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16. Abstract

Accelerated bridge construction (ABC) is the solution of choice to upgrade substandard bridges or construct new bridges while maintaining traffic flow and optimizing safety through work zones. However, the perception of higher construction costs for ABC versus conventional construction continues in spite of numerous ABC projects having lower construction costs compared to conventional construction. This inaccurate perception and the fear of cost overruns are causing some bridge owners to be reluctant to implement ABC technologies, especially those technologies related to bridge system moves, which can provide the greatest benefits for safety and traffic flow.

While the traditional contracting method for state departments of transportation (DOTs) is primarily unit price contracting, there are alternatives, including cost plus, lump sum, lump sum with a guaranteed maximum price, and progressive lump sum with a guaranteed maximum price. To date, there has been little investigation into the use of these alternative contracting methods for ABC projects. This project explored the use of these options to understand the state of practice regarding contracting methods and provide insights and lessons learned for DOTs.

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ABC Synthesis of Available Contracting Methods

Final Report
October 2020

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CHAPTER 1: LITERATURE REVIEW

Overview of Procurement and Bidding

ABC Procurement and Bidding Processes

Accelerated bridge construction (ABC) projects are designed to reduce the amount of time that it takes for a bridge to be constructed. This type of construction can result in the need for procurement systems other than low-bid procurement. The procurement systems identified as part of this research include different types of best value procurement that emphasize the project schedule and/or the contractor's technical expertise.

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

The advantage of best value procurement is that it allows for innovation, the project schedule, and the contractor's safety record to be a part of the bid. Best value procurement, however, is typically associated with alternative delivery methods such as design-build (DB) and construction manager/general contractor (CMGC). This can be a challenge when using best value procurement because some contractors feel that such delivery methods lead to a non-competitive procurement process that results in certain contractors gaining more contracts than others. Further challenges are that some states do not have experience with these delivery methods and that alternative delivery methods cannot be used in some states because of legislative restrictions. However, alternative delivery methods may work well for ABC projects because they emphasize the teaming of the designer and the contractor.

Beyond the typical best value procurement process, which considers project cost and the contractor's technical expertise, some procurement processes specifically focus on bringing project schedule into the procurement process. One schedule-focused best value procurement system is A+B bidding. A+B has two components. The first is a bid based on the unit prices of the equipment, which is typically submitted for most roadway projects. The second component is the number of days that are needed by the contractor to complete the project. The basic formula for finding the total bid is

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

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

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

Table 1. A+B bidding example

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

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

Another schedule-focused best value procurement system is A+B+C bidding. This approach is similar to A+B bidding, but it has an added component. There is no hard rule for what the third component must be, though it is often milestone timeframes. The C component could be a cost that would only accrue during a portion of the project rather than the entire project. For example, B could be tied to the completion of the project as a whole while C could be tied to the completion of a certain portion of it.

A third schedule-focused tool that can be used is lane rental. Lane rental charges the contractor a fee for the amount of time that a lane or shoulder is closed by the contractor (Carpenter et al. 2003). The duration of time that the lane is closed can be measured in days or hours. The fee for lane rental is based on the road user costs, similarly to the way that these costs are used for A+B bidding. There are three types of lane rental: lane-by-lane rental, continuous site rental, and bonus/rental charge (Carpenter et al. 2003). Lane-by-lane rental involves charging the contractor for the amount of time that each lane is closed. Continuous site rental charges the contractor for each day that lanes are closed. Finally, bonus/rental charge is used to award contracts similarly to A+B bidding by considering the cost of the work and the time cost of the project. In this method, the time cost is determined by the time lanes are closed and the user cost of closing the lanes.

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

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

Using best value procurement with alternative delivery methods allows the owner to determine where incentives enter the contract. This is because using best value procurement removes the need for I/D clauses, as the schedule is now a part of the bid. As a result, the contractor bids a shorter schedule to win the job instead of being award additional money for finishing early.

ABC Bid Items

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

Table 2. Example of a wide range of bid item values

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

Source: ADOT 2017

As the table shows, the four bids proposed a wide range of values for all of the bid items shown. It is important to note that a wide range of values does not always indicate a lack of understanding of bid items. Contractors may lump other components into a particular bid item, leading to a higher bid price for the item in question but possibly a lower price for another. Another reason for differing bids is that some contractors might have the equipment or experience needed to complete the specific bid items at lower costs than their competitors.

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

Overview of Contracting Methods

Every project has several decisions that the owner must make for the project to move forward. Some examples include deciding which project delivery method to use, which procurement method to use, and the contract type. The combination of these decisions yields numerous possibilities for the owner to meet the needs of the project.

The contract is an agreement between the various parties involved in a project. This agreement outlines the requirements, obligations, and responsibilities of each party. The contract also details 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 contract 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. Fundamentally, they cover the risk, responsibility, and payment between the parties. All parties should be aware of the other contracts that exist on a project, at minimum knowing which parties hold contracts with other parties, to be aware of the relationships on the project. This allows for the parties to support communication within the project and to support the goals of the other parties.

Below is a discussion of the different types of contracts that are used on transportation projects.

Lump Sum Contract

A lump sum contract is characterized by one entity agreeing to complete a certain scope of work for a specified sum of money. This is sometimes referred to as a fixed price contract. For instance, a contractor may agree to build a box culvert for $10 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, scenarios exist in which the owner and the contractor can agree to amend the cost and scope of the contract, which is typically accomplished with a change order.

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 $10 million, then 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. However, the chances of this occurring are mitigated by hiring reputable contractors using a competitive procurement method.

Another risk to the owner is the possibility that the results of the project will not meet the owner's expectations. This risk can be mitigated with a competitive procurement process. Contractors and designers often prefer to lose money on a project and still deliver quality results than to tarnish their reputation or damage their relationship with the owner. In the construction industry, reputation and relationships matter, and owners and contractors are likely to work together in the future if all goes well on the current project. However, designers and contractors do not want to habitually lose money on their projects.

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 payment type used unless the project is small and short in duration. Another option is to schedule specified portions of the lump sum to be paid at regularly scheduled intervals, for example, a portion of the lump sum 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, which 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 architect or 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 architect or 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. The advantage for the entity doing the work is the possibility of significant profit if the project is run efficiently.

Unit Price Contract

The second contract type is the unit price contract. This is the most frequently used contract type in highway construction. A unit cost price contract involves bidding an amount of money per unit, and it is paid for each unit that is installed on the project. For a highway project, there is usually, for example, a price per ton of asphalt, a price per cubic yard of concrete, and a price per pound for reinforcing bars. 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; if 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. An example would be a proposal that may have estimated the removal of 35 cubic yards of soil and 15 cubic yards of rock, which are typically different unit prices, with rock removal costing more than soil removal; on the project, the actual numbers for the project may end up being reversed. Similarly, contaminated soil may be discovered during construction whose removal was not specified in the contract nor bid on by the contractor. If the contractor agrees to remove the soil, the owner would be required to pay a higher unit price than expected.

One of the risks to the contractor is that the contractor could 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 units than proposed in the design.

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 $50 per ton and 125 tons are placed in one month, the contractor is paid $6,250 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 come up on any contract type.

Cost Plus and Cost Plus with Guaranteed Maximum Price Contracts

The third 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, and labor to the owner, which then reimburses the contractor for the receipts and pays the agreed-upon fee.

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 shifts the risk from the owner to the designer, contractor, or construction manager when determining the GMP.

Time and Material Contract

A less commonly used contract type is the time and material contract. The use of this contract type is typically limited to change orders because it has a high degree of risk. The risk is primarily due to the variability in the amount of time or materials required, though another risk is that the materials needed to mitigate an unforeseen problem might require extra cost to complete the project on schedule. 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.

Comparison of Contract Types

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 no schedule growth or were completed early 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 (Bogus et al. 2009). 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), DB, CMGC, and public-private partnership (P3).

Design-Bid-Build

Design-bid-build is the most widely used project delivery method for roadway and bridge construction in the United States. This method has three distinct phases that are sequential and have minimal to no overlap. Detailed plans and specifications are prepared by engineers during the design phase, either within the company or by consultants. About 5% to 10% percent of the project's total cost is spent on this phase. Construction companies (contractors) then bid on the contract, and the project is usually awarded to the lowest responsible bidder. A majority of the project cost is in the build (or construction) phase, where the work is completed by the construction company. 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 fact that the sequential nature of the project usually produces longer schedules for completion, and the fact that the total cost is unknown until the contract is officially assigned.

Design-Build

The next most widely used alternative project delivery system is DB. An advantage of DB is that it combines the design and construction phases into a single contract. DB is used because it often offers time and cost savings over the conventional DBB method (Orabi et al. 2016). DB allows construction to start before the plans are fully developed. Further, there is less likelihood of a discrepancy between the design stage and construction. 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 DBB process, while the best value method considers other factors, as discussed above. DB seems to outperform DBB on almost every front, but DBB can be a better fit for some projects depending on the situation, and its use is sometimes required by law (Orabi et al. 2016).

A recently completed study of highway projects in Florida (Tran et al. 2018) found that for both new construction projects, including new bridge construction, and reconstruction projects, including bridge reconstruction, there was a statistical difference in intensity, measured in dollars spent per day, between DB and DBB. Projects delivered using DB were more intense, costing more dollars per day, than DBB projects. There were differences in cost and schedule growth, though they were not found to be statistically significant at an p-value of 0.05. There was a difference when the alpha value is increased to 0.10, with DBB reconstruction projects experiencing greater cost growth than DB reconstruction projects (Tran et al. 2018).

Construction Manager/General Contractor

Another project delivery method is CMGC. With this delivery method, the owner has a contract with a contractor and a separate contract with a designer. The crucial aspect of this delivery method is that the contractor is involved in the design to provide constructability reviews, cost estimates, scheduling information, and other factors that the construction manager believes can increase the constructability of the project. The contractor is usually chosen based on qualifications and experience. 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).

Public-Private Partnership

A fourth project delivery system is P3. P3 involves a public agency, such as a state transportation agency, entering into a contract with a private entity. The private entity is then responsible for all or some of the following: engineering, construction, operation, financing, and maintenance (PennDOT 2020). The main advantage of P3 is that it allows public agencies access to private capital. Other advantages of P3 are that it allows for innovative materials and techniques, accelerated project delivery, and a better allocation of risks between stakeholders (PennDOT 2020).

CHAPTER 2: METHODOLOGY

The Accelerated Bridge Construction University Transportation Center (ABC-UTC) database available from the ABC-UTC website (http://utcdb.fiu.edu/) served as the main source of data for the three analyses conducted for this project. The database contained 108 projects at the time of the study. Two additional projects were added to this data set after the authors were made aware of them by various means. These projects were the Poplar Street Bridge in St. Louis, Missouri, and an Iowa DOT lateral slide project, IA 1 over Camp Creek 3.1 miles south of IA 22. With these two additions, the data set for the analysis constituted a total of 110 projects.

However, not all projects were utilized for every analysis. Chapters 3, 4, and 5, which describe the three analyses completed for the project, detail which projects were removed from the data set for each analysis and for what reason.

In total, the data set spans the years 1973 through 2019. Additional supplemental information was gathered from relevant DOT publications, contract documents, and a survey of state transportation agency bridge engineers to verify the results of the analysis.

CHAPTER 3: APPLICABILITY OF DELIVERY METHODS TO ABC PROJECTS

Methodology

The first analysis conducted on the data set of ABC projects involved the delivery methods used for the projects. To analyze the delivery methods, a sample was gathered from the ABC-UTC database. Five projects were removed from the data set because they listed the delivery method as “other,” “P3,” or “design-build by in-house forces.”

For the remaining projects, the database included information about the components that qualified the projects as ABC. The ABC-UTC database recognizes three types of ABC components: structural, geotechnical, and construction. Structural components are prefabricated elements or systems that reduce the amount of time needed to construct the bridge. Geotechnical components are solutions for foundations, walls, and rapid embankments that also reduce the amount of time needed to construct the bridge. Construction components are methods that move either completed bridges or bridge elements into their final place.

The data were sorted into the three categories of components listed in the ABC-UTC database. (Note that the population used in this analysis is not a representative sample of the three ABC components.) The data were also analyzed by the type of project delivery method used, the ABC component used on the project, and the component’s relationship to the project delivery method.

Results

Figure 1 shows the percentage of each delivery method used on ABC projects from 2005 until 2013. The percentages shown in the figure are representative of the projects in the sample.

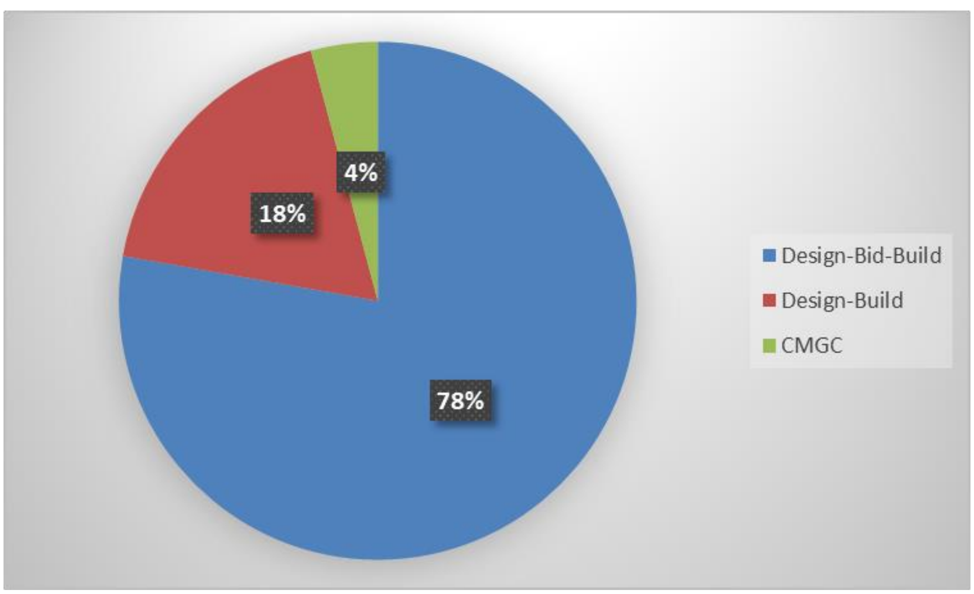

Figure 1. ABC delivery methods from 2005 to 2013

Figure 2 shows that there was a spike in the number of ABC projects after 2005. Note that the number of ABC projects has not decreased recently; rather, the apparent decrease in the number of projects since 2011 indicates that updated information is not yet available within the database.

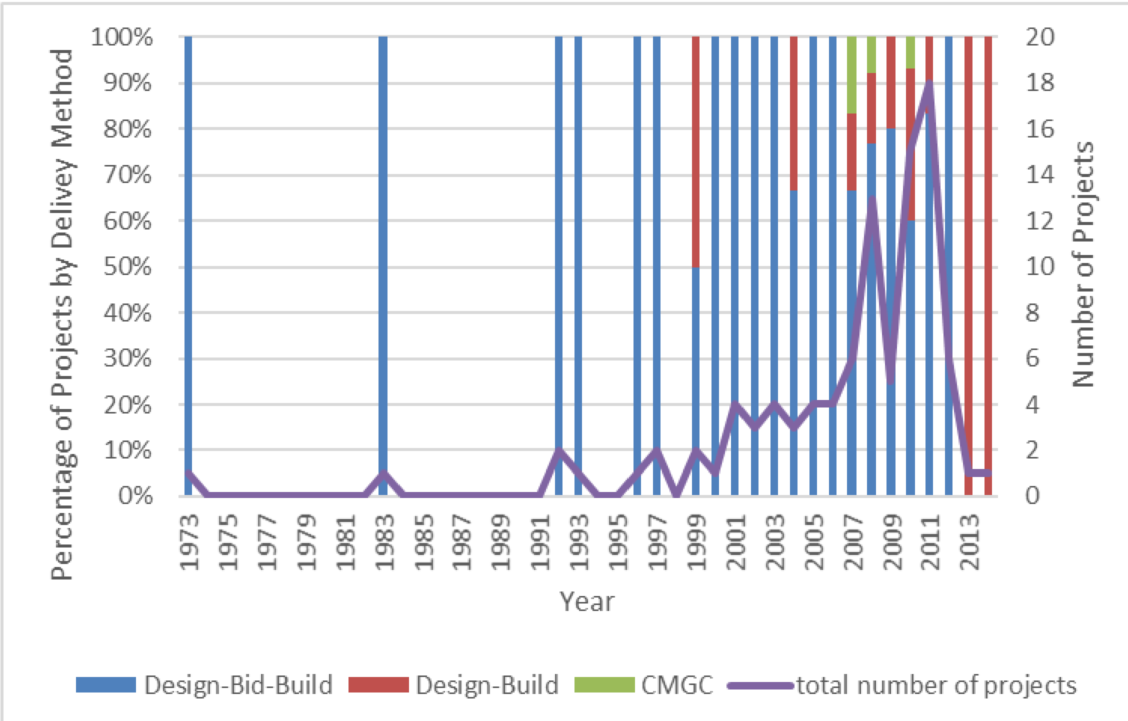

Figure 2. ABC delivery method percentage by year (N=102)

The first delivery method analyzed is DBB. As seen in Figures 3 and 4, for DBB projects the majority of ABC components used were structural. It is hypothesized that this is because most structural components are prefabricated bridge element systems (PBES), and PBES can be designed without a specific contractor's means and methods in mind (please note that for the purpose of this analysis PBES are categized as structural even though in some certain instances they could also be categorized as geotechnical or construction related). An important note to be made is that a single project can have multiple ABC components.

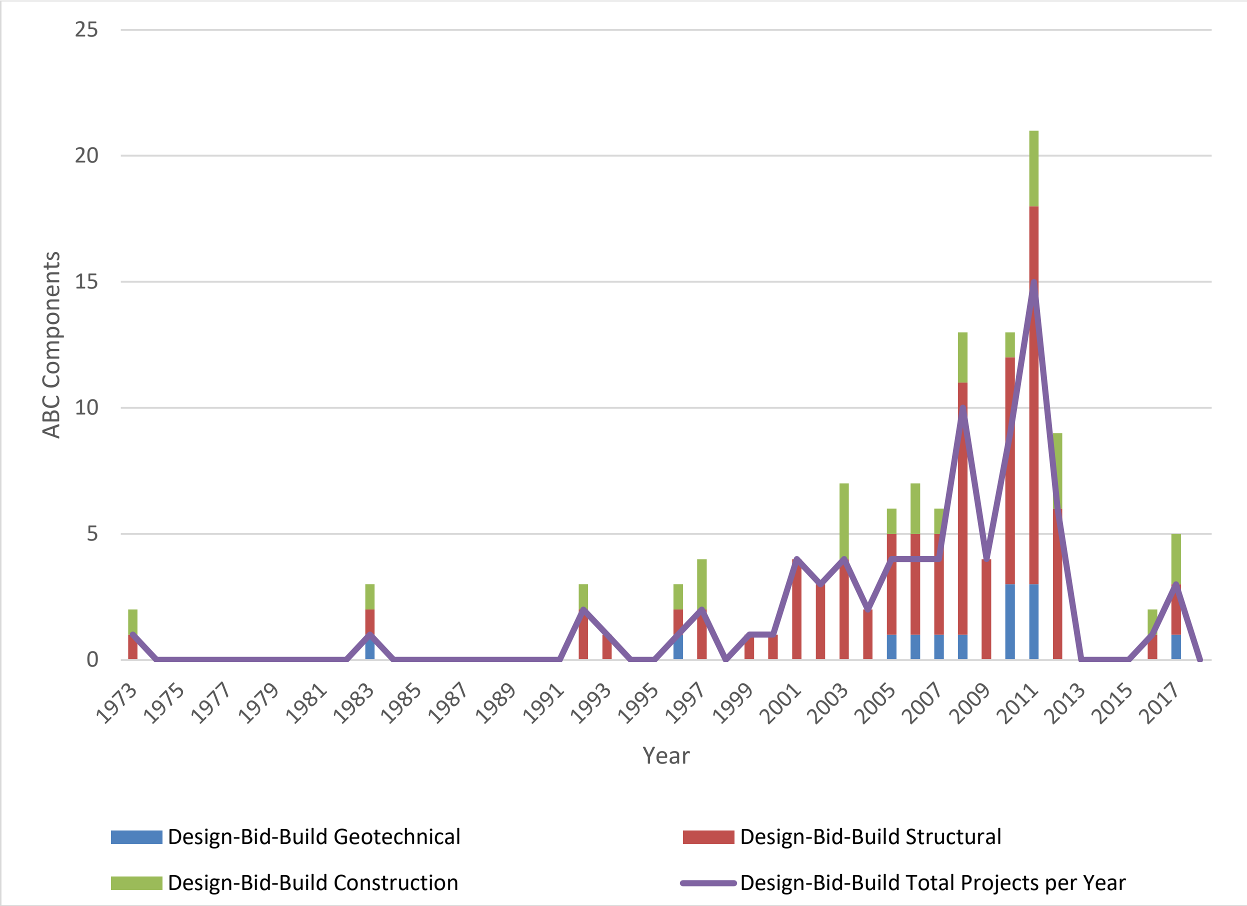

Figure 3. ABC components used for design-bid-build projects (N=83)

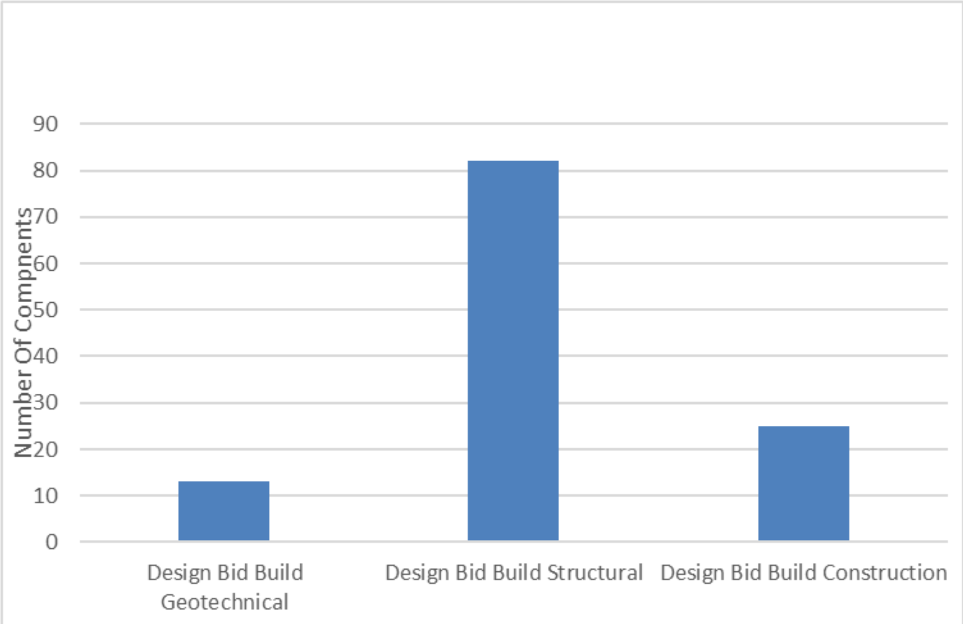

Figure 4. Comparison of types of ABC components used for design-bid-build projects (N=83)

The second delivery method analyzed is DB, which makes up 16 percent of the data set since 1973. Figure 5 shows the number of projects and the ABC components that were used in a given year, and Figure 6 compares the numbers of geotechnical, structural, and construction components used overall. Similar to the DBB projects, the number of DB projects peaked around 2009. Also similar to the DBB projects, the most common ABC component was structural, though construction components followed closely. This finding shows that projects with PBES components are often delivered using DB, possibly because they are well understood, but the finding also shows that ABC construction methods, such as lateral slides or self-propelled modular transport (SPMT), are commonly delivered using DB because the designer is able to take a specific contractor's means and methods into account.

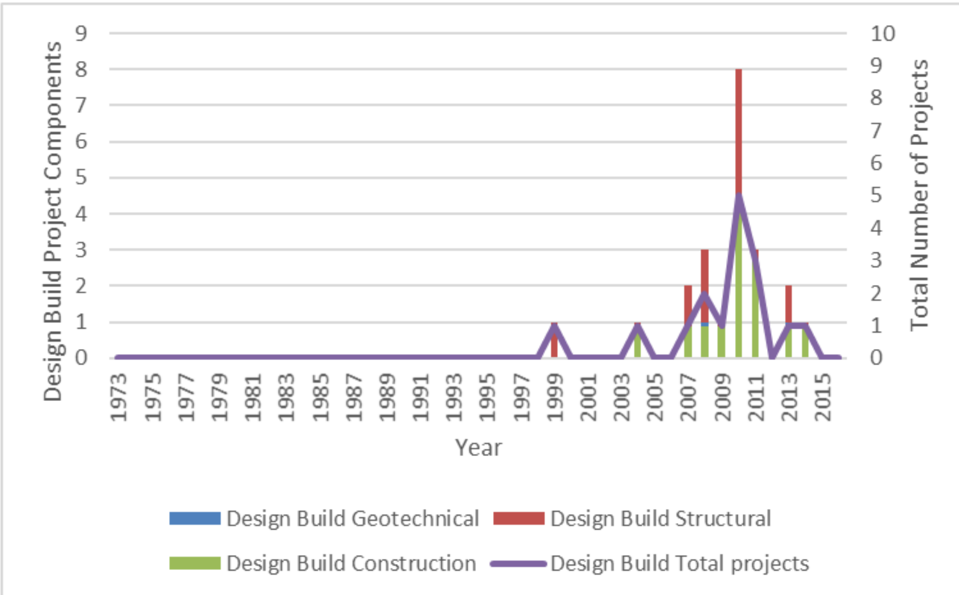

Figure 5. ABC components used for design-build projects (N=16)

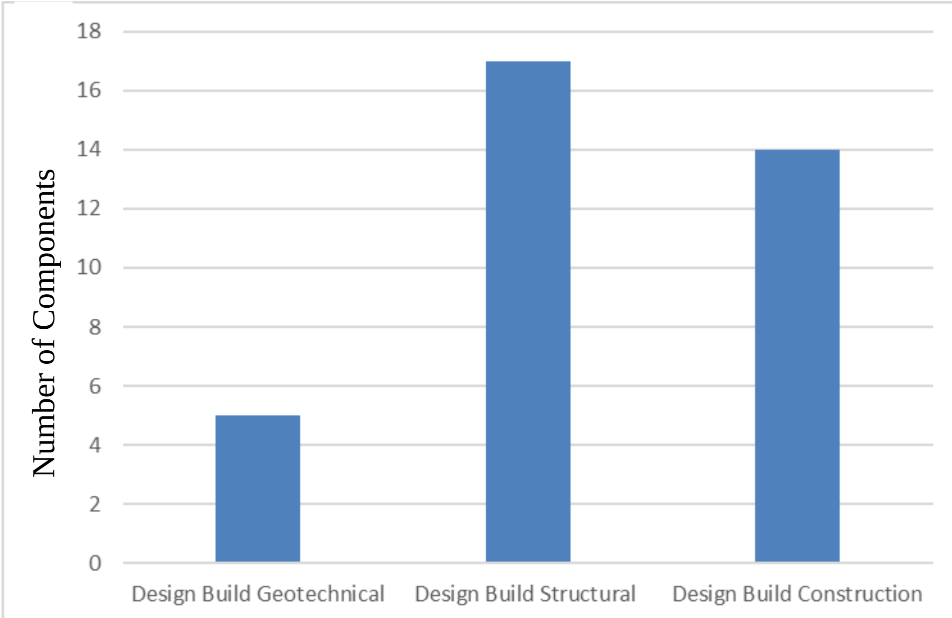

Figure 6. Comparison of types of ABC components used for design-build projects (N=16)

The final delivery method analyzed is CMGC. This delivery method was used for the smallest proportion of projects, only 3 percent. This is because CMGC has only recently begun to be used by transportation agencies on any type of project. Figures 7 and 8 show that the small number of CMGC projects have used all three ABC components equally. This fits with the strengths of the delivery method: the designer and contractor work together to ensure that the design has a high level of constructability, which allows the designer to include multiple different components and experiment with new methods. There was one CMGC project each in 2007, 2008, and 2010. The grouping of the projects between 2007 and 2011 is similar to the spikes that were seen in Figures 2, 3, and 5.

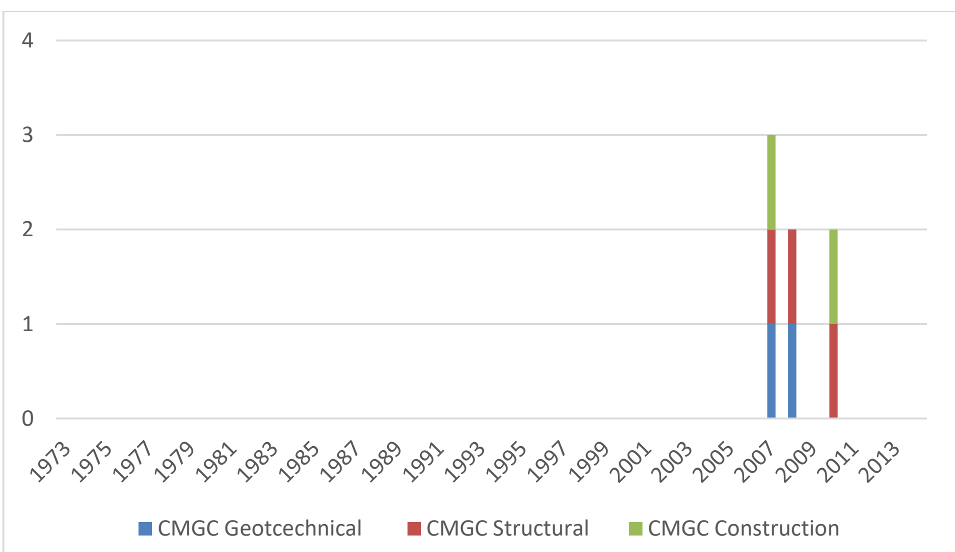

Figure 7. ABC components used for CMGC projects (N=3)

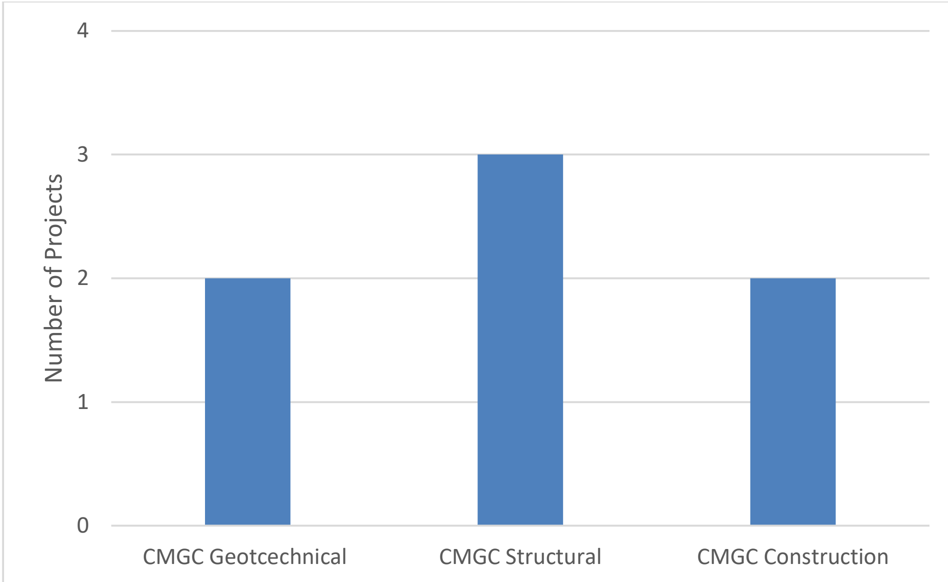

Figure 8. Comparison of types of ABC components used for CMGC projects (N=3)

The rise of alternative delivery methods has made it possible for ABC projects to utilize more innovative construction processes. As shown in Figure 9, the number of ABC projects that utilize construction components spikes at the same time that the use of alternative delivery methods spikes, which is at the same time as an overall spike in the number of ABC projects.

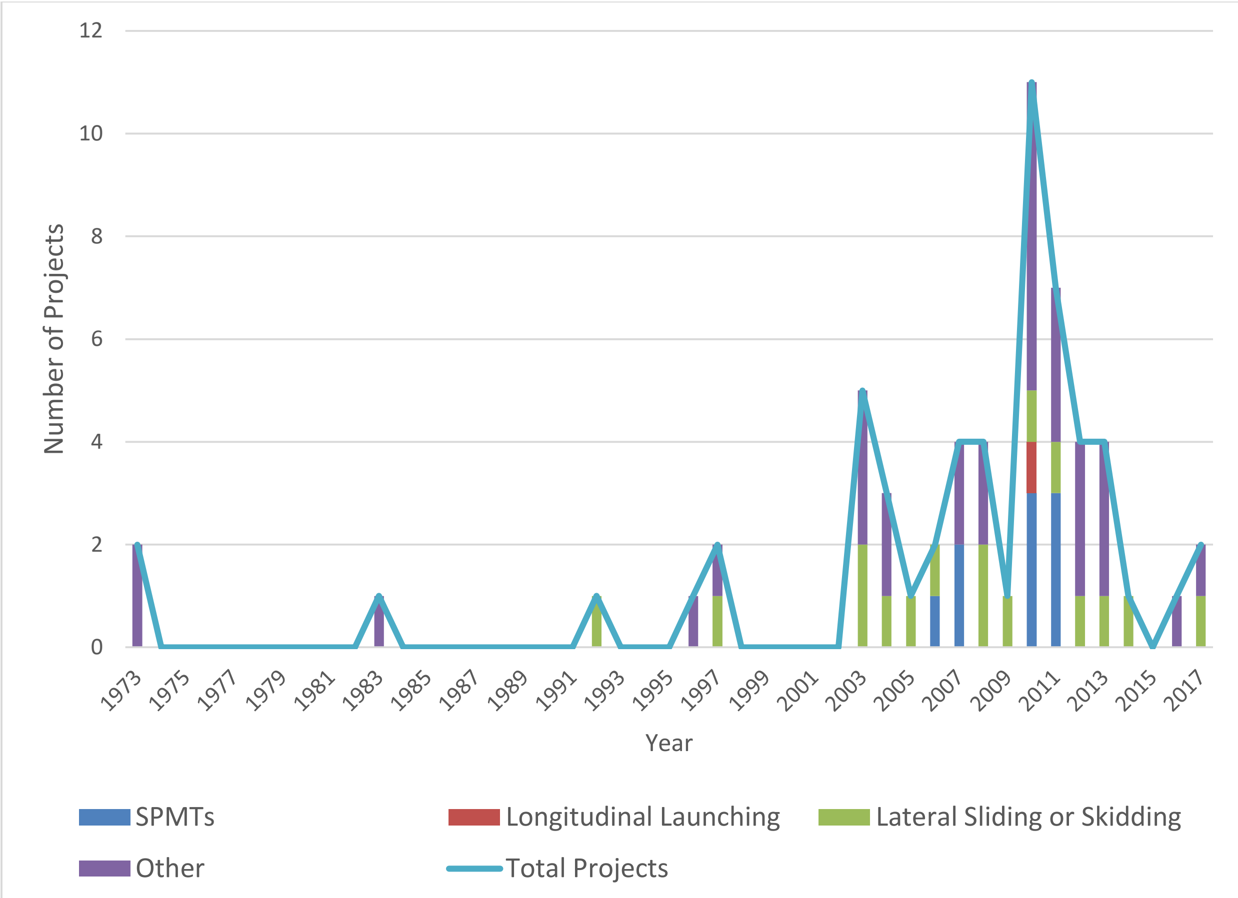

Figure 9. Number of ABC projects using different construction methods by year (N=57)

The primary conclusion that can be drawn from the analysis of the ABC projects in this chapter is that alternative delivery methods have allowed transportation agencies to be more innovative in their approach to ABC, though ABC is still predominately delivered using DBB. The findings also show that ABC is impacted by changes and advances that are made in the transportation field. Figure 10 shows the overall trends in the use of ABC components and project delivery methods from 1973 to 2019, as evident in the analysis of the sample of ABC projects from the ABC-UTC database.

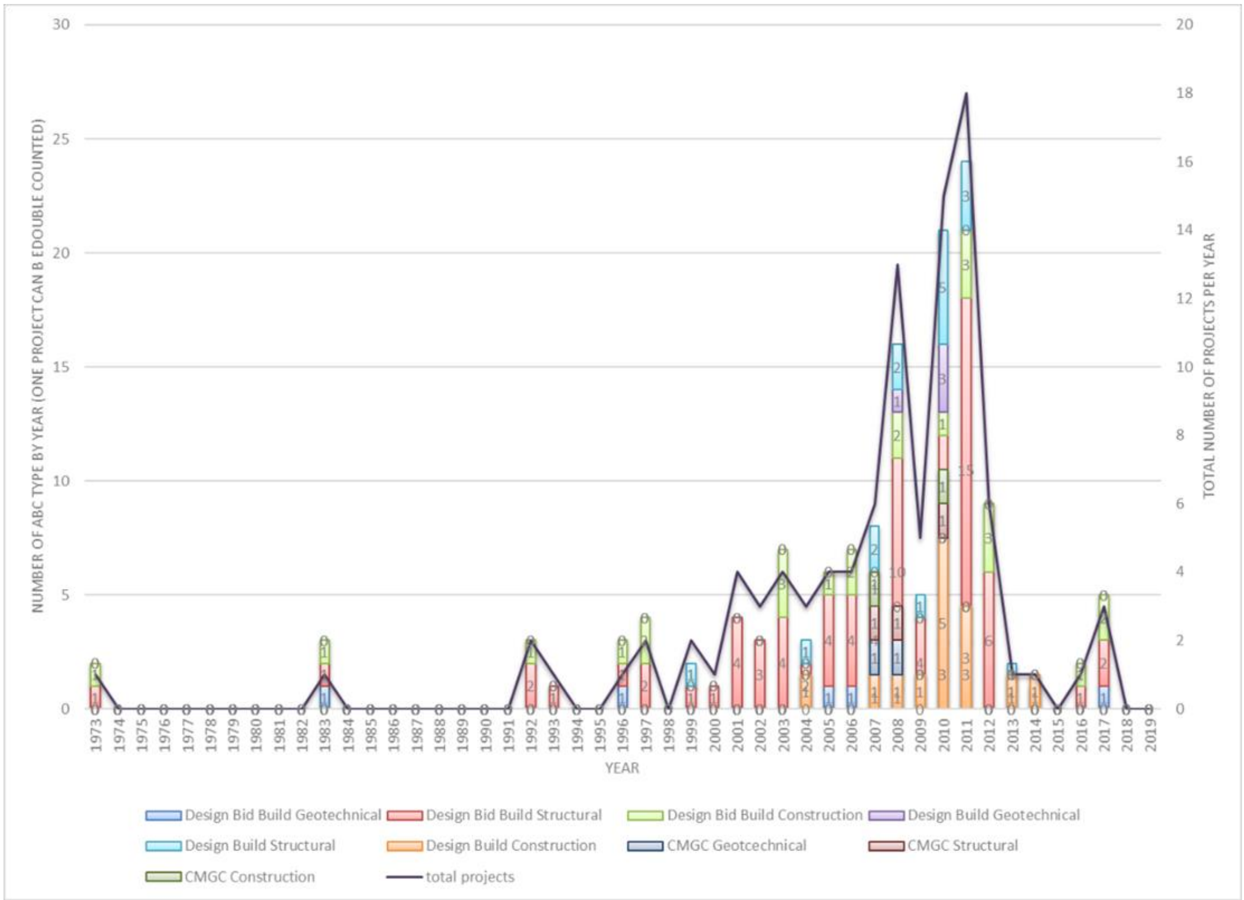

Figure 10. Use of different combinations of delivery methods and types of ABC components by year [N=102]

Discussion

The results above summarize the findings from the research team's analysis of how the project delivery method affects the type of ABC project that is possible and the frequency with which the different delivery methods have been used. The research team investigated this information for three reasons. The first reason is that there is a misconception that ABC projects can only be completed using alternative delivery methods. The second reason is that procurement and contracting practices differ among the various delivery methods. The third reason was to provide examples to transportation agencies of what is possible and common when using each delivery method. The remainder of this section details the findings of the analysis of delivery methods and their implications.

The notion that ABC projects can only be performed when using alternative delivery methods is a misconception. Since 1973, DBB has accounted for 81 percent of all ABC projects. More recently, even with the rise of alternative delivery projects, DBB still accounts for 78 percent of ABC projects. In fact, DBB can be used with any of the different ABC components. Alternative delivery methods, though, can expand the opportunities to use ABC by allowing for more innovative approaches to be used.

All three delivery methods included in the analysis have utilized all three ABC components: structural, geotechnical, and construction. DBB projects were found to utilize structural components the most, while construction was found to be the second most common component for that delivery method. DB projects follow a similar trend to DBB projects, though there is a notable increase in the use of construction components. CMGC projects made equal use of all three ABC components, but there was a total of only three CMGC projects. These results show that when looking at the possible combinations of delivery methods and components for ABC projects, DBB is most used for projects that heavily feature structural components. DB projects can also use structural components, though this delivery method more easily allows for ABC projects to utilize construction components. A more detailed breakdown of the bid items that are most commonly used for each ABC component is provided in the following chapter.

Finally, delivery, procurement, and contracting methods are intertwined. Understanding the capabilities of each delivery method in relation to ABC allows transportation agencies to understand the risks and benefits inherent in the various combinations of delivery, procurement, and contracting methods.

CHAPTER 4: ANALYSIS OF BID TABS AND BIDDER ANALYSIS FOR ABC PROJECTS

Methodology

The second analysis conducted on the ABC projects in the data set involved the bid tabs and the number of bidders on each project. Three data sets were developed for this analysis. The first data set focused on the bid tabs from the projects identified, and the second focused on the number of bidders for each project and the relationship between the winning bid and the engineer's estimate. The third data set focused on the relationship between the number of bidders on an ABC project and the year the project took place.

The data set for the bid tabs was extracted from the larger data set described in Chapter 2 of this report. Initially, the only projects that were included were SPMT or lateral slide projects that had been completed in the last five years (2013 to 2019). The list was then expanded to include projects as far back as 2010 to increase the sample size. The research team then expanded the list again by randomly selecting projects going back to 2010 that included additional elements of ABC. This data set also included two projects that were not included in the ABC-UTC database. This filtering resulted in a data set of 28 projects. The research team then identified whether bid tabs were available for each of the projects, and 20 projects were found to have bid tabs publicly available. The 20 projects included 3 DB projects and 17 DBB projects. After the projects with bid tabs were identified, the research team looked through the bid tabs and developed a list of bid items associated with ABC projects and the ways each bid item was paid for (e.g., per linear foot, each, lump sum). A summary table was then created dividing the projects into three categories—construction, structural, and geotechnical—to match the types of ABC components recorded in the ABC-UTC database. The three categories were then subdivided into subcategories that were found to be the most prevalent.

The second data set for this analysis was developed from the projects that were identified in the previous paragraph. The data set included projects that were delivered using DBB and alternative delivery methods. The data set was reduced based on whether information was publicly available for the number of bidders on a project, the amount of the winning bid, and the engineer's estimate. This resulted in a data set of 16 projects. The research team then recorded the winning bid, the number of bidders, and the engineer's estimate for each project identified. The winning bid was then divided by the engineer's estimate to determine the ratio of the winning bid to the engineer's estimate to determine whether the bid was above or below the contracting agency's estimate. From here, the ratio of the winning bid over the engineer's estimate was graphed alongside the number of bidders per project. The resulting graph can be seen in the discussion below. The research team also examined the descriptive statistics to determine the median number of bidders on the projects identified and the mean number of bidders per project.

The third data set was created to determine the average number of bidders per project per year. This data set was larger than the second data set because there was no need to remove projects if they did not have information about the winning bid or the engineer's estimate. This resulted in a project sample of 59. The projects were then grouped by the year in which they took place, and the average number of bidders per project per year was calculated.

Results

Tables 3 through 9 show the types of bid items that were identified in the data set and the way the bid items were paid for. The results show that for alternative delivery projects, the most common way to pay for ABC projects is by lump sum. This finding aligns with the way most alternative delivery projects are procured, where most of the risk is transferred to the contractors. For DBB projects, the most common type of bid item measurement was “each.” The most common bid items were precast structural members; paying for these items by each precast member allows contracting agencies to assign more risk to the contractors instead of using a different measurement such as linear feet or cubic yards of concrete.

Table 3. Bid items and bidding measurement per project – construction

Project	Moving the Bridge	
	Lump	Each
Design-Build Projects		
Cedar Street Bridge (Wellesley)	1	
Phillipston Bridge	1	
Maryland Avenue		
Subtotal ABC Components	*2*	*0*
Subtotal Design-Build Projects	*2*	*0*
Design-Bid-Build Projects		
I-20/LA 3249 (Well Road) Bridge		1
Bridge NB-355 at Milepost A-57.66	1	
I-44 Bridge over Gasconade River		
OR 213 Bridge over Washington Street	1	
Willis Avenue Bridge over Harlem River		
IA 1 over Camp Creek	1	
TH-36 Keller Lake		
TH-53 Bridge over Paleface River		
Rock County Road 55 Bridge over Railroad		
US 6 Bridge over Keg Creek		
Little Cedar Creek Bridge		
TH 61 Bridge over Gilbert Creek		
Poplar Street Bridge Westbound		
Poplar Street Bridge Eastbound		
Sacramento Wash Crossing at Oatman Highway (historic Route 66)		
Bridge 1-438 on N463 Blackbird Station Road over Blackbird Creek		
Franklin Avenue Bridge Rehabilitation		
Subtotal ABC Components	*3*	*1*
Subtotal Design-Bid-Build Projects	*3*	*1*
Total ABC Components	**5**	**1**
Total Projects for Each ABC Component	**5**	**1**

Table 4. Bid items and bidding measurement per project – structural

Project	Precast Member					Pretensioned/ Prestressed Member		UHPC
	Lin. ft	Lump	yd^3	Each	ft^2	Each	Lin. ft	yd^3
Design-Build Projects								
Cedar Street Bridge (Wellesley)		1						
Phillipston Bridge		1						
Maryland Avenue	1			1				
Subtotal ABC Components	*1*	*2*	*0*	*1*	*0*	*0*	*0*	*0*
Subtotal Design-Build Projects	*1*	*2*	*0*	*1*	*0*	*0*	*0*	*0*
Design-Bid-Build Projects								
I-20/LA 3249 (Well Road) Bridge								
Bridge NB-355 at Milepost A-57.66								
I-44 Bridge over Gasconade River								
OR 213 Bridge over Washington Street								
Willis Avenue Bridge over Harlem River				1				
IA 1 over Camp Creek				1		1		1
TH-36 Keller Lake				3			1	
TH-53 Bridge over Paleface River							1	
Rock County Road 55 Bridge over Railroad							1	
US 6 Bridge over Keg Creek								
Little Cedar Creek Bridge						1	1	1
TH 61 Bridge over Gilbert Creek				4			1	
Poplar Street Bridge Westbound							1	
Poplar Street Bridge Eastbound							1	
Sacramento Wash Crossing at Oatman Highway (historic Route 66)				10				
Bridge 1-438 on N463 Blackbird Station Road over Blackbird Creek			2		1			1
Franklin Avenue Bridge Rehabilitation								
Subtotal ABC Components	*0*	*0*	*2*	*19*	*1*	*2*	*7*	*3*
Subtotal Design-Bid-Build Projects	*0*	*0*	*1*	*5*	*1*	*2*	*7*	*3*

Table 5. Bid items and bidding measurement per project – geotechnical

Project	Micropiles	Drilled Shafts/Pilings			
	Lin. ft	Lin. ft	Lump	yd^3	ft^2
Design-Build Projects					
Cedar Street Bridge (Wellesley)					
Phillipston Bridge					
Maryland Avenue					
Subtotal ABC Components	*0*	*0*	*0*	*0*	*0*
Subtotal Design-Build Projects	*0*	*0*	*0*	*0*	*0*
Design-Bid-Build Projects					
I-20/LA 3249 (Well Road) Bridge					
Bridge NB-355 at Milepost A-57.66	1				
I-44 Bridge over Gasconade River					
OR 213 Bridge over Washington Street			1		
Willis Avenue Bridge over Harlem River		1			
IA 1 over Camp Creek		1			
TH-36 Keller Lake					
TH-53 Bridge over Paleface River					
Rock County Road 55 Bridge over Railroad					
US 6 Bridge over Keg Creek					
Little Cedar Creek Bridge					
TH 61 Bridge over Gilbert Creek					
Poplar Street Bridge Westbound		1			
Poplar Street Bridge Eastbound		1			1
Sacramento Wash Crossing at Oatman Highway (historic Route 66)		1		1	
Bridge 1-438 on N463 Blackbird Station Road over Blackbird Creek		1			
Franklin Avenue Bridge Rehabilitation					
Subtotal ABC Components	*1*	*6*	*1*	*1*	*1*
Subtotal Design-Bid-Build Projects	*1*	*6*	*1*	*1*	*1*

Table 6. Bid items and bidding measurement per project – totals

Project	Total ABC Bid Items	Total of Each Type of ABC Component
Design-Build Projects		
Cedar Street Bridge (Wellesley)	2	2
Phillipston Bridge	2	2
Maryland Avenue	2	1
Design-Bid-Build Projects		
I-20/LA 3249 (Well Road) Bridge	1	0
Bridge NB-355 at Milepost A-57.66	2	2
I-44 Bridge over Gasconade River	0	0
OR 213 Bridge over Washington Street	2	2
Willis Avenue Bridge over Harlem River	2	2
IA 1 over Camp Creek	5	3
TH-36 Keller Lake	4	1
TH-53 Bridge over Paleface River	1	1
Rock County Road 55 Bridge over Railroad	1	1
US 6 Bridge over Keg Creek	0	0
Little Cedar Creek Bridge	3	1
TH 61 Bridge over Gilbert Creek	5	1
Poplar Street Bridge Westbound	2	2
Poplar Street Bridge Eastbound	3	2
Sacramento Wash Crossing at Oatman Highway (historic Route 66)	12	2
Bridge 1-438 on N463 Blackbird Station Road over Blackbird Creek	5	2
Franklin Avenue Bridge Rehabilitation	0	0
Total Projects		**20**

Table 7. Examples of bid items for the construction component

Payment Type	Item
Lump sum	Bridge structure, one direction Moving bridge Prefabricated bridge superstructure move
Each	Span movement

Table 8. Examples of bid items for the structural component

Payment Type	Item
Lump sum	Prestressed reinforced concrete members box-beams
Per linear foot	Prestressed beams INV-T 18 in. type(s)1,2,3 Prestressed concrete box beams 33x48 (p) Prestressed beams int-t type 1,2,3 Nu 53, prestressed concrete girder nu-girder Prestressed concrete box beams 33x48 (p) Nu 53, prestressed concrete girder nu-girder
Per cubic yard	Precast concrete retaining wall Ultra-high performance concrete Ultra-high performance concrete in-fill placement
Each	Precast concrete headwall Supplemental description precast pier element Precast abutment Supplemental precast pier wall Supplemental description precast pier cap element Supplemental description precast wingwall element Supplemental description precast abutment element Miscellaneous work (prefabricated interior deck unit) Miscellaneous work (prefabricated exterior deck unit) Miscellaneous work (prefabricated interior approach slab) Miscellaneous work (prefabricated exterior approach slab) Miscellaneous work (prefabricated moment slab) Miscellaneous work (prefabricated abutment cap) Miscellaneous work (prefabricated abutment backwall) Miscellaneous work (prefabricated abutment cheekwall) Beams, pretensioned prestressed concrete btc120 Beams, pretensioned prestressed concrete erect as per plan Panels pretensioned concrete, erect as per plan

Table 9. Example of bid items for the geotechnical component

Payment Type	Item
Lump sum	Retaining wall, MSE
Per linear foot	Micropiles Piles, steel hp 14 x 89 Drilled shafts Drilled shaft foundation (60 in.) Furnish precast prestressed concrete pile
Per cubic yard	Geofoam Miscellaneous work (geogrid-reinforced backfill)

The research team's investigation of the number of bidders versus the ratio of the winning bid to the engineer's estimate for each project resulted in a parabolic curve that shows the number of bidders needed to obtain the optimal price (Figure 11). The data sample consisted of 16 projects, including both alternative delivery and DBB projects. The general trend of the data shows a parabolic shape because only 16 projects were included in the sample; no statistical analysis was conducted. The results of the analysis show that to obtain the best price for an ABC project, it is best to have three to five bidders for the project.

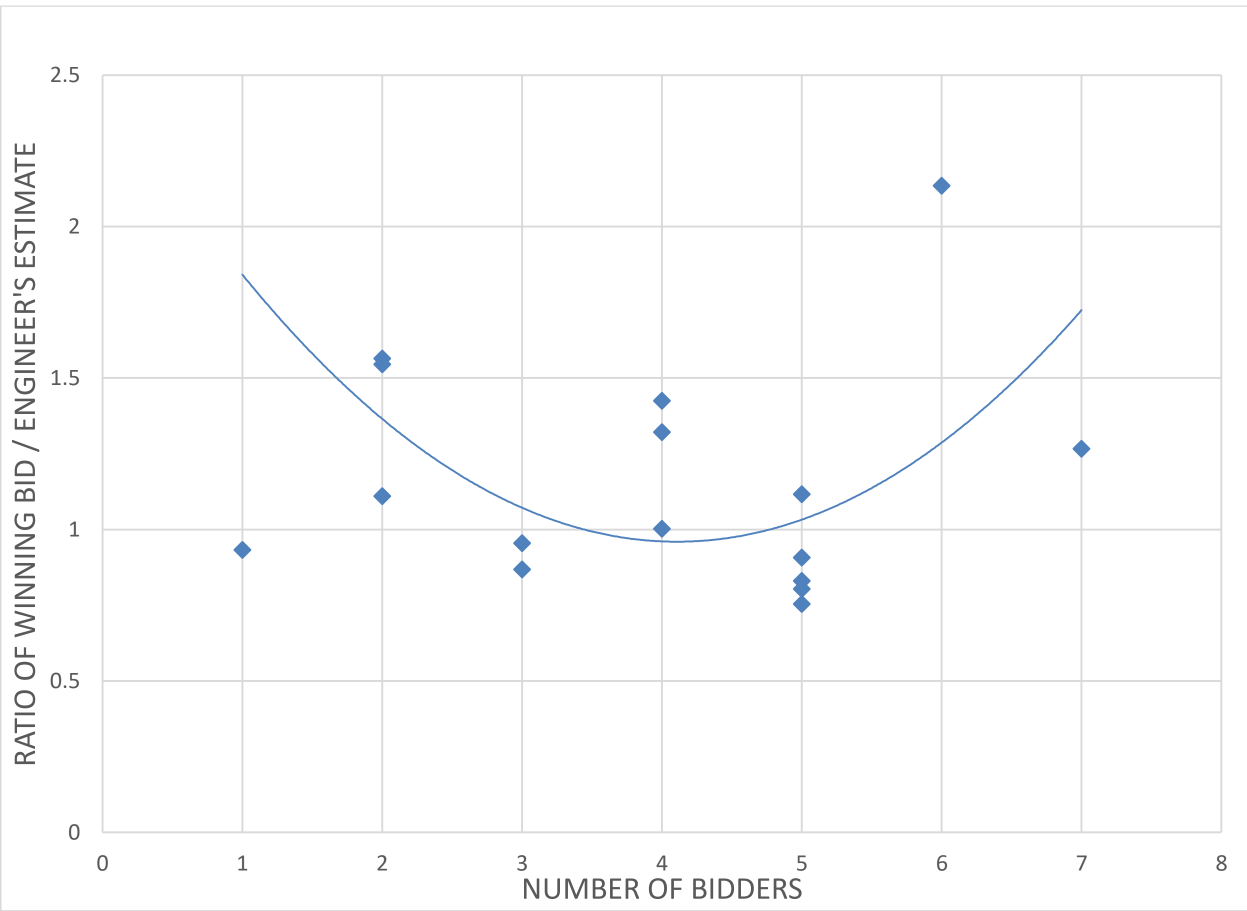

Figure 11. Number of bidders versus ratio of winning bid over engineer's estimate

There is an average of four bidders per project for the 16 projects. The median number of bidders is also four. The research team then examined the data from across several years from 1996 to 2018 to determine whether there was a relationship between the average number of bidders per project per year (Figure 12) and the number of ABC projects that had been completed each year, a trend that might be similar to that observed in Figures 2, 3, 5, 7, and 9 regarding the relationship between project delivery method and total number of ABC projects. The results of the investigation show that the trends in the average number of bidders per project per year and the total number of ABC projects per year were not similar. The average number of bidders per project per year has held relatively stable between three and five bidders per year and doesn't follow the trend of the number of projects per year.

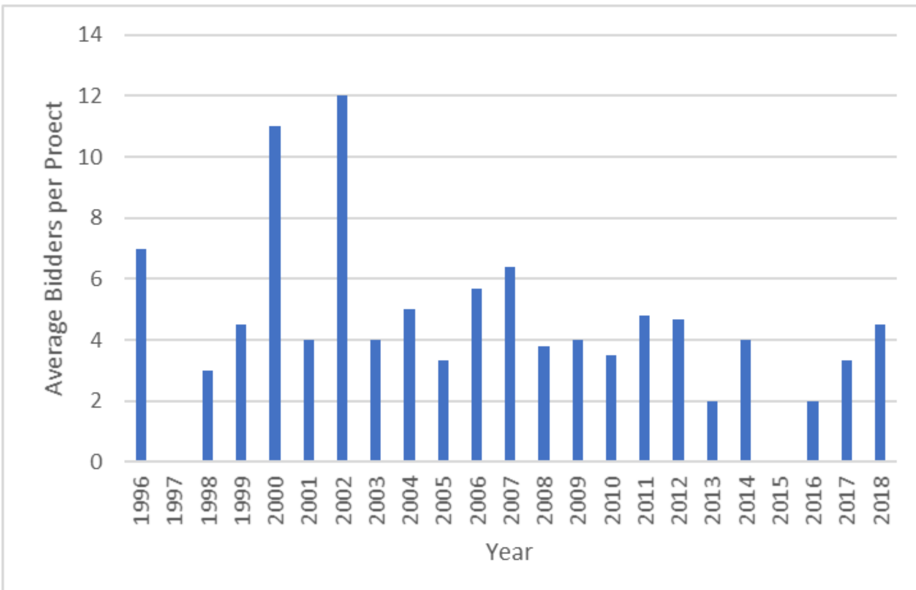

Figure 12. Average number of bidders per project per year

Discussion

The findings summarized above for the bid tabs and bidder analysis provide several interesting results, most notably regarding the most common ABC bid items and their units of measure. In addition, the analysis revealed the optimal number of bidders and the relationship between the prevalence of ABC projects and the number of bidders for each project.

Tables 1 through 4 show that there are differences between the different delivery methods in terms of how items on projects are measured. The most common type of measurement for the projects that used alternative delivery methods is lump sum, which reflects most of the projects procured using best value. For the projects that used the DBB project delivery method, the most common types of measurement differed by ABC component. For structural component bid items, precast elements are typically paid for using the unit of measurement of "each," though other ways to pay for precast elements include lump sum, linear foot, cubic yard, or square foot.

Construction component bid items, which are ways to move the bridge into its final position (such as SPMT and lateral sliding), were most commonly paid for using the unit of measurement of “lump sum.” Geotechnical component bid items are typically paid for using the unit of measure of “linear feet.”

Tables 4 through 7 provide examples of bid items that have been included on past ABC projects. These tables are included to provide contracting agencies with a sense of the bridge elements that have been used on ABC projects in the past and how they were bid.

Figure 11 shows the optimal range in terms of the number of bidders for obtaining the best price on an ABC project. The figure shows that the optimal range is between three and five bidders per project. This result is similar to the findings of Anderson et al. (2006), which showed that for projects of varying dollar amounts, the minimum number bidders required to obtain the best price is five bidders.

Figure 12 shows that as ABC projects have become more common, the average number of bidders per project has remained roughly the same.

CHAPTER 5: ANALYSIS OF SPECIFICATIONS FOR ABC PROJECTS

Methodology

The data set of projects used for the analysis of specifications initially consisted of the 28 projects described in the methodology section of the previous chapter. After the research team searched for publicly available specifications for these 28 projects, the data set was reduced to 21 projects. The specifications identified for these 21 projects are shown in Table 10. The research team then read the specifications specifically looking for items related to ABC construction, which means that any items that would only be relevant to non-ABC projects were not considered. Once the ABC items were identified, the research team examined how each item was measured and paid for.

Table 10. ABC specifications

Project	State	Delivery Method	Link
Bridge NB-355 at Milepost A-57.66	Pennsylvania	DBB	http://utcdb.fiu.edu/special%20provisions.pdf
OR 213 Bridge over Washington Street	Oregon	DBB	http://utcdb.fiu.edu/OR213-SP-Section%2000220-Traffic.pdf
Maryland Avenue Bridge	Minnesota	DBB	http://utcdb.fiu.edu/2017-12-0320:17:54.pdf
I-20/ LA 3249 (Well Road) Bridge	Louisiana	DBB	http://utcdb.fiu.edu/SP_451-06-0148_proposal_sheets_A1-D-27.pdf
Cedar Street Bridge (Wellesley)	Massachusetts	DB	http://utcdb.fiu.edu/Contract%20Award.pdf
I-44 Bridge over Gasconade River	Missouri	DBB	http://utcdb.fiu.edu/MO-Gasconade-J8I2167_Job_Special_Provisions.pdf
I-15 / Sam White Lane Bridge	Utah	DB	http://utcdb.fiu.edu/Sam%20White_special%20provisions.pdf
Phillipston Bridge	Massachusetts	DB	http://utcdb.fiu.edu/ABC%20SpecialProvisions.pdf
Willis Avenue Bridge over Harlem River	New York	DBB	http://utcdb.fiu.edu/Willis%20ABC%20Specifications.pdf
Ben Sawyer Swing Bridge	South Carolina	DB	http://utcdb.fiu.edu/Attachment_A-Agreement_Exhibit1-9%20(1).pdf
I-15 / Pioneer Crossing Bridge	Utah	DB	http://utcdb.fiu.edu/SP%2003253S%20SPMT_08-31-09.pdf
IA 1 over Camp Creek	Iowa	DBB	https://iowadot.gov/contracts/biddocuments/december2018; search project number BRF-001-4(50)--38-92
TH-36 Keller Lake	Minnesota	DBB	http://utcdb.fiu.edu/2017-10-2320:42:40.pdf
TH-53 Bridge over Paleface River	Minnesota	DBB	http://utcdb.fiu.edu/Br%2069071%20Special%20Provisions.pdf
Rock County Road 55 Bridge over Railroad	Minnesota	DBB	http://utcdb.fiu.edu/2017-10-2320:27:59.pdf

Project	State	Delivery Method	Link
US 6 Bridge over Keg Creek	Iowa	DBB	http://utcdb.fiu.edu/ADDENDUM.15FEB014.A01.pdf, http://utcdb.fiu.edu/ADDENDUM.15FEB014.A02.pdf, http://utcdb.fiu.edu/ADDENDUM.15FEB014.A03.pdf, http://utcdb.fiu.edu/SP090109-PrefabAppSlab.pdf, http://utcdb.fiu.edu/SP090110-PrefabSub.pdf, http://utcdb.fiu.edu/SP090111-PrefabSuper.pdf, http://utcdb.fiu.edu/SP090112a-UHPC.pdf
TH 61 Bridge over Gilbert Creek	Minnesota	DBB	http://utcdb.fiu.edu/Br%2025024%20Special%20Provisions.pdf
Sacramento Wash Crossing at Oatman Highway (historic Route 66)	Arizona	DBB	http://utcdb.fiu.edu/Specif_Addendum-AZ-Sacramento%20Wash.pdf, http://utcdb.fiu.edu/Specif-AZ-Sacramento%20Wash.pdf
Bridge 1-438 on N463 Blackbird Station Road over Blackbird Creek	Delaware	DBB	http://utcdb.fiu.edu/T201407104%20-%20Proposal%20with%20Addendum%20No.%201%20and%20Q&A.pdf
Franklin Avenue Bridge Rehabilitation	Minnesota	DBB	http://utcdb.fiu.edu/AS-BUILT_Conformed_Franklin_Specification(S,SB,SL%20&%20WM)%2004-04-17.pdf
Larpenteur Avenue Bridge	Minnesota	DB	http://utcdb.fiu.edu/2017-10-1815:33:21.pdf

Results

Specifications were examined for both DBB and alternative delivery projects. The results of the analysis of the specifications are divided between alternative delivery and DBB projects.

Alternative Delivery Projects

The specifications for the alternative delivery projects showed that the typical way for ABC projects to be paid for is based on progress reports and a schedule of values. An example of a specification for a DB project is as follows:

> *Measurement and Basis of Payment*
>
> *The Department will make partial payments according to Section 109, Standard Specifications for Highway Construction, and as modified by the following schedule:*
>
> *Basis of Payment*
>
> *Percentage of Contract Unit Price of Item After the Engineer has approved the CPM Baseline schedule 60 After the Engineer has approved the As-Built CPM schedule 40*
>
> *The Department will pay for the accepted quantities at the contract price as follows:*
>
> *Item Description 1080300 CPM Progress Schedule*
>
> ***Attachment A – Agreement***
>
> ***C. Contract Payments***
>
> *1. <u>Schedule of Values</u>*
>
> *Prior to execution of the Agreement, the CONTRACTOR shall provide a Schedule of Values acceptable to SCDOT and work may not start until the Schedule of Values is approved by SCDOT. The Schedule of Values will serve as the basis for monthly progress payments requested by and made to CONTRACTOR throughout the Work. If the Contract Price is adjusted, CONTRACTOR shall revise its Schedule of Values to reflect the adjustment in the Contract Price. The revised Schedule of Values must be approved by SCDOT prior to the time for the subsequent request for a progress payment otherwise no progress payments will be made.*
>
> *2. <u>Mobilization</u>*

Mobilization shall not exceed 5% of the Contract Price.

(SCDOT 2008)

Design-Bid-Build Projects

For the DBB projects, the specifications typically matched what was on the bid sheet. There was one project where, because it involved staged construction, the contracting agency offered the contractor a partial payment for each precast wingwall, precast abutment, and precast pier element that was constructed in the first stage. All the specifications examined made sure to note for the precast bridge elements that the payment was to cover all labor costs, manufacture costs, and transportation costs. Example specifications are provided below:

E. Method of Measurement of Inverted T-beams will be made by the linear foot for the summation of beam lengths measured out-to-out of beam along the centerline of beams.

F. Basis of Payment for Item No. 2405.603, "PRESTRESSED BEAM INV-T 18" TYPE _", for invert T-beams will be made at the Contract price per linear foot for each type, and shall be compensation in full for all costs of materials, shop drawings, fabrication, construction of the test section specimen for the roughened surface, transportation and erection of the beams in their final position, as described above.

SB-8.15 Basis of Payment

Payment for Item No. 2405.602, "PRECAST PIER ELEMENT", will be made at the Contract price per each for each precast pier cap element.

Payment for Item No. 2405.602, "PRECAST ABUTMENT ELEMENT", will be made at the Contract price per each for each precast abutment element.

All payment for these items will be compensation in full for all costs of manufacturing, transporting, grout installation, erecting the precast concrete elements in their final position with any required temporary bracing, and closure pours, as shown in the Plan. All payment for these items shall also include accessories, mock-up panels, labor, materials, equipment and temporary supports to install abutments and piers to the completion of the work.

(MnDOT 2013)

UHPC

090112a.04 METHOD OF MEASUREMENT. The concrete quantities shown on the plan, measured by the cubic yard, are for contractor's information only.

090112a.05 BASIS OF PAYMENT. This item and all incidental items required to provide this item per contract documents including labor, materials, equipment and testing is subsidiary to other items and will not be paid for separately.

(Iowa DOT 2011)

090111.05 BASIS OF PAYMENT.

A. Interior Superstructure Module 1. Payment will be full compensation for the manufacturing, furnishing, and placement of each interior superstructure module 1. All items required to assemble each interior superstructure module 1 into a prefabricated superstructure per the plans, including labor, materials and equipment, shall be considered incidental to this item and will not be paid for separately.

(Iowa DOT 2011)

Discussion

The research team investigated the specifications for the ABC projects in the data set to determine what worked for previous ABC projects and to expand upon the discussion in Chapter 4 of the bid items that were successfully used. The findings of this investigation show that ABC projects do not require extensive changes to existing specifications. The example specifications provided in the results section of this chapter show that the most important part of writing specifications is to ensure that all aspects of the work to be done are included in the specification. For example, on projects that use precast bridge elements, it is important that the specification covers the costs of manufacturing and transporting the member, the labor required to put the precast element in place, and any work that is required to tie the precast element into the structure (such as closure pours). However, it is possible to utilize specifications from similar non-ABC projects when designing and specifying an ABC project.

CHAPTER 6: SURVEY FINDINGS

Methodology

On June 17, 2020, a survey was sent to 48 recipients in the bridge engineering sections of different state transportation agencies, and recipients were given two weeks to respond. The survey asked a total of 13 questions, some specific to an ABC project identified by the respondent and some more generally focused on the agency's policy for ABC projects. A total of 11 responses were received, 3 of which stated that the respondent's agency does not conduct accelerated bridge construction projects. The results of the survey are summarized in this chapter.

Results

Two questions were asked regarding the delivery method that is predominately used by the agency for ABC projects and the delivery method used for the identified project. Figure 13 shows the responses to the question on the agency's most prevalent delivery method. Seven of the eight respondents answered that their agency most frequently uses design-bid-build for its ABC projects.

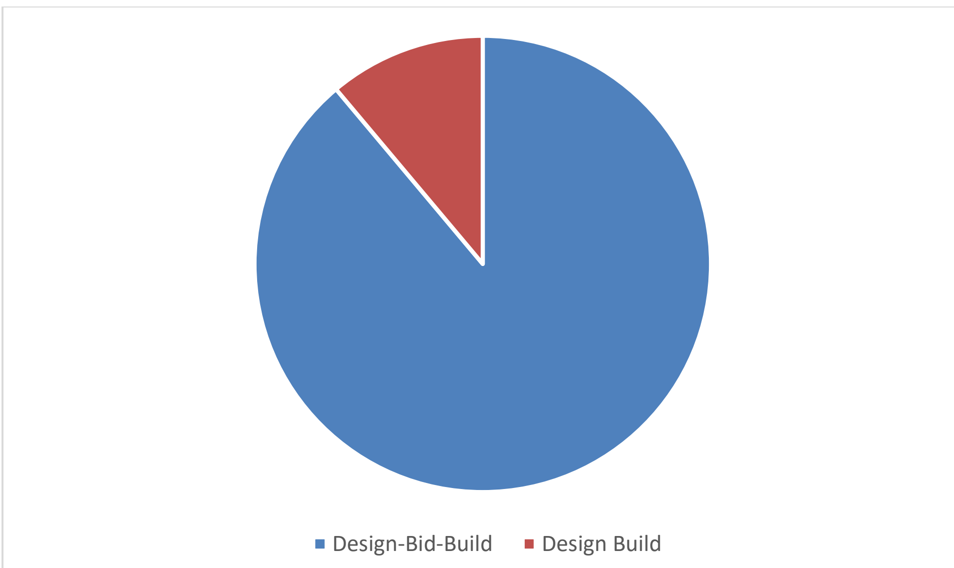

Figure 13. Most prevalent delivery methods among responding agencies

The second question was on the delivery method used for the identified project. Figure 14 shows that the responses were similar to those for the previous question and indicate that design-bid-build was the most used delivery method for the identified ABC projects.

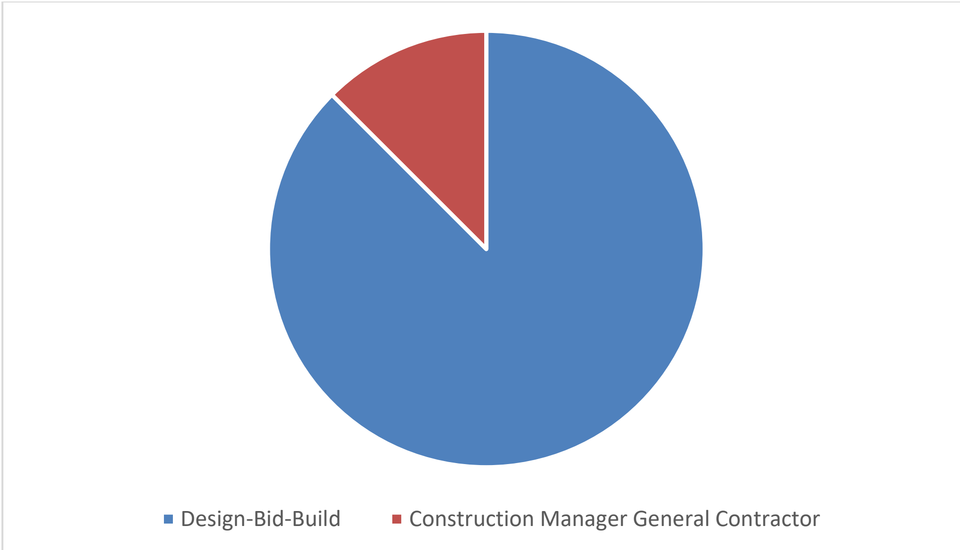

Figure 14. Delivery methods used for the identified projects

The next questions asked respondents to identify how their agencies accelerated the construction of the identified bridge and what specific technologies and methods were utilized. Seven respondents identified structural technologies, while six respondents identified construction methods. The technologies identified by the respondents are shown in Table 11.

Table 11. ABC technologies and methods identified

State	ABC Technologies and Methods
Pennsylvania	Cast-in-Place Concrete Pipe Piles, Flowable Backfill, Precast Pile Cap, Precast Retaining Wall, Full-Width Concrete-Decked Concrete Beam Unit, Precast Approach Slab, Latex-Modified Overlay, Lateral Slide
Vermont	Adjacent Slab Beam, Precast Approach Slab, High-Early-Strength Low Shrinkage Concrete Joint
New York	Full-Depth Precast Deck Panel w/o Post Tensioning, Ultra-High Performance Concrete, Ultra-High Performance Concrete Closure Joint,
South Carolina	Ultra-High Performance Concrete, Next-D Beam, Ultra-High Performance Concrete Closure Joint, Asphalt Overlay w/Membrane
Montana	Full-Depth Precast Deck Panel w/o Post Tensioning, Cast-in-Place Reinforced Concrete Closure Joint, High-Early-Strength Low-Shrinkage Concrete Joint, Standard Concrete Overlay
Colorado	Micropile, Self-Compacting Backfill, Precast Approach Slab, Asphalt Overlay w/Membrane, Lateral Slide
Iowa	Ultra-High Performance Concrete, Precast Pile Cap, Precast Wingwall, Precast Abutment Footing, Prestressed Concrete Beam, Ultra-High Performance Concrete Closure Joint, Lateral Slide
Michigan	Decked Press Brake Folded Plate Girders (Galvanized), Ultra-High Performance Concrete Closure Joint, Thin-Bonded Epoxy Overlay,

A question was asked about the procurement method that was used for the identified project. Figure 15 shows the percentage of projects that used each procurement method. The respondents identified low bid as the most common procurement method.

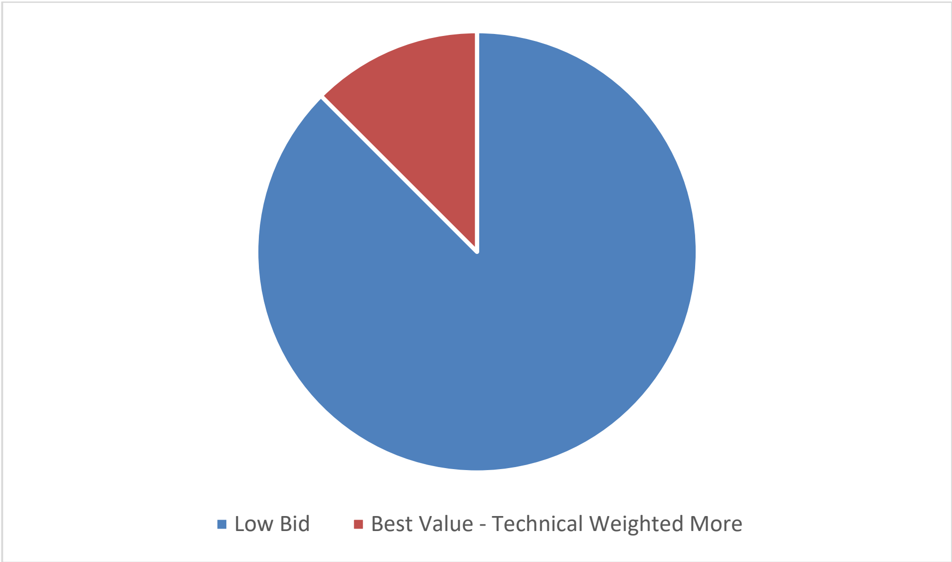

Figure 15. Procurement methods used for the identified projects

Given that the most common project delivery method was identified as design-bid-build, a relationship between design-bid-build and low bid is apparent.

The final questions related to the specifications and special provisions used for the identified project. The questions asked whether the specifications and special provisions used for the project were unique to ABC projects or similar to the specifications and special provisions used for traditional projects. Four of the respondents indicated that the specifications their agencies used for the identified project were similar to those for traditional projects. The remaining respondents stated that special provisions were used for ultra-high performance concrete and accelerated concrete. One respondent stated that decked beams were paid for by the square foot instead of being paid for by the pound for the beams and by the cubic yard for the deck. The special provisions and specifications unique to the project were that ultra-high performance concrete was used, deck beams were paid for by the linear foot, and precast approach slabs were paid for by the unit.

The results of the survey are combined in Table 12 to show the relationships between the procurement methods, delivery methods, and accelerated technologies used.

Table 12. Cumulative results of the survey

Delivery Method	Procurement Method	Accelerated Portion
Design-Bid-Build	Low Bid	Structure, Construction
Design-Bid-Build	Low Bid	Structure, Construction
Design-Bid-Build	Low Bid	Construction
Construction Manager/ General Contractor	Best Value – Technical Weighted More	Structure, Construction
Design-Bid-Build	Low Bid	Structure
Design-Bid-Build	Low Bid	Structure
Design-Bid-Build	Low Bid	Structure, Construction

Discussion

The survey results confirm some of the findings described earlier in this report.

The results of the survey and of the earlier investigations agree that the most commonly used delivery method for ABC is DBB. Moreover, the results of the survey showed that both alternative delivery methods are also used, specifically that some agencies have primarily used DB for their ABC projects while one agency used CMGC for a project. This result fits well with the findings described in Chapter 3, that DBB is the most prominent delivery method, followed by DB and then CMGC.

The procurement method used for ABC projects was also investigated in both the survey and the analysis of bid tabs in Chapter 4. It was inferred from the latter investigation that most of the projects analyzed used low bid procurement. The survey results confirm this finding: the respondents stated that their agencies predominately used low bid for their procurement. The lone project that did not use low bid was a CMGC project that used a best value approach that gave more weight to technical knowledge.

Finally, the survey results validated the findings of the investigation into the specifications used for ABC projects and provided additional examples of specifications used in the industry. Four of the eight respondents stated that the specifications used for the ABC projects they identified were similar to those used for traditional bridge construction projects. Some respondents noted that special provisions were used for ultra-high performance concrete. Other examples included measuring precast approach slabs by the unit and measuring decked beams by the linear foot. It is theorized that these types of measurement systems were used because they allow for more efficient measurement of the items in question and easier measurement if multiple items, such as those used in decked beams, are combined into a single item.

CHAPTER 7: CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

Conclusions

The primary goal of this research project was to build consensus and understanding of the preconstruction management of ABC projects by providing examples of and analyzing the bidding and contracting methods that have been associated with past successful projects. Another goal was to examine the relationships that exist between ABC projects, the number of bidders for those projects, and the project delivery methods.

The research team also developed some recommendations to assist in the development of ABC projects. The first recommendation is that in order to obtain the best price for ABC projects, it is optimal to have between three and five bidders. The second recommendation is that with slight revisions, the specifications and bid items from non-ABC projects can be applied to ABC projects.

The investigation also yielded several notable findings. An important finding is that it is possible to perform ABC projects using any project delivery method. At the same time, the analysis of the applicability of delivery methods to ABC projects showed that DBB is the most common delivery method. Building on this conclusion, the research team was able to see which ABC components were the most common. For all of the delivery methods, it is clear that structural elements are the most common component. Typically, this means that ABC projects tend to use PBES. As the investigation progressed, it became clear that PBES are paid for by “each” precast element that is put into the bridge. When looking only at alternative delivery methods, an increase in the use of construction and geotechnical ABC components was observed. This is most likely because alternative delivery methods allow for the designer to design the project specifically for the contractor’s means and methods. Construction components including SPMTs and lateral slides were bid the same way across the different delivery methods, typically as “lump sum” bid items. The reasoning behind bidding these items as lump sum is that it transfers the risk to the contractor and that any given project typically only requires one bridge move, though it is possible to have multiple bridge moves on a project.

The research team also looked into how the number of bidders on ABC projects has changed as ABC has become more common. However, the findings of this investigation showed that the average number of contractors bidding on ABC projects has remained approximately the same since 1996.

The research team also investigated specifications for ABC projects. The findings of the investigation show that specifications for non-ABC projects can be adapted for ABC projects with minimal changes. However, it is important to note that specifications for ABC projects should be inclusive of all work and the items necessary for the project to be successful, such as the manufacture of each bid item, its transportation, and any work necessary to tie it into the bridge.

Limitations

The limitations of this research project are that the information collected from the ABC-UTC database might not be representative of all ABC projects conducted in the United States during the analysis period. Another limitation is the small sample sizes that were used for the analysis of the specifications and bid items.

Future Research

The next step for this research would be to identify how specifications developed by agencies that have been using ABC extensively have changed as those agencies have become more experienced with ABC projects. Another way to complement the analysis of ABC specifications would be to develop models of the bidders based on the types of ABC components included in the project and the total cost of the project.

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