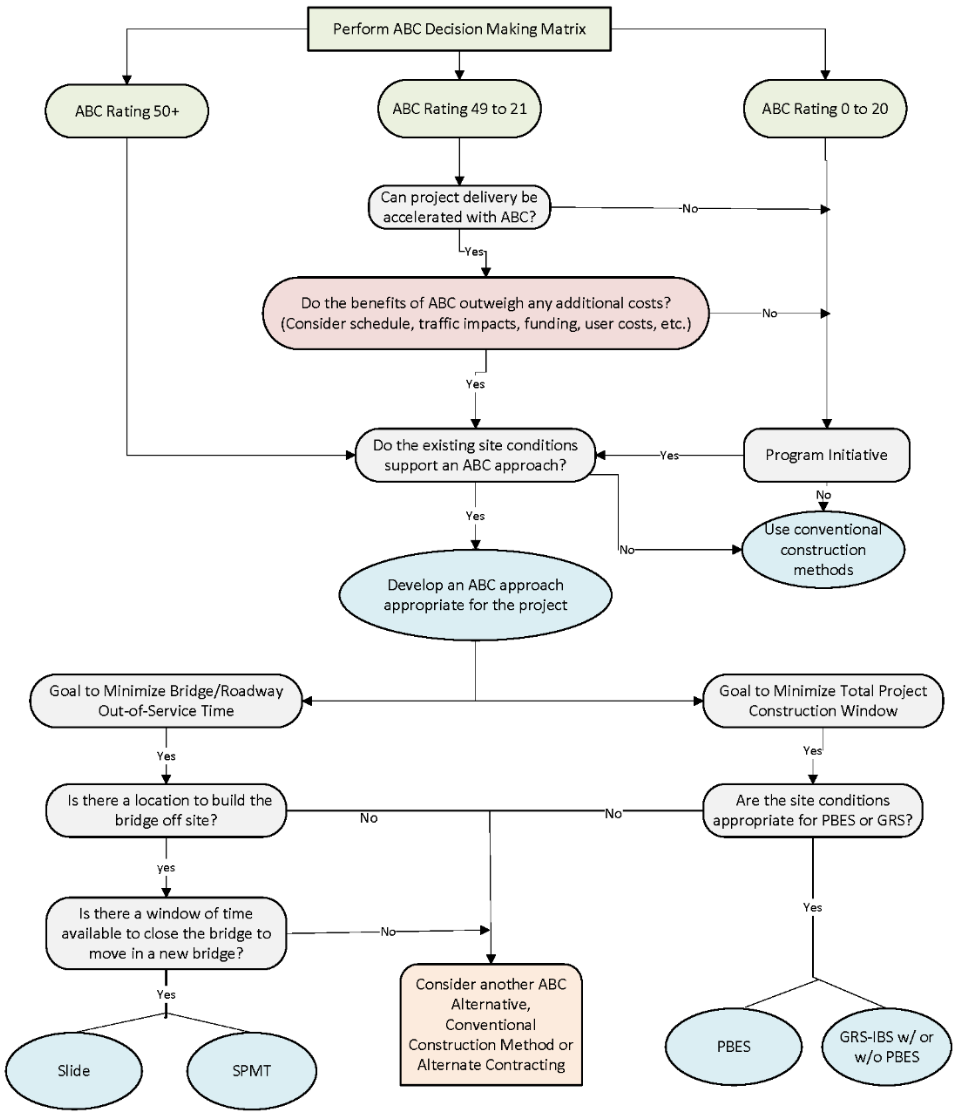
Figure 2. Oregon AHP criteria list

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).

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 traditional 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 Contracting Methods

On any project, a number of important decisions need to be made by the owner. These decisions include the project delivery method, the procurement method, and the contract type. These can be used in any combination and should be chosen based on the needs of the project and of the owner.

The contract is the agreement between the various parties involved in a project. This agreement outlines the requirements, obligations, and responsibilities of each party. The contract also deals with risk allocation and payment procedures for the work done on the project. The different types of contracts are lump sum, unit price, cost plus, and cost plus with a guaranteed maximum price (GMP).

Various parties may hold contracts with each other. The nature of the contracting is somewhat dependent on the project delivery method. The owner may hold a contract with a designer, one or more contractors, a construction manager, and/or a tenant for the project. A construction manager may hold a contract with a contractor. The designer may hold a contract with subconsultants. The lead contractor, or general contractor, may hold a contract with subcontractors. All of these relationships and contracts have different purposes, but they all boil down to responsibilities, risks, and payment. All parties should know about the other contracts on the project, at least who holds them, so that they can be cognizant of the various relationships to support project communication and the goals of each of the parties.

Lump Sum or Fixed Price Contract

One type of contract is the lump sum contract, also sometimes referred to as a fixed price contract. A lump sum contract is characterized by one entity agreeing to complete a certain scope of work for a specified sum of money. For instance, a contractor may agree to build a box culvert for $1 million. The entity that specifies the lump sum or fixed price for the work is the majority risk holder. In the box culvert example, there is some risk for the owner, but the primary risk holder is the contractor because if the project ends up costing more than expected, it is the contractor that must pay for the overrun. However, if the overrun is because of an owner-directed change, then there may be a price adjustment through a change order to the lump sum of the project.

Since the contractor is the biggest risk taker in this project, the contractor also stands to make the most money. If the project can be delivered under the specified amount of $1 million, the remaining funds are profit for the contractor. In this way, there is some risk to the owner that the contractor could make more profit on the project than what is generally seen in the market, which indicates that the owner may have overpaid for the results delivered. Of course, assuming that a reputable contractor was hired through a competitive procurement process, this possibility should not often arise.

Another risk to the owner is the possibility that the results of the project will not meet the owner's expectations. Again, however, this possibility should not arise if a reputable firm was selected through a competitive procurement process.

Payment on lump sum contracts is often made in one of three ways. There may be one payment at the completion of the work for the full specified amount. This is generally not the case unless the project is small and short in duration. Another option is to schedule specified portions of the lump sum to be paid upon completion of certain deliverables or at regularly scheduled intervals. For example, a designer may be paid 40% of the lump sum after delivering the structural plan sheets and another 15% upon delivery of other detail sheets. Alternatively, a portion of the lump sum may be paid every six months. This is usually stipulated in the procurement process but is invariably spelled out in the contract documents. An issue with this type of payment scheme is that the definition of the percentage of work done can be subjective. Additionally, if a contractor works ahead and accomplishes more than was anticipated in six months, the payment schedule may not reflect the actual work completed.

The third payment option for lump sum contracts is based on a schedule of values, and typically in conjunction with the critical path method cost-loaded schedule, which can be verified by the owner and itemizes the respective costs for certain types of work. The contractor might develop a schedule of values at the start of the project and each month compare the progress made to the schedule of values.

For example, earthwork may be 8% of the project costs, foundations are 8%, structural steel placement is 15%, and so forth. At the end of each month, the contractor would then estimate the amount of work completed. For example, perhaps 45% of the earthwork is completed at the end of the first month and 10% of the foundations have been placed. With concurrence about the amount of work performed and approval from the construction manager, the owner would then pay the contractor 45% of 8% of the contract sum for the earthwork plus 10% of 8% for the foundations. In the second month, the contractor determines that all of the earthwork is completed, 50% of the foundations are in place, and 5% of the structural steel is in place. Again with concurrence and approval from the construction manager, the owner would pay the contractor for the portions of work completed. However, in this month the owner would not pay 100% of 8% of the contract sum for the earthwork, since the contractor was already paid in the first month for some of this work; instead, the owner would pay the difference. An issue with this payment mechanism is, again, that determining the percentage of work completed can sometimes be subjective.

The advantages of the lump sum contract for the owner are that the total price for the project is known up front and the majority of the risk is on the entity doing the work. However, the responsibility of major risks (such as unforeseen conditions, third party risks, etc.) are typically spelled out in the contract terms regardless of the payment terms; as such, quantity risk or overrun are the most likely risks for the contractor with lump sum contracts. The advantage for the entity doing the work is the possibility of significant profit if the project is run efficiently.

Unit Price Contract

Another contract type is the unit price contract. This is the most frequently used contract type in highway construction. With a unit price contract, an amount is usually specified for each unit installed. There are usually multiple types of units on each project. For instance, a project might include a price per cubic yard of concrete, a price per ton of steel, a price per square foot of geofabric, etc. For a highway project, there is usually a price per ton of asphalt, a price per cubic yard of concrete, a price per pound for reinforcing bars, etc. Within each unit, the contractor embeds the overhead, profit, labor, equipment, material, and other costs. These embedded costs may be different for each unit. For example, a contractor might include a higher profit margin on some units than others, and more labor or equipment might be associated with the installation of one type of unit compared to another.

With this type of contract, the risk to the owner lies in the final price of the project. The price estimate tends to be reasonably accurate because the bids or proposals for projects that use this type of contract usually include the price per unit, so assuming that the quantity take-offs of the units (or the unit counts) are accurate for the project, the final cost is known. The risk is whether the counts are accurate or can realistically be estimated.

A risk to the contractor for this type of contract is that the contractor may miscalculate the unit prices. For example, if employee fringe benefits are omitted from the unit prices, the contractor would have to cover those costs outside of the contract amount. Another risk to the contractor is that the project may require fewer quantity take-offs for particular units than expected, resulting in less profit.

The payment process for a unit price contract is simple. The number of units installed are counted, usually every two weeks or once a month, and then that number is multiplied by the price per unit. The resulting price is then paid to the contractor. For instance, if asphalt is $55 per ton and 150 tons are placed in one month, the contractor is paid $8,250 that month for placing the asphalt. One question that can arise regarding payment is when a unit should be considered completed and the unit price paid. For instance, should the unit price be paid for reinforcing bars for concrete when they are delivered, when they are tied, or after the concrete is placed so they are in their final installed form on the project? However, this question can also be an issue for any contract type.

Cost Plus Contract

Another type of contract is the cost plus contract. This type of contract is similar to a unit price contract, but instead of embedding all of the costs associated with a unit into the unit price, the contractor bills the owner for the actual cost of the material, labor, and equipment, along with a separate fee that is specified and agreed to in advance. A single fee may apply to the entire project, regardless of the material, equipment, etc. that the project requires.

The risk for the owner is that the contract may not specify a maximum dollar amount for the project, so the owner could end up paying more than expected. Meanwhile, designers or contractors need to ensure that they include all applicable costs and profits in the fee portion. Payment is based on a count of the units and presentation of the receipts for the materials, equipment, etc. to the owner, who then reimburses the contractor for the receipts and pays the agreed-upon fee.

Cost Plus with Guaranteed Maximum Price Contract

One variation on the cost plus contract is cost plus with GMP. This is the same as a cost plus contract, with the exception that the designer, contractor, or construction manager guarantees the maximum price that the owner will pay for the work performed. With this stipulation, the owner may pay less than expected, but, unless there are owner-directed changes, the owner will not pay more than the guaranteed maximum. This alleviates some of the owner’s risk but puts more risk on the contractor, who agrees to the GMP.

Time and Material Contract

A less commonly used contract type is the time and material contract. This type of contract is typically limited to change orders because of the risks involved. Change orders are used to address issues that come up during the course of a project’s execution, usually during construction but sometimes during the design process too. The risk arises because the amount of time or materials is variable and because typically a higher price, or premium, is placed on materials that are not specified in the original contract; these materials may need to be rush ordered so that the project’s completion schedule is not held up.

A limited amount of research has been conducted comparing the different contract types, but a study of water and wastewater projects involved some comparisons between lump sum contracts and cost plus with GMP contracts. The study found that a higher proportion of projects with a cost plus with GMP contract had a schedule growth of 0% or lower compared to projects with a lump sum contract, regardless of the project delivery method. This indicates that a cost plus with GMP contract offers a better chance to finish a project on time or early than a lump sum contract. This same study also found that projects with a cost plus with GMP contract, regardless of the project delivery method, had a lower mean cost growth and lower median cost growth for design and construction than projects with a lump sum contract. A statistically significant difference was also found between the contract types in terms of the proportion of projects that had no cost growth or negative cost growth. Forty-two percent of the surveyed water and wastewater projects that had cost plus GMP contracts came in at or below the contracted amount, while only 19% of the surveyed projects with lump sum contracts experienced no cost growth or were delivered for less than the contracted sum. Again, these findings are regardless of project delivery type. However, it is not known whether these findings extend beyond water and wastewater projects.

Overview of Project Delivery Methods

Several project delivery methods are used for ABC. The methods used and referenced in this study are design-bid-build (DBB), design-build (DB), and construction manager/general contractor (CMGC).

Design-Bid-Build Project Delivery

Design-bid-build is the most widely used project delivery method for roadway and bridge construction in the United States. In this method, the three phases are sequential and have minimal to no overlap. In the design phase, detailed plans and specifications are prepared by engineers either from within a construction company, as a third-party consultant, or by the owner. About 5% to 10% percent of the project's total cost is spent on this phase. Construction companies then bid on the contract, and the project is usually awarded to the lowest responsible bidder. The build (or construction) phase involves the majority of the project costs and is completed by the construction company according to the contract. The benefits of a DBB contract include the ease with which designs can be changed before construction begins, the fact that the design is usually 100% complete before construction, the fixed cost of the contract, and the known bid costs. The disadvantages of this method consist of shared responsibility for delivery of the project, the sequential nature of the project usually producing longer schedules for completion, and the fact that the total cost is unknown until the contract is officially signed.

Design-Build Project Delivery

The next most common project delivery system is design-build. An advantage of design-build is that it combines the design and construction phases into a single contract. Design-build is used because it often offers time and cost savings over the conventional design-bid-build method (Orabi et al. 2016). It does this by allowing construction to begin before the plans are fully developed. In addition, design-build offers a lower likelihood of a discrepancy between the plans from the design stage and the construction itself. The project is awarded using either the low bid or best value method. The low bid method is the same as the method used in the design-bid-build process, while the best value method considers other factors, such as the contractor's qualifications and experience, innovation, technical approach, quality control methods, and project management. Design-build seems to outperform design-bid-build on almost every front, but design-bid-build can be a better fit for some projects depending on the situation, and its use is sometimes required by law (Orabi et al. 2016).

Construction Manager/General Contractor Project Delivery

The least common of the three studied delivery methods is construction manager/general contractor. This delivery method allows the owner to include a construction manager, usually chosen based on qualifications and experience, in the design process to give input on constructability. During the design phase, the construction manager provides input regarding scheduling, pricing, phasing, and any other subject that he or she believes will create a more constructible project. When the project design phase reaches 60% to 90% completion, the owner usually negotiates a guaranteed maximum price with the construction manager that is based on the scope and schedule of the project. If that price is agreed upon, a contract is written and the construction manager becomes the general contractor. This method is also called construction manager at risk in some states (FHWA 2017).

Current Practices: Alternative Delivery Methods

Traditionally, state transportation agencies have used design-bid-build for all of their projects, though some states have been moving towards using alternative delivery methods such as DB and CMGC. Projects using these alternative delivery methods are often awarded based on the contractor's qualifications, which can lead to pushback from some contractors due to the subjectivity of the selection process. Another obstacle to using alternative delivery methods is that the project award process in some states is legislatively controlled.

Design-build projects can be procured by selecting a contractor based on low bid, best value, or qualifications. Nationally, 44 states are able to use design-build to some degree for transportation projects (DBIA 2019). However, only eight states are authorized to use qualifications-based selection for the procurement of design-build projects as of 2019.

Design-build is used for several reasons. First, design-build requires only one contract to administer construction, whereas design-bid-build and CMGC both require multiple contracts. Design-build also allows for accelerated construction times because the design and construction phases can overlap and allows for enhanced constructability because the designer only needs to design for one contractor. It also results in fewer changes and claims and less litigation (DBIA 2015).

CMGC can be procured using best value or qualifications-based selection. Twelve states were authorized to use CMGC in 2010 (Gransberg and Shane 2010). Since that report was written, California, Minnesota, and Tennessee have also authorized the use of CMGC.

The reasons to use CMGC vary: time constraints, a need for flexibility, a need for preconstruction services, a desire for interaction during the design process, and possibly financial constraints (Gransberg and Shane 2010). According to the Minnesota DOT (MnDOT), the advantages of using CMGC are that it allows the agency to retain control of the design, it allows the agency to independently select the best designer and the best contractor, and it can lead to the faster completion of projects because longer lead times can be accommodated. CMGC also allows for a more streamlined design and can help to foster innovation in the project development stage (MnDOT n.d.).

The benefits of using alternative delivery methods are that they give agencies more control over the cost of the project, accelerate the project schedule, and bring the opportunity for innovation into the project. As a result of these benefits, alternative delivery methods are beginning to be used more frequently, and agencies are receiving legislative approval to begin using them.

Decisions Regarding the Use of Alternative Delivery Methods

The decision regarding which project delivery method to use on a project can be critical. A study by Bingham et al. (2018) found that the factors most influencing the choice of project delivery method are the urgency of the project, cost of the project, and best method for risk allocation.

A recently completed study (Bypaneni and Tran 2018) identified eight risk factors that impact the project delivery selection process:

- Delays in railroad agreements
- Project complexity
- Uncertainty in geotechnical investigation
- Delays in the right-of-way process
- Unexpected encounters with utilities
- Work-zone traffic control
- Challenges in obtaining environmental documentation
- Delays in delivery schedule

Many of the benefits to alternative delivery methods discussed in the previous section may address some of these identified risks. With any construction project, common general goals include the following:

- Completing the project on schedule, with minimized project delivery time
- Minimizing the cost of the project and completing the project on budget
- Meeting or exceeding quality expectations

- Maximizing the life cycle performance of the project

To accomplish these goals, alternative delivery methods can be an attractive means to improve project efficiency. MnDOT, for example, uses an alternative delivery scoping checklist to identify projects early that may be candidates for alternative delivery methods. Since the vast majority of agency projects still use DBB, a checklist approach such as this is beneficial for identifying the unique projects that would benefit from alternative delivery methods. As an example, the project features that MnDOT considers in its scoping checklist are shown below (received via communication with MnDOT). Note that ABC, shown in bold, is identified as an element to consider.

- Total project cost estimate in excess of $20,000,000
- Grading in excess of $5,000,000
- Complex, costly, or otherwise substantial staging
- Complex (e.g., curved steel), unusual, or major bridges
- Work on historic bridges or other highly sensitive infrastructure
- Highly complicated third-party risks (e.g., railroad, major utilities, Section 4(f) impacts)
- Use of alternative pavements
- Multiple viable options for interchange type, alignments, or other components (bridge versus tunnel, stabilized embankment versus wall, etc.)
- Highly constrained budgets and room for “scope variation”
- Known acceleration needs (e.g., projects that are likely to be advanced in the future)
- Major constructability concerns (e.g. access problems, options that may affect design)
- Major construction schedule constraints
- Significant traffic impacts and delay on major routes (Interstates, principal arterials, etc.)
- Implementation of new technology (accelerated bridge construction, BIM, etc.)
- A lack of final design staff
- Existence of other, similar projects (that could potentially be packaged together)

Should an agency consider using an alternative delivery method (and if it is legislatively able to do so), a decision-making process for delivery method selection is recommended. Decision matrices have been developed by many agencies and often consider the following elements:

- Delivery schedule
- Project complexity
- Design responsibilities
- Cost
- Risks
- Experience with alternative delivery methods
- Level of desired agency involvement
- Contractor experience

The decision-making processes used by four states and the role of risk assessment in selecting a project delivery method are described in the following sections.

Minnesota Department of Transportation

MnDOT addresses the decision matrix elements described above in its project delivery selection process by considering the opportunities and obstacles presented by different project delivery methods. Figure 4 shows a sample table from MnDOT's project delivery selection template for the topic of Project Complexity and Innovation.

<table>
<tr><th colspan="2">DESIGN-BID-BUILD</th></tr>
<tr><th>Opportunities</th><th>Obstacles</th></tr>
<tr><td>☐ MnDOT can have more control of design of complex projects
☐ MnDOT and consultant expertise can select innovation independently of contractor abilities
☐ Opportunities for value engineering studies during design, more time for design solutions
☐ Aids in consistency and maintainability
☐ Full control in selection of design expertise
☐ Complex design can be resolved and competitively bid</td><td>☐ Innovations can add cost or time and restrain contractor's benefits
☐ No contractor input to optimize costs
☐ Limited flexibility for integrated design and construction solutions (limited to constructability)
☐ Difficult to assess construction time and cost due to innovation</td></tr>
<tr><th colspan="2">DESIGN-BUILD</th></tr>
<tr><th>Opportunities</th><th>Obstacles</th></tr>
<tr><td>☐ Designer and contractor collaborate to optimize means and methods and enhance innovation
☐ Opportunity for innovation through draft RFP, best value and ATC processes
☐ Can use best-value procurement to select design-builder with best qualifications
☐ Constructability and VE inherent in process
☐ Early team integration
☐ Sole point of responsibility</td><td>☐ Requires desired solutions to complex designs to be well defined through technical requirements (difficult to do)
☐ Qualitative designs are difficult to define (example. aesthetics)
☐ Risk of time or cost constraints on designer inhibiting innovation
☐ Some design solutions might be too innovative or unacceptable
☐ Quality assurance for innovative processes are difficult to define in RFP</td></tr>
<tr><th colspan="2">CMGC</th></tr>
<tr><th>Opportunities</th><th>Obstacles</th></tr>
<tr><td>☐ Highly innovative process through 3 party collaboration
☐ Allows MnDOT the control of a designer/contractor process for developing innovative solutions
☐ Allows for an independent selection of the best qualified designer and best qualified contractor
☐ VE inherent in process and enhanced constructability
☐ Risk of innovation can be better defined and minimized and allocated
☐ Can take to market for bidding as contingency</td><td>☐ Process depends on designer/CM relationship
☐ No contractual relationship between designer/CM
☐ Innovations can add cost or time
☐ Scope additions can be difficult to manage
☐ Preconstruction services fees for contractor involvement
☐ Cost competitiveness – single source negotiated GMP</td></tr>
</table>

MnDOT 2015

Figure 4. MnDOT's project delivery opportunity and obstacle checklist for project complexity elements

Identifying the opportunities and obstacles that are unique to each project can provide a clear choice of project delivery method. Often, the inherently short durations of ABC projects add a degree of complexity to the project as a whole. As such, ABC projects tend to lend themselves well to alternative delivery methods if those are available to an agency.

To better compare the three main project delivery methods discussed in this report in terms of MnDOT's decision matrix, Table 1 summarizes the characteristics of each method.

Table 1. Summary of opportunities and obstacles for three project delivery methods

Method	Opportunities	Obstacles
DBB	• DOT, contractors, and consultants have a high level of experience with the traditional system • Schedule is more predictable and more manageable • Short procurement period • Time to communicate/discuss design with stakeholders • MnDOT has complete control over the design • Competitive bidding provides low cost construction for a fully defined scope of work • Increased certainty about cost estimates • Risk allocation is widely understood/used • Reduced chance of corruption and collusion	• Requires time to perform a linear design-bid-construction process • Design and construction schedules can be unrealistic due to lack of industry input • No contractor input to optimize costs • Minimizes competitive innovation opportunities • Can reduce the level of constructability since the contractor is not brought into the project until after the design is complete • Cost reductions due to contractor innovation and constructability are difficult to obtain • DOT accepts risks associated with project complexity (the inability of designer to be all-knowing about construction) and project unknowns • Low bid-related risks • Can require a high level of DOT staffing of technical resources • No contractor input into the process

Method	**Opportunities**	**Obstacles**
DB	• Less DOT staff required due to the sole-source nature of DB • Potential to accelerate schedule through parallel DB process • Shifts schedule risk to DB team • Allows innovation in resource loading and scheduling by DB team • Designer and contractor collaborate to optimize means and methods and enhance innovation • Does not require much design to be completed before awarding project to the designer-builder (between ~10% and 30% complete) • Performance specifications can allow for alternative risk allocations to the designer-builder • Avoids low bid risk in procurement • Two-phase process can promote strong teaming to obtain "best value"	• Request for proposal development and procurement can be extensive • Must have very clear definitions and requirements in the RFP because it is the basis for the contract • If design is too far advanced, it will limit the advantages of DB • Less DOT control over design • Unknowns and associated risks need to be carefully allocated through a well-defined scope and contract • Limitation of availability of DOT staff with skills, knowledge, and personality to manage DB projects

Method	Opportunities	Obstacles
CMGC	• More efficient procurement of long-lead items • Can provide a shorter procurement schedule than DB • Team involvement for schedule optimization • Contractor input for phasing, constructability, and traffic control may reduce overall schedule • DOT-designer-contractor collaboration to reduce project risk can result in low project costs • Cost is known earlier than for DBB • Contractor can have a better understanding of the unknown conditions as design progresses • Innovative opportunities to allocate risks to different parties (e.g., schedule, means and methods, phasing) • DOT can improve efficiency by having more project managers on staff than specialized experts	• Strong DOT management is required to control schedule • Process depends on designer-construction manager relationship • Scope additions can be difficult to manage • Cost competitiveness: GMP negotiated by a single source • Three-party process can slow progression of design • Non-competitive negotiated GMP introduces price risk • Limited to risk capabilities of CMGC • Limitation of availability of MnDOT staff with skills, knowledge, and personality to manage CMGC projects • DOT must learn how to negotiate GMP projects • Currently, a large pool of contractors with experience in CMGC is not available, which reduces competition and availability

Source: MnDOT 2015

While this list is not exhaustive, it provides a good starting point to compare and contrast the strengths and weaknesses of each delivery method.

When considering CMGC, for example, it is not as likely that the agency will receive an extremely competitive bid, because the contractor is not competing against other contractors but instead against an independent cost estimate. This means that, while the price may be fair, it is not necessarily the low price that would result from using the DBB method. However, the contractor will be experienced and have an incentive to avoid claims or significant disputes because the contractor is involved in the project from the beginning. This risk assessment is considered up front and allows the risk to shift more to the contractor than the agency.

Utah Department of Transportation

The Utah DOT (UDOT) is among the most experienced when it comes to using CMGC. As such, the agency has developed a process for selecting CMGC for a given project. This process has three phases: the concept phase, the design phase, and the construction phase. If CMGC is selected during the concept phase, the project moves into the design phase, and a consultant and CMGC are procured. During the concept phase, a risk analysis is conducted, and the results are shown to an evaluation team that compares the project to the characteristics of the delivery methods. It is also worth noting that if the project is federally funded, approval from the FHWA is needed before moving forward with CMGC (Gransberg and Shane 2010).

UDOT has developed a document identifying essential elements, applicability, advantages, risks/limitations, and procurement methods for each of the delivery methods that it uses: DBB, CMGC, DB, and progressive DB. Table 2 compares the three methods examined in the present study.

Table 2. UDOT project delivery method decision matrix

<table>
<tr><th>Delivery Method</th><th>DBB</th><th>DB</th><th>CMGC</th></tr>
<tr><td>Essential Elements</td><td>• Traditional delivery system
• Owner contracts separately for design and construction services
• Bid based on complete plans and specifications
• Owner retains high level of control and risk</td><td>• Combines design and construction under a single contract
• Two-phase selection process using qualifications in the first phase and price plus technical components in the second phase
• Traditionally a lump sum contract</td><td>• Construction contract is negotiable
• Selection criteria include qualifications, experience, strategic approach, and price elements
• Owner contracts separately for design and construction services
• Owner engages a construction manager to act as a construction advisor during preconstruction and general contractor during construction</td></tr>
<tr><td rowspan="2">Applicability</td><td rowspan="2">• Projects where the owner needs to completely define the scope
• Project scope can be best defined using prescriptive specifications
• Significant risks or third-party issues that can be best resolved or managed by the agency</td><td>• Projects that benefit from innovation in design or construction
• Projects having a high sense of urgency that would benefit from an expedited project delivery
• Well-defined project scope
• Projects having manageable public controversy, third-party issues, or environmental issues
• Performance specifications</td><td>• Projects where owner requires greater control of design
• Projects with multiple phases and contracts
• Go slow to go fast
• Concept-level-only scope
• Complete or obtainable environmental documents and permits for the entire project
• Established project footprint</td></tr>
<tr><td colspan="2">• Time or funding constraints*</td></tr>
</table>

<table>
<tr><th>Delivery Method</th><th>DBB</th><th>DB</th><th>CMGC</th></tr>
<tr><td rowspan="2">Advantages</td><td rowspan="2">• Applicable to a wide range or projects
• Well established and easily understood
• Owner retains design control
• Provides the lowest initial price that responsible, competitive bidders can offer
• No legal barriers in procurement and licensing
• Well-established legal precedents</td><td>• Streamlines and enhances coordination through a single point of responsibility for design and construction
• May reduce design and construction duration
• Allows accelerated delivery by fast-tracking design and construction in phased packages
• Earlier schedule and cost certainty
• Can reduce owner risks</td><td>• Identifies and reduces/mitigates risk
• Allows fast-tracking of early procurement items and construction phases prior to completed design
• Transparent pricing
• Owner issues addressed prior to price development, with cost certainty earlier in the process
• Can send project out to DBB if a fair price cannot be negotiated
• Reduces errors, change orders, and material overruns
• Minimizes/eliminates need for lengthy procurement
• Owner retains control over design
• Opportunity for shared savings provides an incentive for construction manager (CM) to control costs and work within funding limits</td></tr>
<tr><td colspan="2">• Allows for innovation, quality, and constructability review during design*
• Improves constructability*</td></tr>
</table>

Delivery Method	**DBB**	**DB**	**CMGC**
Risks/limitations	• Tends to yield base-level quality • Higher level of inspections/testing by the agency • Initial low bid might not result in ultimate lowest cost or final base value • Agency bears risk of design adequacy	• Potential to reduce opportunities for smaller construction firms • Less owner control over final design • Higher procurement costs and stipends for proposers • Traditional funding may not support fast-tracking construction or may require accelerated cash flow • Considerable time needed for RFP creation	• Potential appearance of unfairness in sole-source selection process • Potential for failure to agree on price and may require extra time to send project out for bid • Added CM fees during preconstruction • Fair market price, not lowest price
Procurement Methods	• Qualified low bid • A+B bidding • Alternate bids • Additive alternates	• Best value selection with price component • Qualified low bid	• Best value selection based solely on qualifications

*Similarities between DB and CMGC
Source: UDOT 2018

This table enables UDOT to compare the project delivery methods and discuss which delivery method is best for a given project.

While it may appear that a best value approach puts an innovative bid and a low bid at odds, many agencies have found that this is not the case. An interview with the UDOT revealed that the agency has had many projects in which the low bid for DB was also associated with the highest technical score. This is likely because the contractor had put in a great amount of preparatory work to understand the project and had bid properly and efficiently, implementing innovation where possible to save either time or money against conventional approaches. In these cases, the bid process results in increased innovation, but the agency does not pay a premium for it.

Arizona Department of Transportation

The Arizona DOT (ADOT) has developed a scoring method to determine the project delivery methods. This scoring method compares DBB, DB, and construction manager at risk (i.e., CMGC). The scoring sheet takes into account project-level, agency-level, policy/regulatory-level, and special consideration criteria. In this process, the project team weights the project's goals in order to determine the appropriate delivery method for the specific project. The scoring summary, shown in Table 3, does include suggested weights for the factors, but teams can modify these weights.

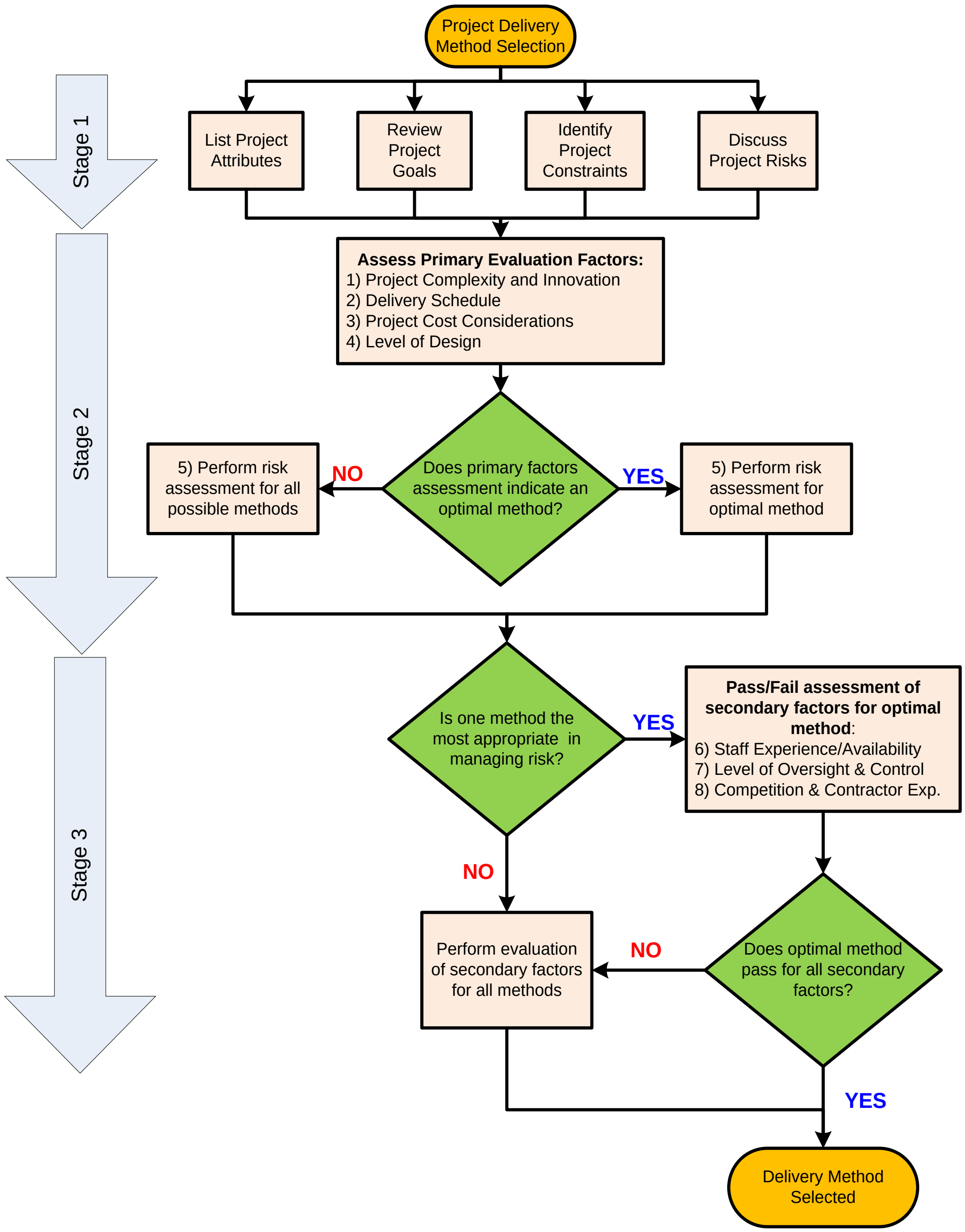
Table 3. ADOT project delivery method scoring summary

Weight of Selection Factor	Selection Factor	Weight of Individual Goal
40%	*Project Level*	
	Project complexity	20
	Budget	20
	Schedule	20
	Risk	20
	Scope	20
20%	*Agency Level*	
	Staffing availability int/ext	20
	Experience int/ext	20
	Agency goals/objectives	20
	Agency control of project	20
	Third party coordination	20
20%	*Policy/Regulatory Level*	
	Balanced procurement	30
	Environmental regulations	30
	Tribal impacts	20
	Stakeholder/community	20
20%	*Special Considerations*	
	Total project delivery cost	30
	Staffing pressures	30
	Modification opportunities	20
	Project life cycle costs	20

Source: ADOT n.d.

Colorado Department of Transportation

The Colorado DOT (CDOT) has a three-stage process for determining the project delivery method for a project, as shown in Figure 5.



CDOT 2019

Figure 5. CDOT project delivery selection process

CDOT emphasizes that "no single project delivery method is appropriate for every project. Each project must be examined individually to determine how it aligns with the attributes of each available delivery method."

To examine each project, typically three to seven people are asked to participate in the analysis process. Participants are asked to complete the Project Delivery Description, Project Delivery Goals, and Project Delivery Constraints worksheets prior to attending a workshop for the project, which constitutes a majority of Stage 1.

The Project Delivery Description worksheet includes project attribute information such as the project's name, location, estimated budget, required delivery date, funding amount, features of work, major milestones, stakeholders, obstacles, safety issues, and sustainability requirements. The Project Delivery Goals worksheet allows the participants to specify the goals for the project. General example goals are included on the worksheet, but participants are encouraged to think beyond these. The Project Delivery Constraints worksheet allows for identification of general constraints related to funding, financing, schedule, laws, and third-party agreements, along with project-specific constraints. Again, a list of general project constraints is provided, but participants are encouraged to think beyond these general constraints.

At the project workshop, participants complete Stage 1 by reconciling their lists from their individually completed worksheets and discussing the project risks.

Other worksheets and forms that participants complete throughout subsequent stages of the selection process include a Project Risk worksheet and a Project Delivery Selection Matrix and Summary form. The Project Delivery Decision Selection Matrix and Summary form allows participants to begin the second and third stages of the selection process by considering the project delivery method to be used. In Stage 2, participants document the opportunities and obstacles of each delivery method in terms of five primary selection factors. During Stage 3, three secondary selection factors are reviewed by the workshop participants. The primary and secondary factors from Stages 2 and 3 are each assigned a rating by participants. Table 4 summarizes these primary and secondary factors.

Table 4. CDOT project delivery selection matrix

Selection Factor	Delivery Method	Consideration
Primary		
Project Complexity and Innovation	DBB	Allows agency to fully resolve complex design issues and qualitatively evaluate designs before procurement of the general contractor. Innovation is provided by agency/consultant expertise and through traditional agency-directed processes such as value engineering (VE) studies and contractor bid alternatives.
	DB	Incorporates designer-builder input into design process through best value selection and contractor-proposed alternate technical concepts (ATCs), which are a cost-oriented approach to providing complex and innovative designs. Requires that desired solutions to complex projects be well defined through contract requirements.
	CMGC	Allows independent selection of designer and contractor based on qualifications and other factors to jointly address complex innovative designs through three-party collaboration between agency, designer and contractor. Allows for a qualitative (non-price-oriented) design but requires agreement on construction agreed price (CAP).
Delivery Schedule	DBB	Requires time to perform sequential design and procurement, but if design time is available has the shortest procurement time after the design is complete.
	DB	Ability to get project under construction before completing design. Parallel process of design and construction can accelerate project delivery schedule; however, procurement time can be lengthy due to the time necessary to develop an adequate RFP, evaluate proposals, and provide for a fair, transparent selection process.
	CMGC	Quickly gets contractor under contract and under construction to meet funding obligations before completing design. Parallel process of development of contract requirements, design, procurements, and construction can accelerate project schedule. However, schedule can be slowed down by coordinating design-related issues between the CM and designer and by the process of reaching a reasonable CAP.

Selection Factor	Delivery Method	Consideration
Level of Design	DBB	100% design by agency or contracted design team, with agency having complete control over the design.
	DB	Design advanced by agency to the level necessary to precisely define contract requirements and properly allocate risk (typically 30% or less).
	CMGC	Can use a lower level of design prior to procurement of the CMGC and then joint collaboration of agency, designer, and CMGC in the further development of the design. Iterative nature of design process risks extending the project schedule.
Project Cost Considerations	DBB	Competitive bidding provides low-cost construction for a fully defined scope of work. Cost accuracy limited until design is completed. More likelihood of cost change orders due to contractor having no design responsibility.
	DB	Designer-builder collaboration and ATCs can provide a cost-efficient response to project goals. Costs are determined with design-build proposal early in design process. Allows a variable scope bid to match a fixed budget. Poor risk allocation can result in high contingencies.
	CMGC	Agency-designer-contractor collaboration to reduce risk pricing can provide a low-cost project; however, non-competitive negotiated CAP introduces price risk. Good flexibility to design to a budget.
Risk Assessment	DBB	Risk allocation for design-bid-build is best understood by the industry but requires that most design-related risks and third-party risks be resolved prior to procurement to avoid costly contractor contingency pricing, change orders, and potential claims.
	DB	Provides opportunity to properly allocate risks to the party best able to manage them, but requires risks allocated to designer-builder to be well defined to minimize contractor contingency pricing of risks.
	CMGC	Provides opportunity for agency, designer, and contractor to collectively identify and minimize project risks and allocate risk to appropriate party. Has potential to minimize contractor contingency pricing of risk but can lose the element of competition in pricing.

Selection Factor	Delivery Method	Consideration
Secondary		
Staff Experience and Availability	DBB	Technical and management resources necessary to perform the design and plan development. Resource needs can be more spread out.
	DB	Technical and management resources and expertise necessary to develop the RFQ and RFP and administer the procurement. Concurrent need for both design and construction resources to oversee the implementation.
	CMGC	Strong, committed agency project management resources are important for success of the CMGC process. Resource needs are similar to DBB, except agency must coordinate CM's input with the project designer and be prepared for CAP negotiations.
Level of Oversight and Control	DBB	Full control over a linear design and construction process.
	DB	Less control over the design (design desires must be written into the RFP contract requirements). Generally less control over the construction process (designer-builder often has quality assurance [QA] responsibilities).
	CMGC	Most control by agency over both the design and construction and over a collaborative agency-designer-contractor project team.
Competition and Contractor Experience	DBB	High level of competition, but general contractor (GC) selection is based solely on low price. High level of marketplace experience.
	DB	Allows for a balance of price and non-price factors in the selection process. Medium level of marketplace experience.
	CMGC	Allows for the selection of the single most qualified contractor, but CAP can limit price competition. Low level of marketplace experience.

Source: CDOT 2019

For each delivery method, information is provided to aid participants in identifying the aspects of the methods relevant to the different factors. Items specifically related to ABC concepts include the opportunities to accelerate the project schedule under both DB and CMGC because of their parallel processes. This feature of these methods is also noted as a design and construction risk because of the potential pressure on the schedule. CMGC is also noted for being "valuable for new non-standard types of designs where it is difficult for the agency to develop the technical requirements that would be necessary for [DB] without industry input" (CDOT 2019).

The participants then rate each factor for each method, indicating the appropriateness of each delivery method for the project. Instead of using a numerical rating, as seen in other states, CDOT uses a graphical representation to indicate most to least appropriate, as shown in Figure 6.

Rating Key	
++	Most appropriate delivery method
+	Appropriate delivery method
–	Least appropriate delivery method
X	Fatal Flaw (discontinue evaluation of this method)
NA	Factor not applicable or not relevant to the selection

CDOT 2019

Figure 6. CDOT project delivery method opportunity/obstacle rating key

Risk Assessment

While project complexity and timeline are often concepts an agency considers when choosing among alternative delivery methods, another is assessing risk, which is a component of many of the decision-making processes summarized above. Risk assessment is a part of every project, regardless of delivery method, but is especially important when selecting alternative delivery methods. To highlight the risks that have been identified by MnDOT, Figure 7 shows a sample of the agency's project delivery selection template, which includes many important scenarios to consider. Again, note that some of these items also appear in the decision matrices of the other states described above.

Environmental Risks	External Risks
☐ Delay in review of environmental documentation	☐ Stakeholders request late changes
☐ Challenge in appropriate environmental documentation	☐ Influential stakeholders request additional needs to serve their own commercial purposes
☐ Defined and non-defined hazardous waste	☐ Local communities pose objections
☐ Environmental regulation changes	☐ Community relations
☐ Environmental impact statement (EIS) required	☐ Conformance with regulations/guidelines/ design criteria
☐ NEPA/404 Merger Process required	☐ Intergovernmental agreements and jurisdiction
☐ Environmental analysis on new alignments required	
Third-Party Risks	**Geotechnical and Hazmat Risks**
☐ Unforeseen delays due to utility owner and third-party	☐ Unexpected geotechnical issues
☐ Encounter unexpected utilities during construction	☐ Surveys late and/or in error
☐ Cost sharing with utilities not as planned	☐ Hazardous waste site analysis incomplete or in error
☐ Utility integration with project not as planned	☐ Inadequate geotechnical investigations
☐ Third-party delays during construction	☐ Adverse groundwater conditions
☐ Coordination with other projects	☐ Other general geotechnical risks
☐ Coordination with other government agencies	
Right-of-Way/ Real Estate Risks	**Design Risks**
☐ Railroad involvement	☐ Design is incomplete/ Design exceptions
☐ Objections to ROW appraisal take more time and/or money	☐ Scope definition is poor or incomplete
☐ Excessive relocation or demolition	☐ Project purpose and need are poorly defined
☐ Acquisition ROW problems	☐ Communication breakdown with project team
☐ Difficult or additional condemnation	☐ Pressure to delivery project on an accelerated schedule
☐ Accelerating pace of development in project corridor	☐ Constructability of design issues
☐ Additional ROW purchase due to alignment change	☐ Project complexity - scope, schedule, objectives, cost, and deliverables - are not clearly understood
Organizational Risks	**Construction Risks**
☐ Inexperienced staff assigned	☐ Pressure to delivery project on an accelerated schedule.
☐ Losing critical staff at crucial point of the project	☐ Inaccurate contract time estimates
☐ Functional units not available or overloaded	☐ Construction QC/QA issues
☐ No control over staff priorities	☐ Unclear contract documents
☐ Lack of coordination/ communication	☐ Problem with construction sequencing/staging/phasing
☐ Local MnDOT issues	☐ Maintenance of Traffic/Work Zone Traffic Control
☐ Internal red tape causes delay getting approvals, decisions	
☐ Too many projects/new priority project inserted into program	

MnDOT 2015

Figure 7. General project risks to consider, per MnDOT's selection process

Supplemental Agency Interview Information Related to Alternative Delivery Methods

During the information collection efforts associated with this project, which included both interviews with agency representatives and a review of existing literature, the importance of letting the project drive the choice of delivery method was a common theme. A well-suited project delivery method is critical for projects that include complexities associated with, for example, traffic phasing or significant public relations needs. A CDOT representative noted that when CMGC is the method used, the contractor's qualifications that are necessitated by the project can be identified during the contractor selection process to ensure that the contractor has the requisite amount of relevant experience prior to the work beginning. This type of contractor preselection is not possible with traditional DBB projects and low bid procurement, though agencies are developing new methods to adapt to these needs via prequalified bidder identification efforts that would allow agencies to disqualify contractors that do not have the needed capabilities prior to bidding.

All of the agency representatives interviewed for this research project expressed that while they may not receive the lowest possible bid on a project that uses CMGC, they feel that they get a good value overall for the project. This is because of the savings due to the reduced number of change orders, increased innovation during the design process, a shift of risk from the agency to the contractor, and other factors. In other words, while the lowest bid may not always result from CMGC, the value added due to the collaboration between the contractor and the agency allows for other savings to be realized. When comparing the costs of different delivery methods for a project, it is important to identify where the cost of the project is being measured. If the cost of the project is measured on bid day, CMGC is typically costlier than traditional DBB. However, a UDOT representative noted during the interview that if the cost is measured at project close-out, the cost of CMGC is lower than or approximately equal to the cost of DBB. This close-out cost takes into account the savings due to the reduced number of change orders for CMGC compared to DBB delivery, which are associated with unforeseen conditions and utilities, right-of-way delays, and other risks.

Not all projects can or should be completed using alternative delivery methods, including ABC projects. Once particular ABC methods have been used by an agency and familiarity has been achieved, the benefits of alternative delivery methods begin to taper off unless other project complexities exist. Taking all variables into account during the project delivery selection process is therefore critical to achieving efficient and cost-effective project delivery.

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.

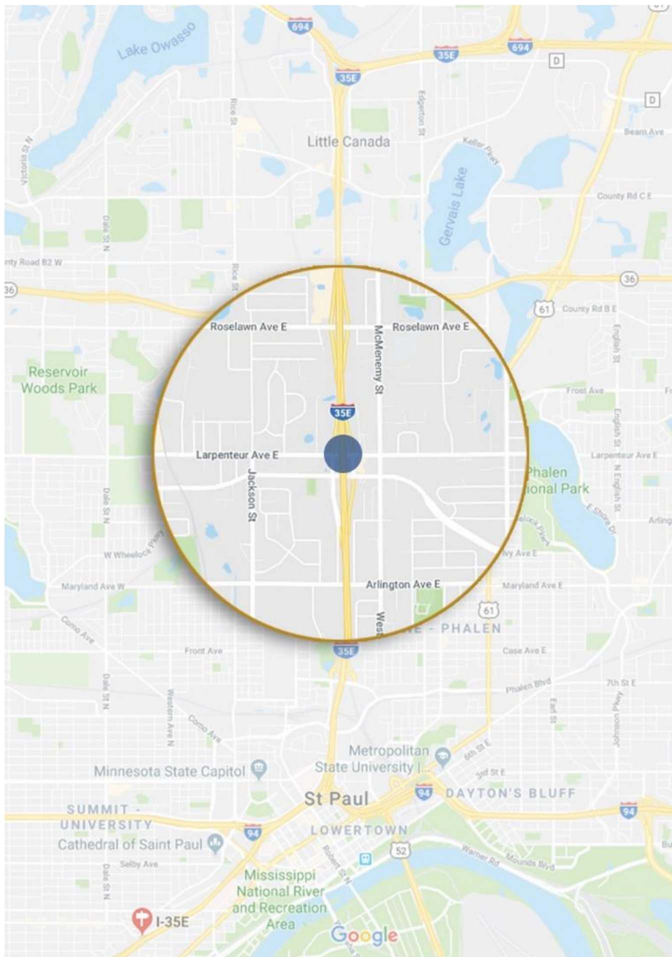
The results of this information collection are included in this report, as well as in four standalone case study summaries that can be found on the ABC-UTC website at the following hyperlinks:

- 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 8. 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 9. 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 10. 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

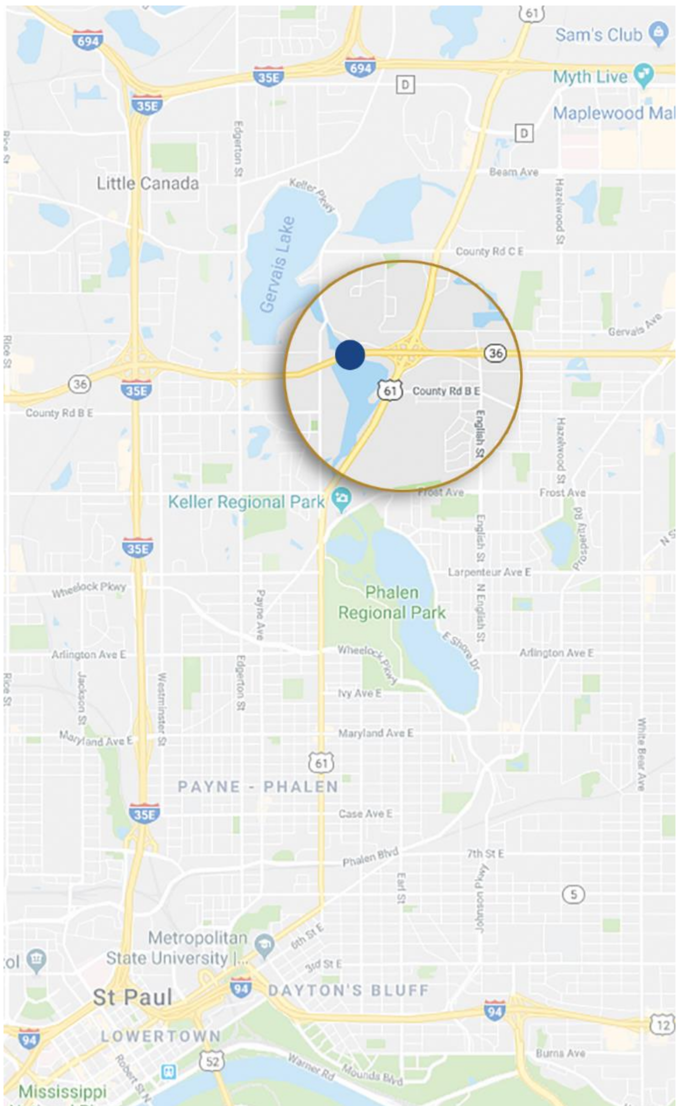
- For construction, it is recommended to have multiple contingency plans.

- 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 11. 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 12. 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 procured 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 13. 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 14. Precast abutment setting over piles with projecting, hooked, reinforcing steel bars

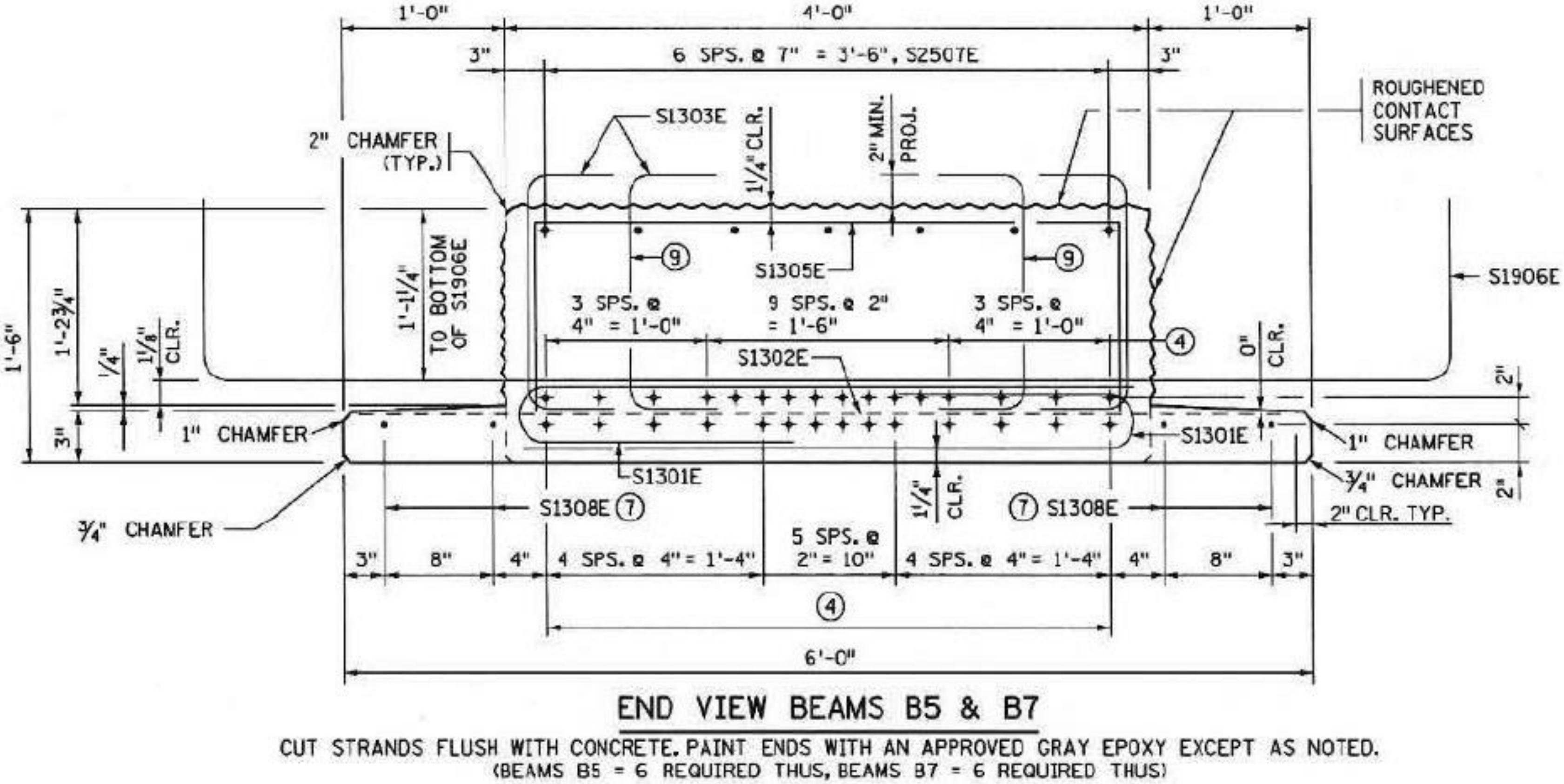
After grouting the substructure units, the inverted T-beams were placed for the three-span bridge using a crane. The beams were set on narrow elastomeric pads that extended the full length of the substructure.

MnDOT

Figure 15. Precast abutment set showing pile grout pockets with wingwalls that consisted of a permanent sheetpile wall with a CIP facing and top coping

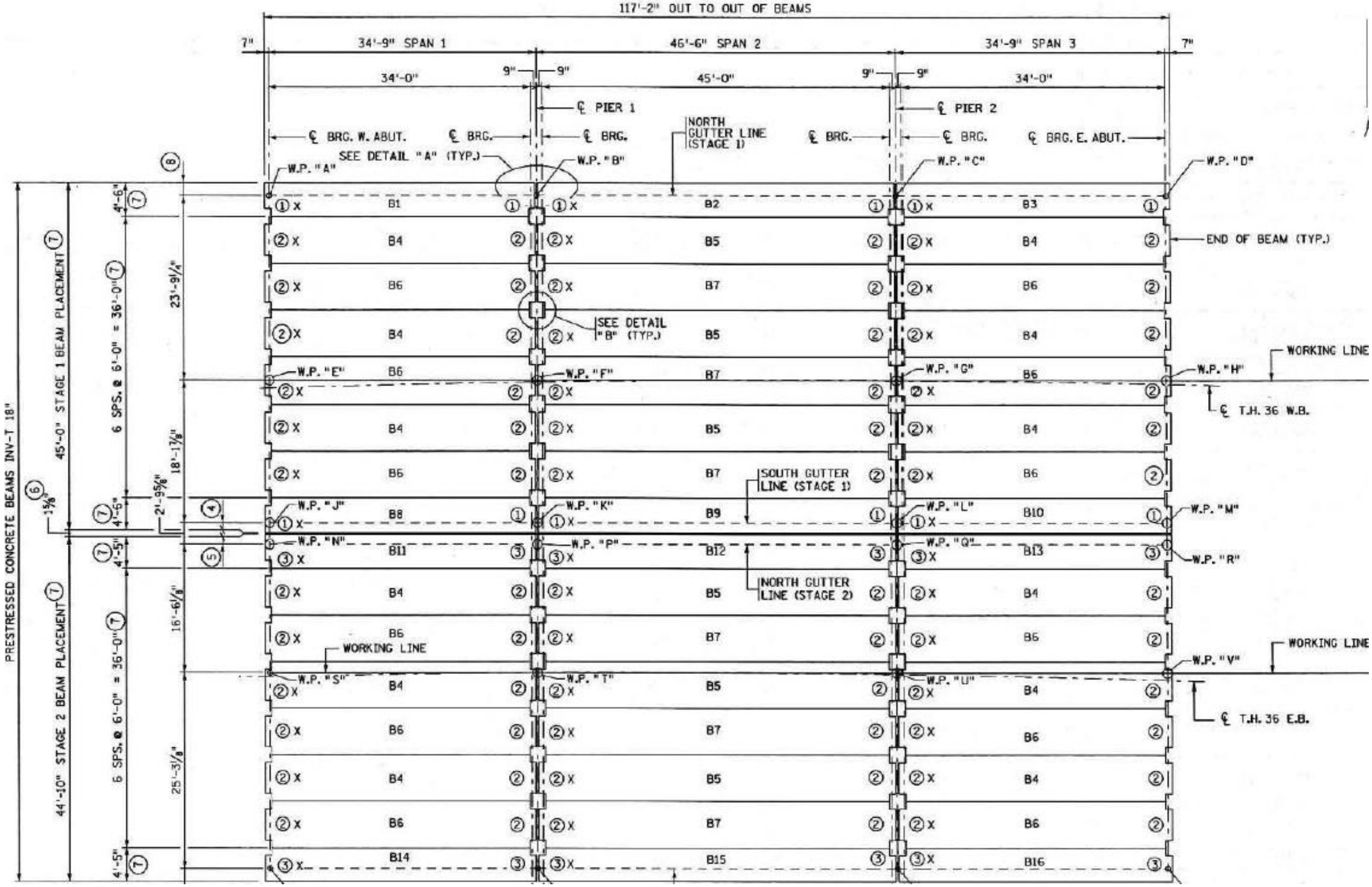
At the piers and abutments, dowels extended up into the coped areas of the flanges to tie the superstructure to the substructure. These dowels were isolated from the superstructure by using pipe insulation. The isolation of the dowels frees up local restraints to permit superstructure thermal expansion,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



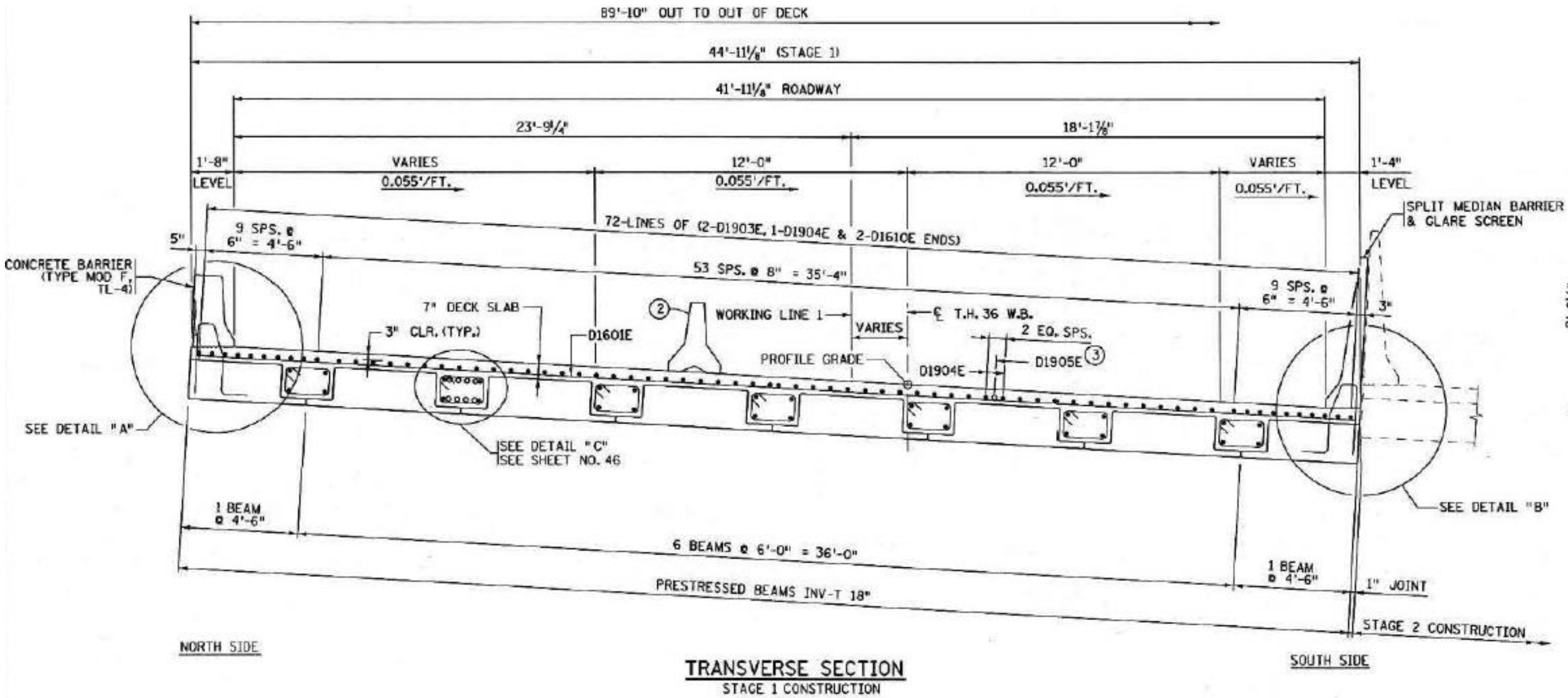
MnDOT

Figure 16. Interior inverted T-beam details showing flanges are coped over supports to enable substructure connectivity



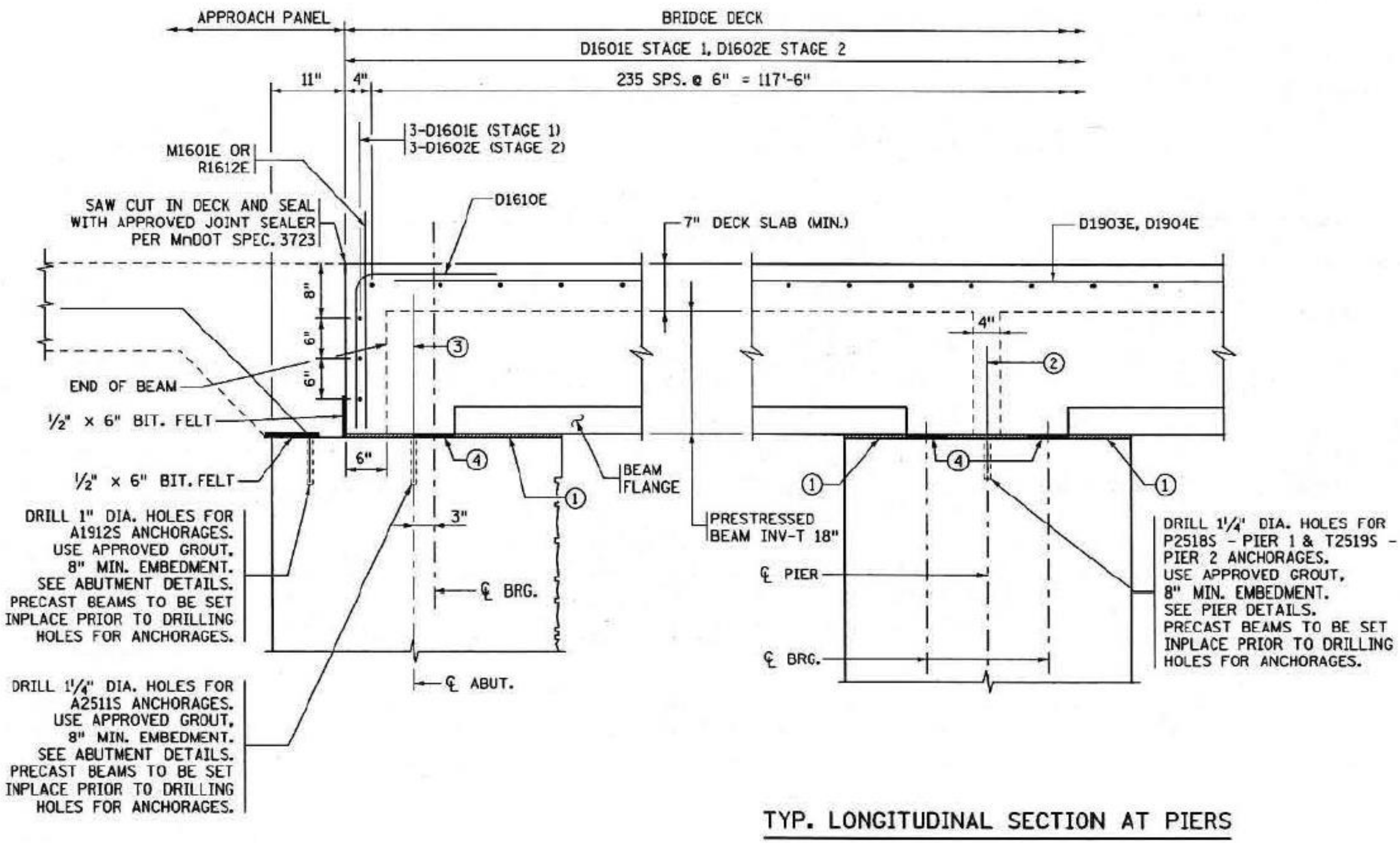
MnDOT

Figure 17. Plan view of three spans of inverted T-beams



MnDOT

Figure 18. Superstructure cross-section with deck reinforcement and interconnecting diaphragm reinforcement



MnDOT

Figure 19. 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 20. Keller Lake Bridge view from trail under bridge

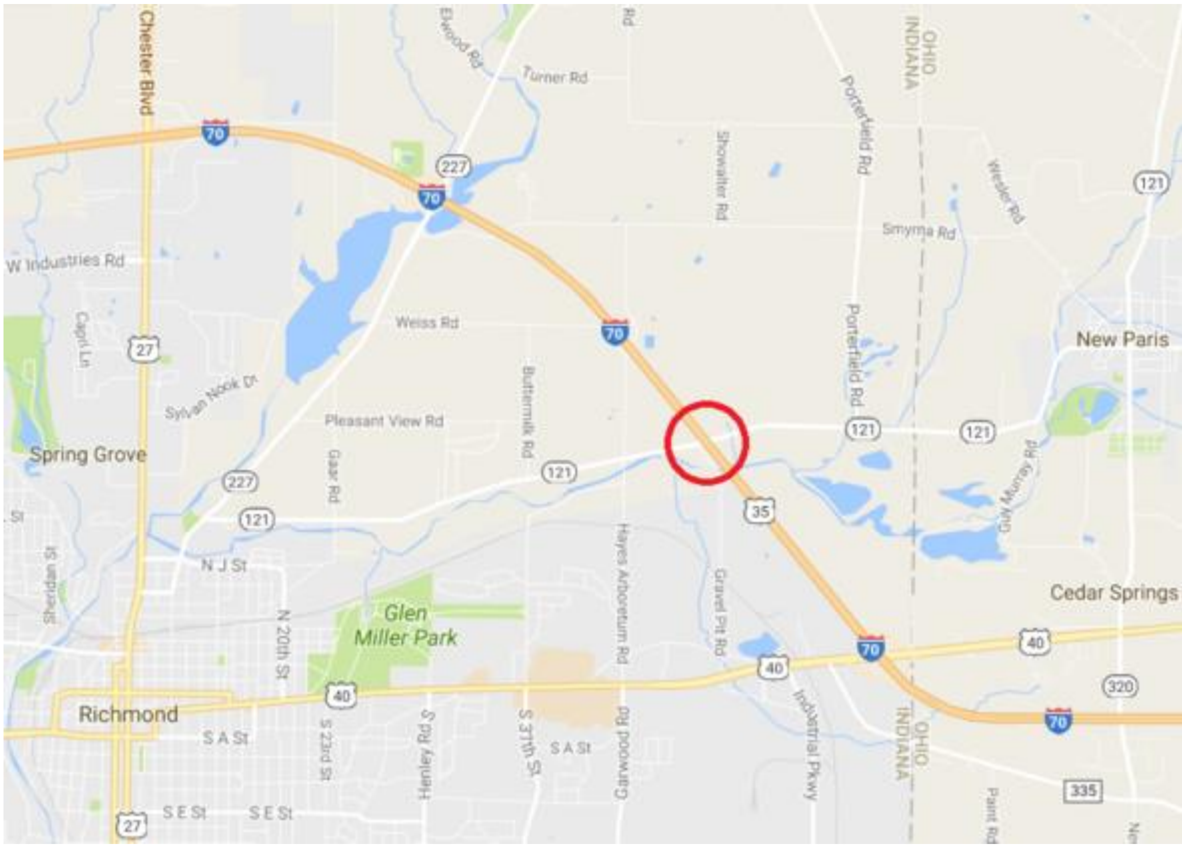
Key Takeaways

- 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 21. 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.

Figure 22. 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.

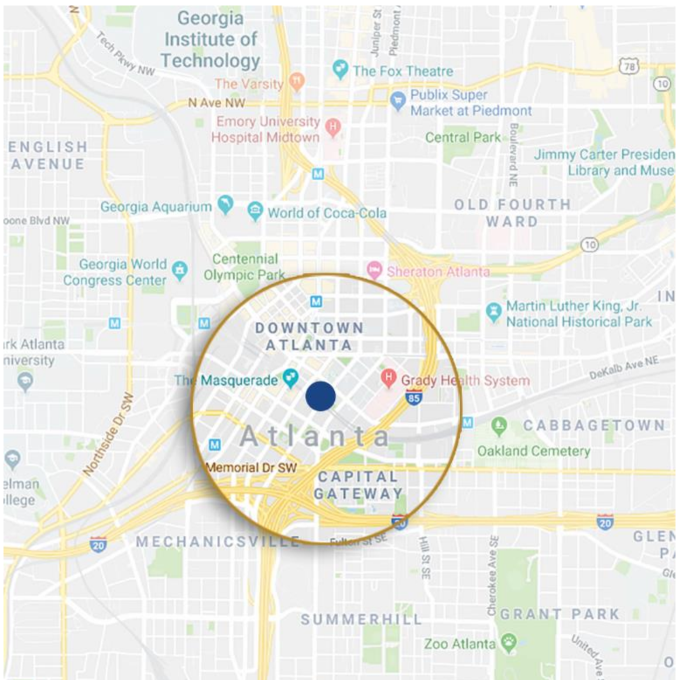
- The slide-in engineering that had to be done by the contractor was subcontracted out and was stamped by the engineer only after the engineer of record (EOR) for the bridge approved the plans.

- 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 23. 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.

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

Figure 24. 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.

REFERENCES

ADOT. n.d. *ABC Decision Flowchart*. Arizona DOT. https://www.azdot.gov/docs/default-source/bridge-group/abc-flowchart.pdf?sfvrsn=2.

——. n.d. *ADOT ABC Decision Making Matrix*. Arizona DOT. Excel file available at https://www.azdot.gov/business/engineering-and-construction/bridge/guidelines/accelerated-bridge-construction.

Bingham, E., G. E. Gibson, Jr., and M. El Asmar. 2018. Measuring User Perceptions of Popular Transportation Project Delivery Methods Using Least Significant Difference Intervals and Multiple Range Tests. *Journal of Construction Engineering and Management*, Vol. 144, No. 6, pp. 1–10.

CDOT. 2019. Project Delivery Selection Matrix – Blank Form. Colorado Department of Transportation, Denver, CO. Word document available at https://www.codot.gov/business/designsupport/adp-db-cmgc/pdsm/project-delivery-selection-approach-blank-form/view.

DBIA. 2015. *Choosing a Product Delivery Method: A Design-Build Done Right Primer*. Design-Build Institute of America, Washington, DC. https://dbia.org/wp-content/uploads/2018/05/Primers-Choosing-Delivery-Method.pdf.

——. 2019. DBIA State Maps. https://dbia.org/advocacy/state/.

FHWA. 2005. *Framework for Prefabricated Bridge Elements and Systems (PBES) Decision-Making*. Federal Highway Administration, Washington, DC. https://www.fhwa.dot.gov/bridge/prefab/if06030.pdf.

——. 2017. Construction Program Guide: Construction Manager / General Contractor Project Delivery. https://www.fhwa.dot.gov/construction/cqit/cm.cfm.

Gransberg, D. D. and J. S. Shane. 2010. *NCHRP Synthesis 402: Construction Manager-at-Risk Project Delivery for Highway Programs.* National Cooperative Highway Research Program, Washington, DC.

Iowa DOT. 2018. *LRFD Bridge Design Manual.* Iowa Department of Transportation Office of Bridges and Structures, Ames, IA.

MnDOT. n.d. Construction Manager / General Contractor Overview. Minnesota Department of Transportation, St. Paul, MN. www.dot.state.mn.us/const/tools/cm-gc-overview.html.

——. 2015. Project Delivery Method Selection Workshop Template. Minnesota Department of Transportation, St. Paul, MN. Word document available at https://www.dot.state.mn.us/pm/deliverymethod.html.

Orabi, W., A. Mostafavidarani, and M. Ibrahim. 2016. *Estimating the Construction Cost of Accelerated Bridge Construction.* Civil and Environmental Engineering, Florida International University, Miami, FL.

Oregon State University. 2012. Overview of ABC Alternative Selection Decision Tool and Validation – Oregon-Led Pool Funded Study. FHWA Office of Operations Peer Exchange Workshop: Innovative Contracting and Accelerated Construction Techniques for Work Zone Safety and Mobility, June 5–6, Denver, CO. https://ops.fhwa.dot.gov/wz/p2p/arw/p7_tang.htm.

UDOT. 2018. *Project Delivery Methods*. Utah Department of Transportation, Salt Lake City, UT. https://www.udot.utah.gov/main/uconowner.gf?n=23976327019648709 (available from https://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:4552).

WisDOT. 2018. *Bridge Manual.* Wisconsin DOT, Madison, WI. https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/strct/bridge-manual.aspx.