PUBLIC CONSTRUCTION PROJECTS: AN EXAMINATION OF DELIVERY METHODS AND CONTRACT TYPES

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ABSTRACT

U.S. public sector construction project leaders face challenges to complete projects on budget and on time. Given the breadth of projects and limited resources, state Departments of Transportation must find creative ways to deliver high quality services in a cost effective manner. The focus of this study is primarily on road construction because the U.S. road system is vast requiring constant maintenance and new design to sustain the growing transportation needs of the public. In this research, we examine the major delivery methods and contract types in construction to improve decision making which will enhance project quality and optimize resources.

Keywords: construction project, delivery method, contract type, department of transportation, public sector

INTRODUCTION

State departments of transportation (DOTs) in the U.S. are facing endless challenges of maintaining and improving road conditions while carefully allocating limited public funds among competing activities. It is expected that over the next 10 years, the cost to manage the nation's road systems will exceed available funding at all government levels (Federal Highway Administration, 2008). According to a 2008 federal strategic plan, the total number of vehicle miles traveled (VMT) has increased by 67% to 2.5 trillion miles from 1980, which is a direct result of a 48% growth in population and the continued proliferation of urban sprawl into more traditional suburban areas outside of major cities. Consequently, state DOTs must make use of efficient construction and project management methods to keep pace with the spike in demands.

Successful project execution is crucial in addressing some of the issues the current road system faces. It was estimated that, during 2007 - 2026, approximately $106 billion would be needed to maintain the aging bridges and highways in the U.S. (Federal Highway Administration, 2008). In 2008, approximately 11.9% of the bridges were structurally deficient and 13.3 % were considered functionally obsolete. If funding levels remain flat over the next 12 years, it is expected that road conditions will worsen by 17% (Federal Highway Administration, 2008) due to anticipated increases in material costs and gains in VMT. As the population expands and the vehicle travel miles multiply, the state DOTs' ability to effectively manage these projects is paramount to the performance and safety of the U.S. road system.

Delivery methods refer to ways in which the responsibilities are assigned to parties involved in the design and construction of a project. Given the variety of project delivery methods available, we will limit our discussion to three possibilities: design-bid-build (DBB), design-build (DB), and emerging methods. Coupled with various options such as operating, financing, and maintaining, new delivery methods emerge.

Once the delivery method has been chosen, the contractual as well as working relationships among all parties involved in a project are defined. These relationships are typically structured in the form of a set of legally enforceable commitments known as a contract. There are many types of contracts in use in the public construction industry. Regardless which of them is used, however, the ultimate goal is the same for the state DOT, i.e., to complete the project on time and to specifications at the lowest possible price while allowing the contractor to make a fair profit. The use of different contract types allow the state DOTs to outsource certain projects based on their risk, time horizon, and funding availability. In general, there are three primary contract types: unit price, lump-sum, and cost-plus. Unit price contracts involve the establishment of a fixed price for defined work units when the quantity is difficult to estimate (Benator & Thumann, 2003). Lump-sum contracts are used for well-defined work and the state DOT will pay the contractor a fixed amount that is agreed upon in advance by both parties. In cost-plus contracts, the state DOT reimburses the contractor for most of the direct expenditures plus a fee for overhead and profit. Each contract type has explicit advantages and disadvantages, which will be discussed later in greater detail.

The purpose of this study is two-fold. First of all, we will extend the knowledge base of delivery methods and contract types by examining each in respect to one another to develop insight which will enhance project decision making for the state DOT. Since our study is focused on state DOTs, we view them as agencies of their respective state governmental structures. Therefore, we will use the two terms state “DOT” and “agency” interchangeably. As the research exists today, delivery methods and contract types are often investigated separately with little understanding of how they link to each other. By establishing a clear linkage, we assert that practitioners will be better informed to make decisions that will result in on time and on budget project completions. This allows the agency to maximize the use of available resources. Secondly, the work presented herein will provide researchers with relationships between delivery methods and contract types that can be tested empirically. There is a large body of existing literature that surveys the delivery methods and contract types outlined in this study. However, there is little empirical support of any relationship between the two offered by way of these works. We contend that this study will provide insight into relationships between delivery methods and contract types, which could be examined at a later date.

The remainder of this paper is organized as follows. In what follows next, we will provide an overview of a few traditional and emerging delivery methods currently used by DOT professionals. We will then discuss three primary contract types utilized in construction management. Several factors that must be considered when choosing the appropriate delivery method and contract type are discussed next along with their implications. Finally, we will summarize our key findings from this study and discuss directions for future research.

PROJECT DELIVERY METHODS

In the general context of construction management, project delivery refers to the way in which the responsibilities to provide design and construction services are assigned. At present, three major project delivery methods are widely used: design-bid-build (DBB), design-build (DB), and emerging methods. Each of them will be delineated in the subsequent subsections.

Design-Bid-Build (DBB)

DBB is the traditional method of choice by agencies (Culp, 2011). In using DBB, the state DOT enters into two contractual relationships to deliver the project, one with the designer/architect and the other with the contractor (Ghavanmifar, 2009). The designer develops the engineering blueprints for the project and the contractor executes those plans by building the facility. Following the release of the design specifications and plans for the request for proposal (RFP), the state DOT typically awards the business based on the lowest responsible bid (Berrios, 2006). The selected contractor then completes the project and the state DOT has the responsibility of operating and maintaining the constructed structure.

Many state DOTs choose the DBB delivery method for several reasons. Firstly, since the state DOT has two contractual relationships, it is likely to obtain the best prices from the designer and the contractor through the competitive bidding process (Lahdenperä, 2010), which ensures transparency of costs (Culp, 2011). Secondly, DBB projects afford the state DOT more control over quality in the design and construction phases of the project. This equates to financial liability for the state DOT due to its ability to impose changes. It also provides financial flexibility because the agency has greater input into changes, which could impact the overall budget. As a result, there are fewer change orders generated because the project specifications and plans are already in place. Design control combined with optimal pricing usually provides the most stable and cost effective project delivery for the state DOT.

However, this delivery method does have shortcomings that both parties must address during the process. One of them, from the state DOT's perspective, is the amount of time it takes to complete projects. In order for the construction activities to begin, the detailed design must be in place, the RFP must be sent out, and the best contractor must be selected. All of these add time to the project schedule and there is no opportunity for design and construction to take place simultaneously (Culp, 2011). Moreover, since there is no contractual relationship between the designer and the contractor, the state DOT has to work with both entities to address any design issues during the construction process. This could strain its relationships with them unless it is an effective communicator (Muller & Turner, 2005).

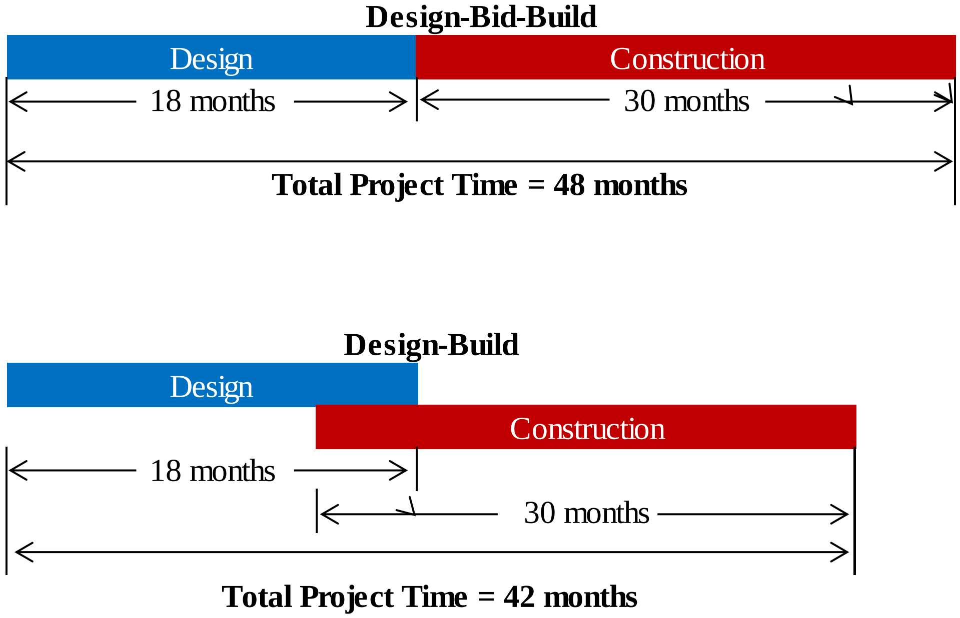
Design-Build (DB)

DB is different from DBB in that the state DOT contracts with only one firm, who is responsible for designing and building a structure or facility. This delivery method is most appropriate when the details of the project are not fully developed at the time of negotiations with the selected designer/contractor but some construction work can be started. A key advantage of DB is that it compresses the overall project timeline by allowing construction activities to begin while the design is being finalized.

This delivery method also relies on a single point of responsibility for the design-build process, which eliminates the need for mediation between the designer and the contractor that may be required of the state DOT in DBB projects. The contractor benefits from the DB approach because the process of design is integrated with that of building, which allows it to best utilize its skills and talents to maximize profitability and minimize changes (Twort & Rees, 2004). Figure 1 illustrates the difference in total project time between the DBB and DB delivery methods. Both contain design and construction timelines with the same duration for each phase. However, since DB allows an overlap between the design and construction phases, the overall timeline is compressed by 6 months.

While the benefits of delivering projects via DB are plentiful, there are issues that could present challenges for the parties involved. For instance, transparency of the cost details at each phase is unavailable, which is a disadvantage for the agency. In addition, the state DOT relies on the designer/contractor to manage the entire project from the beginning to the end. This requires extensive legal agreements to specify the roles and responsibilities of the firm (Joint Committee of AIA & AGC, 2004), which could become a disadvantage for both parties if the contract is overly complex. Finally, since the contractor is responsible for both the design and construction of the facility, it assumes the risk of any change orders that may arise later.

Figure 1. Timeline Compression



If operations is added to the responsibilities of the designer/contractor, the resulting design-build-operate (DBO) option calls for the firm to not only design as well as build the facility, but also operate it on behalf of the state DOT, who retains the ownership. This new delivery method leads to cost savings for the agency (Culp, 2011) and assures the recovery of funds already spent by the contractor. The maintenance option is typically combined with the DB delivery method and the operations option to form a design, build, operate, and maintain (DBOM) or a design, build, finance, operate, and maintain (DBFOM) delivery method, which includes the finance option. In each of these two variations of DB (i.e., DBOM and DBFOM), the contractor agrees to operate and maintain the constructed facility on behalf of the state DOT. By incorporating the maintenance function, the state DOT seeks to hold the contractor responsible for all aspects of designing, building, operating, and maintaining the construction facility. All of the risks associated with the project rest with the contractor. This provides incentive for the contractor to cost effectively complete each phase of the project cycle because each decision made has long-term business impact. Since there are not many contractors willing to and capable of offering finance as an alternative, competitive bidding is not effective under this delivery method (Culp, 2011). DBFOM could defer the cash flow from the state DOT to the designer/contractor because payments are usually not made until the project is completed. However, the contractor may receive revenue generated from the use of a facility or structure built as found in the public use of toll roads. This revenue enables the contractor to repay any equity financing.

Another alternative that involves operations is known as build-operate-transfer (BOT). This arrangement occurs under DB, where the designer/contractor finances, designs, builds and operates the facility before transferring the asset back to the state DOT after a specified period of time. The main advantage of the BOT option is that the agency will acquire the facility in satisfactory condition free of charge at the end of the concession period. BOT project deliveries are forms of turnkey (TK) deliveries (Ahola et al., 2008).

Similar to DB, TK employs a contractor to provide design and construction under a single contract (Ellsworth, 2003). Based on this delivery method, the contractor is usually required to design, procure, install, build, test, and commission the facility (Brown et al., 2002; Ribeiro Ferreira & Rogerson, 1999). TK is usually selected when time is a constraint and the agency is willing to accept design risks in hopes of a timely delivery. A key disadvantage of this delivery method is that the state DOT has little to no control over the quality of the components used throughout the process or the prices paid for those items. Once the constructed facility is operational per the agreement between the agency and the contractor, latter presents a “key” to the fully functional facility to the former (Ellsworth, 2003) and is paid which is different from DB.

Emerging Methods

Several alternatives to the project delivery methods reviewed above have recently emerged. Two of them are construction management at risk (CMAR) and public-private partnerships (PPP). CMAR allows the state DOT to identify and select a firm based upon its expertise and qualifications, which will act as a general manager during the construction process. The construction manager and the design team collaborate to develop a design.

Similar to the DBB delivery method, CMAR requires two contractual relationships for the state DOT. However, in DBB, the construction manager is at risk for the final cost and time of the construction phase (Touran et al., 2011). CMAR is created to provide construction input to the designer to increase the likelihood of building the design as it is planned (Huang, 2011). The state DOT enters into an agreement with a designer and a construction manager, which allows it to continue to influence the design (Minchin, 2009). This effectively reduces the risk for all parties when properly executed. A collaborative approach reduces errors in the design process and allows for a more exact plan for subcontracting in the construction phase (Minchin, 2009).

The CMAR method is best suited for larger, more complex projects that are difficult to define. CMAR seeks to reduce the risk of cost overruns associated with schedule creep and to expedite the construction process without sacrificing quality (Huang, 2011). Key advantages include faster delivery, competitive pricing for subcontractor work, and a single point of accountability for construction. However, upfront commitments could strain resources at a time when they are scarce in the public sector. The primary disadvantage of using CMAR is that it is not competitively bid. Typically, the dollar value of the contract is capped by the use of a lump-sum or guaranteed maximum price (GMP) (Kaplanogu & Arditi, 2009). This cap puts the construction manager “at risk” by establishing a ceiling on the amount he can charge the agency. From the contractor’s perspective, its profit is at risk.

PPPs are increasingly used to provide traditionally supplied government services (Gaffey, 2010). A PPP is a co-operation between a public entity (e.g. state DOT) and a private partner in which the government and the private sector work together on a project where roles, responsibilities, and risks are mutually agreed upon resulting in a long-term contract.

Traditionally, infrastructure projects have always involved public and private entities. The primary advantage of a PPP is that the public sector can complete projects through the cooperative relationship it has with private partners and deliver services that the public needs at a higher efficiency than could be provided by traditional means (Blanc-Brude et al., 2009). It is observed that the public and private partners can focus on what they do best, hence reducing inefficiencies. However, it is generally perceived that private firms and public agencies such as the state DOT have different objectives (Jacobson & Choi, 2008). In some cases, these differences can result in efficiency gains for the delivery of the project and inefficiencies in the on-going operation of the facility. A trade-off is usually made between an outcome with speed and quality and one with use and availability.

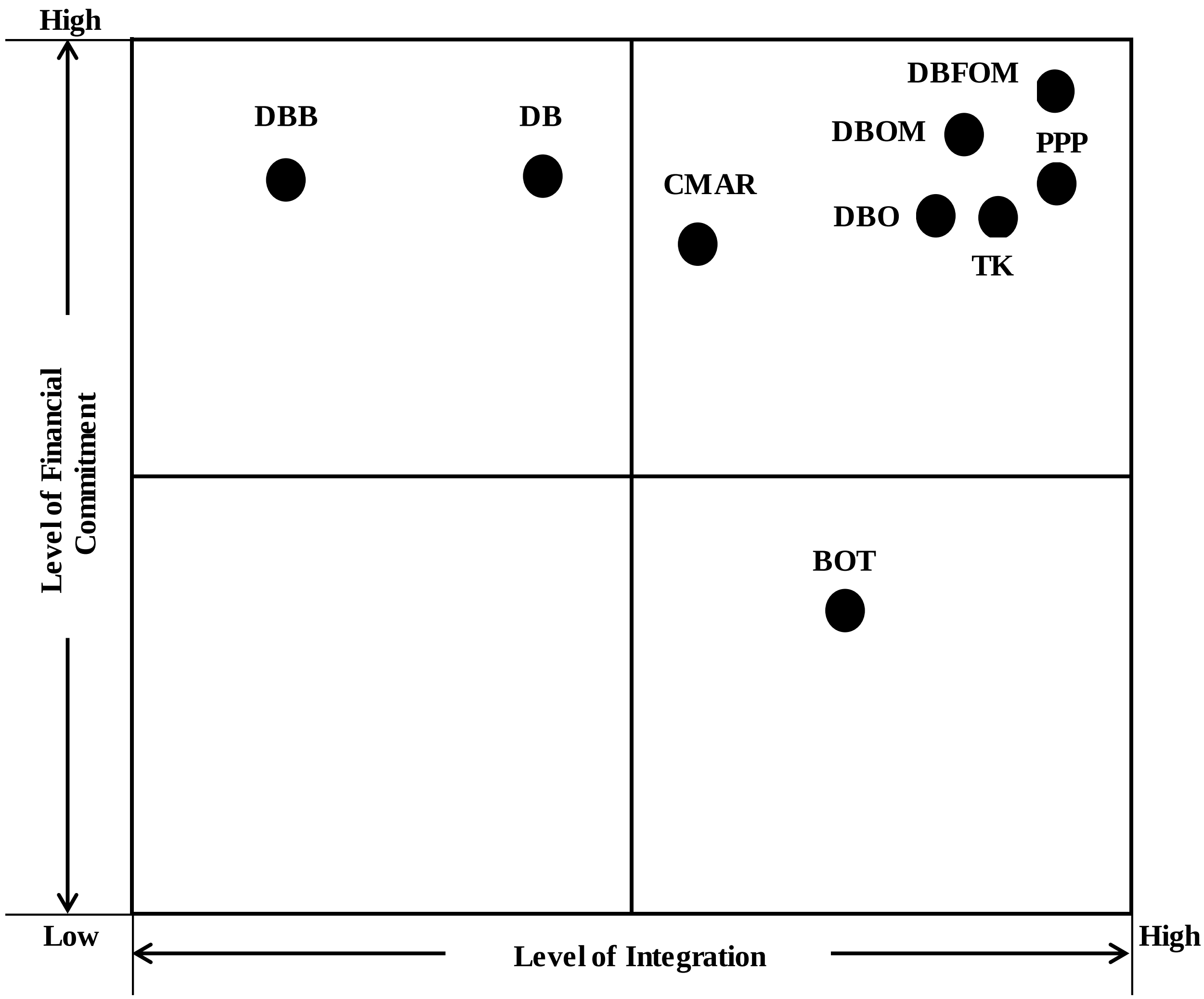
Private firms exist to make a profit, whereas the state DOT exists to maintain and support the transportation needs of citizens. The main deterrent with this project approach is the overall cost. Blanc-Brude, Goldsmith, and Välilä, (2009) report that road construction in Europe may be 24% higher utilizing PPP. This is alarming to the state DOT because it will cost the public more than a traditional delivery method, which could prove difficult in justifying the use of public funds. The costs are potentially higher because the cost of capital is higher for private firms and inefficiencies exist in the administration of the partnership. Given the accelerated access to a needed public facility, PPPs offer state DOTs an interesting option.

To compare and contrast the above-mentioned delivery methods, we construct a graph to show the level of financial commitment and the level of integration the contractor has with the state DOT. In Figure 2, a two-dimensional coordinate system is depicted, where the horizontal axis represents the level of integration the contractor has with the state DOT and the vertical axis represents the level of financial commitment the contractor has in the project. As the contractor collaborates and integrates more with the state DOT, the level of integration between the parties becomes greater. As the level of financial commitment increases, the contractor assumes more risk by investing more of its capital in the project.

Delivery methods that fall in the first quadrant exhibit a high level of integration as well as a high degree of financial commitment with the project. Those that involve financing, operations, or maintenance will be located in this quadrant because they demand a commitment of financial resources from the contractor. As one moves from right to left, the second quadrant represents an area where there is a low level of integration between the state DOT and the contractor, but the financial commitment of the contractor is relatively high. The fourth quadrant represents combinations of a high level of integration and a low level of financial commitment. In this quadrant, the state DOT still works with the contractor, but the financial obligation of the contractor is low, reflecting a low level of risk. The third quadrant represents combinations of a lower level of integration with a low level of financial commitment. As evident in the figure, there are no project delivery methods discussed in this study that would fall in this area.

Upon the selection of the delivery method, it is imperative to define the roles and responsibilities of all parties involved in the project through written contracts. These agreements also serve as instruments to hold all participants accountable. While there are many different types of contracts used in public projects, we will discuss three primary contract types in construction management.

FIGURE 2. CLASSIFICATION OF PROJECT DELIVERY METHODS



CONTRACT TYPES

In the context of contract law typically utilized by federal and state agencies, the word "contract" is often considered the contractual compensation arrangement between the contracting entity (i.e., state DOT) and a contractor (Manuel, 2010). Contracts are used to help allocate cost risk between the state DOT and the contractor. The three most widely-used contract types are: unit price, lump-sum, and cost-plus.

Unit Price Contracts

In the mid-1940s, a contract type was first introduced in the United Kingdom for construction projects. Also known as bill of quantities, it was used by project managers to pay contractors for the work performed based on an agreed-upon price (Twort & Rees, 2004). This form of agreement served as a foundation to set expectations between the contractor and the agency. Today, it has become a worldwide standard and is often referred to as a unit price contract.

Unit price contracts involve establishing a fixed price for each defined work unit. They are frequently used by state DOTs to construct highways, bridges, and dams (Carty, 1995), where the total amount of work is unknown due to earth excavation and other uncontrollable phenomena such as weather. The agency will pay the contractor the agreed-upon unit price for the actual quantity involved in the construction process. For example, in Table 1, a state DOT has requested a bid for an infrastructure project involving four activities: excavation, trenching, embankment, and gravel base. Each of them has a unit cost, which is multiplied by the estimated quantity to determine the cost of the activity. The subtotals are then added up to obtain the total cost of the project. Based on the data, contractor A would win the business award because its bid is lower than that submitted by contractor B. The unit costs will be $6.75 per cubic foot (excavation), $1.25 per linear foot (trenching), $4.25 per cubic yard (embankment), and $6.50 per ton (gravel base) (Ironmonger, 1989). However, the state DOT is responsible for making a payment for the actual quantities completed or consumed (Missbauer & Hauber, 2006).

TABLE 1. EXAMPLES OF UNIT PRICE BIDS

	Contractor A				**Contractor B**			
Bid Item	**Estimated Quantity**	**Unit of Measure**	**Unit Price**	**Total**	**Estimated Quantity**	**Unit Of Measure**	**Unit Price**	**Total**
Excavation	10,000	Cubic Yard (CY)	$6.75	$67,500	10,000	Cubic Yard (CY)	$5.25	$52,500
Trenching	5,000	Linear Foot (LF)	$1.25	$6,250	5,000	Linear Foot (LF)	$1.20	$6,000
Embankment	15,000	Cubic Yard (CY)	$4.25	$63,750	15,000	Cubic Yard (CY)	$6.25	$93,750
Gravel Base	11,000	Ton (T)	$6.50	$71,500	11,000	Ton (T)	$5.50	$60,500
				$209,000				**$212,750**

Under this contract type, the state DOT relies on the contractor to determine the actual quantity of work performed. This is a risk to the agency because it does not know in advance how much to pay the contractor (Carty, 1995). On the other hand, the contractor has provided the state DOT with a fixed unit price for each bid item based on an expected amount of work. So the former assumes some risk since the actual quantity may be above or below the estimate (Carty, 1995). While this is typically minimized due to the expertise and due diligence used to reach the agreed-upon unit price, both parties traditionally limit their risks by explicitly stating the conditions under which the unit price can be adjusted. This is typically established as a percentage over or below the expected quantity. For example, in Table 1, the contract between contractor A and the state DOT could allow for adjustments in the unit price for excavation should the actual quantity excavated deviates from the estimated quantity by 10% or more. If the actual quantity was only 8,500 CY, the contractor could ask to adjust the unit price because the actual quantity was 15% lower than the estimated quantity. In this case, increasing the unit price could offset the potential risk of lost revenue.

Contractors may also utilize the technique of bid unbalancing to offset risks associated with unit price contracts. In an unbalanced bid, the contractor may increase the unit prices of some items to be consumed early in the project and proportionally decrease the unit prices of others to be used at later stages, hence keeping the total cost the same (Clough, Sears, & Sears, 2005). Likewise, state DOTs seek contractual solutions to further mitigate risks facing them. For instance, they may require appropriate documentation of expenses from the contractor before the release of any payment to avoid budget overruns (Missbauer & Hauber, 2006) albeit this could add costs for the latter because of the need to provide detailed bills of quantities for verification purposes. While unit price contracts are commonly used in the construction industry, they are sometimes combined with other contract types to better control costs and reduce risks for state DOTs (Pedwell, Hartman & Jergeas, 1998).

There are inherent advantages for both parties in using unit price contracts. First of all, a project can be awarded to a contractor without knowing the exact quantities to be used. This allows the construction activities to move forward before all the drawings and specifications are completed. Secondly, this type of contractual agreement allows state DOTs to easily determine how much to pay the contractor in case small changes need to be made during the construction process due to unforeseen difficulty. It also provides a level of protection for the contractor since the payment is based on the actual work performed and the unit price will remain fixed unless the contract allows for adjustments in the form of a change order or a contract renegotiation (de Rus & Romero, 2004).

While the unit price contract is popular (Twort & Rees, 2004), it is not without disadvantages. First, state DOTs do not know what the total cost will be until when a project is complete, hence introducing uncertainty into the agency’s budget. Another drawback is the need for inspection oversight by the state DOT to verify the quantities reported by the contractor, which shifts the focus away from quality and directs the resources toward non-value-adding validation activities.

Lump-Sum Contracts

In a lump-sum contract, the contractor agrees to perform a stipulated job of work for the state DOT for a fixed amount of money. It is also responsible for any cost overruns or underruns. Lump-sum contracts are primarily used in projects that are well-defined and their contents can be easily estimated (Twort & Rees, 2004), which allows each contractor to submit a bid on fully completed designs. As such, they are commonly seen in the building construction industry, where detailed plans and drawings requiring little or no modification can be developed.

With a lump-sum contract, the state DOT will have a better understanding of and control over the total project costs (Berends & Dhillon, 2004). Prior to the start of construction, the contractor needs to develop a schedule of values (SOV), which is a breakdown of the project into various work items along with the values. The SOV forms the basis for all progress payments throughout the contractual period. If significant changes to the scope of the work are needed, they must be negotiated between the state DOT and the contractor in accordance with the contract provisions. In Table 2 (Holm, et al., 2005), an example of a lump-sum bid is given for illustration purposes.

TABLE 2. EXAMPLE OF LUMP-SUM BID

BASE BID

Pursuant to and in compliance with the Advertisement for Bids and Instructions to Bidders, the undersigned hereby certifies having carefully examined the Contract Documents entitled

Market Street Sewage Treatment Plant,
prepared by Stellar Engineers, Inc.

and conditions affecting the work, and is familiar with the site; and having made the necessary examinations, hereby proposes to furnish all labor, materials, equipment, and services necessary to complete the work in strict accordance with the above named documents for the sum of

Ten Million Three Hundred Seventy-Eight Thousand Nine H Dollars *($ 10,378,900)*

which sum is hereby designated as the Base Bid.

ALTERNATIVES

The undersigned proposes to perform work called for in the following alternatives, as described in Section 01030 and the drawings of the Contract Documents, for the following resulting additions to or deductions from the Base Bid.

Alternate #1: Delete Selected Landscaping
Fifty Thousand Eight Hundred Dollars *($ 50,800)*

Alternate #2: Delete Paved Parking Lot
Sixty Thousand Two Hundred Dollars *($ 60,200)*

Alternate #3: Add Second Floor Upgrade
One-Hundred Twenty-Five Thousand Five Hundred Dollars *($ 125,500)*

As with the unit price contract, both parties involved in a lump-sum contract are facing some uncertainties. For instance, the contractor must build into the SOV both direct and indirect costs as well as profits to ensure that all project activities are completed as planned and budgeted. However, this may or may not happen because there are many uncontrollable factors such as below-surface work, weather, and so on. Likewise, the state DOT might be concerned about the quality of the project completed by a contractor trying to maximize profits within a fixed sum of money.

One advantage of a lump-sum contractual agreement is that the final cost of the project is known in advance, which allows the state DOT to more effectively plan budgeting activities and improve its communications to the public. In the study by Langford et al. (2003), the use of lump-sum contracts resulted in an 11% reduction in overall expenditures when compared with unit price contracts. Another advantage is that the state DOT will make periodic payments based on rough observations of the work completed by the contractor; there is no need for precise field measurements, hence enabling project managers to pay more attention to quality and other aspects of the construction activities. The biggest disadvantage to the lump-sum contract is that work cannot begin until the construction design is complete due to the detailed specifications and plans required for contractors to bid, which lengthens the project duration for the state DOT. A second disadvantage is the significant cost increase as a consequence of change orders or extras requested by the state DOT, which might result in a shift in the project schedule as well as its budget.

Cost-Plus Contracts

Cost-plus contracts are quite different from their unit price and lump-sum counterparts in that the state DOT agrees to pay the contractor for the costs of labor and materials incurred on the project job plus a fee to cover overhead and profits (Ironmonger, 1989). There are four general types of cost-plus contracts: cost-plus fixed fee (CPFF), cost-plus-incentive fee (CPIF), cost-plus award fee (CPAF), and cost-plus percentage of cost pay (CPPC) (Manuel, 2010). CPFF contracts pay a pre-determined fee that was negotiated during the formation of the contract. CPIF contracts have a larger fee contingent upon meeting or exceeding performance targets, which could include any cost savings or incentives for early completion. CPAF contracts pay a fee based upon the contractor's work performance, which is spelled out in the contract in the form of service level agreements (SLAs). Finally, CPPC contracts include a fee that is a fixed percentage of the cost. As costs grow, the amount of the fee multiplies.

Table 3 is an example of a how the daily work may be tracked for a CPPC contract used by a state DOT for excavation work, which tabulates labor, material, and equipment costs (Connecticut Department of Transportation, 2011). For the labor and material costs, a percentage of them is added to the actual costs. However, a close examination of the table reveals the use of different rates for idle and active equipment to determine equipment costs.

Cost-plus contracts are used only when the state DOT is under severe time constraints and the contractor has to begin construction as quickly as possible often without the benefit of a well-defined scope or project specifications. As such, they are normally negotiated rather than bid, and a high level of communication between the two parties is necessary to avoid any potential disputes in the future. The single most advantageous point of a cost-plus contractual agreement is its flexibility because it allows the state DOTs, the architect/engineer, and the contractor to collaborate on the detailed design and develop an effective plan (Ironmonger, 1989). Another advantage is that the contract does not expose the state DOT to the risk of cost overruns experienced by the contractor albeit the former still bears the risk of project costs exceeding the budgeted amount (Ferguson, 2010). Finally, contractors have no intentions to cut corners to get the job done since labor and material expenses will be reimbursed. In fact, in some cases, when the cost-plus contract is combined with incentives, contractors might actually complete projects ahead of schedule (Brown, 1997).

TABLE 3. DAILY REPORT OF A COST-PLUS CONTRACT

CONTRACTOR PERFORMING WORK: TILCON CONNECTICUT	**STATE OF CONNECTICUT** **DEPARTMENT OF TRANSPORTATION** **BUREAU OF ENGINEERING & HIGHWAY OPERATION** **DAILY REPORT OF COST PLUS**	DATE OF WORK : FEDERAL AID NO:	REPORT NO: PROJECT NO:
DESCRIPTION OF WORK: EXCAVATE AND REPLACE DAMAGED 36" RCP; BACKFILL, COMPACT, AND PAVE; AND M&PT	Payment Type: Progress		CONSTRUCTION ORDER ITEM NO.

LABOR

Class	No.	Total Hours	Rate	Amount
FOREMAN	1	8.00	17.00	136.00
LABORERS	2	16.00	16.00	512.00
OPER (EXC)	1	8.00	22.62	180.96
OPER (LOADER)	1	8.00	21.48	171.84
TEAMSTER	1	8.00	18.13	145.04
Total Labor				**1145.84**
Health Welfare and Pension (HWP)	LAB	24	6.4	**153.6**
	OPER	16	7.7	**123.2**
	TEAM	8	6.21	**49.68**
Insurance and Taxes on Labor (I&TL)			0.456	**522.503**
20% of Labor + HWP + I&TL (Plus)			0.2	**398.965**
Total (Labor + HWP + I&TL + Plus)				**2067.31**

MATERIAL

Description	Quantity	Unit Price	Amount
CLASS A CONC. (CY)	2	300	600.00
36" RCP (LF)	14	25	350.00
Total			**950.00**
Less Discounts			**0.00**
Total			**950.00**
Additional % = 15%			**142.50**
Total			**1092.50**

EQUIPMENT

Size and Class	Idle (I) or Active (A)	No.	Total Hours	Rate	Amount
1/2 TON PICKUP TRUCK	A	1	8.00	7.39	59.12
CAT LOADER	A	1	4.00	40.00	160.00
CAT LOADER	A	1	4.00	30.00	120.00
J. DEERE EXCAVATOR	I	1	3.00	48.00	144.00
J. DEERE EXCAVATOR	I	1	5.00	32.00	160.00
TRIAXLE DUMP	A	1	8.00	32.27	258.16
Total					**901.28**

Inspector: Jim Jones ConnDOT Date: 10/14/98	Contractor's Representative: Chuck Barry - Tilcon Connecticut Date: 10/14/98	Daily Total Progress Total: **$4,061.09**

A key disadvantage of the cost-plus contract is that the state DOT is uncertain about the final cost of the project at the time of the negotiation (Ferguson, 2010; Kelley, 1942) because of the incomplete construction design early in the process. However, as previously discussed, uncertainty can be minimized if the cost-plus contract is combined with a guaranteed maximum price (GMP). GMP is an important aspect of the CMAR delivery method (Minchin, 2009). Another disadvantage is that the project may require additional monitoring of activities due to the incomplete construction design (Malatesta & Smith, 2011). Lastly, contractors are not motivated to minimize construction costs because they will be compensated for all expenses incurred (Nkuah, 2006). This often makes this type of contract undesirable in the public sector (Nagle, 2000). Consequently, it is normally confined to unusual or unpredictable situations such as clean-up or repair of damage caused by storms or floods. State DOTs are prohibited from negotiating cost-plus contracts except under extraordinary circumstances.

DISCUSSION

Today, state DOTs are facing the daunting tasks of building and maintaining the nation’s road systems with limited resources. In particular, increasing material and labor costs coupled with rising vehicle miles traveled pose a myriad of challenges and demand innovative solutions to the complex problems in public construction management.

It is important to note that choosing the appropriate delivery technique for any given road systems project is paramount to the success of the endeavor. There are several factors that must be considered before making a decision regarding the delivery method (Touran et al., 2011; Creedy, Skitmore, & Wong, 2010; Lam, Chan, & Chan, 2008). These include but are not limited to: clarity of scope, schedule, complexity, funding, and state DOT preferences regarding risk and control. Clarity of scope is needed more in the DB and DBB approaches than in emerging methods such as CMAR and PPP. If time is a major constraint, choosing the DBB method would lead to longer project durations. A more appropriate choice could be CMAR because projects can be completed faster than they would if DBB was chosen. CMAR also allows the state DOT to still have design input which could impact the quality of the design. This aspect could be lost in DB because the detailed design is constrained by the schedule and budget set by the designer/builder (Gransberg & Windel, 2008).

If the project is very complex and it is not clear how it will be accomplished, the best alternative may be the DB method because it allows the designer and the contractor to work together to address any potential issues. Delivery method selection determines the number and types of contract to be used. For example, if the DBB method is selected, the state DOT will have two contracts to manage with the designer and contractor, respectively. Since DBB requires a good project definition and fairly stable project conditions, the lump-sum contract can be used (see Table 4) (Kuprenas & Nasr, 2007). Another important consideration in choosing the most appropriate delivery method is the state DOT's preferences. Should the state DOT have access to limited financial resources and, hence be less willing to assume financial risks, it will need to utilize DBFOM or an emerging delivery method such as PPP to implement large scale public projects.

TABLE 4. COMPARISON OF DELIVERY METHODS

	Delivery Method	Main Characteristics	Advantages	Disadvantages	Primary Contract Type
Traditional Methods	Design-Bid-Build (DBB)	- Two contractual relationships - Well-defined project plans	- Fully-defined project scope - Designer and contractor accountable to owner - Best possible price - Higher quality	- Longer project duration - No relationship between designer and contractor - Design change orders may increase final cost	Lump-sum
	Design-Build (DB)	- Single contracting entity - Project plans not fully developed	- Single point of responsibility for design and construction - Faster project delivery (work begins before designs are final) - Project costs are known earlier in process	- Low cost transparency - High dependency on selected contractor - Changes can be difficult and expensive - Cost pressure can erode quality	Unit price
Emerging Methods	Construction Management at Risk (CMAR)	- Construction manager assumes risk for construction - Guarantee price for construction	- Earlier knowledge of costs - Work can begin with incomplete designs; faster project completion - Subcontractors can be screened	- Costs are generally higher than DB; state DOT costs are known later - DOT must manage two contracts - Designer and contractor may have different goals	Lump-sum
	Public-Private Partnership (PPP)	- Cooperation between public and private entities - Requires limited public funding	- Majority of risks shift from public sector to private partner - Funding (partial or full) is provided by a private partner - Projects are completed faster	- Higher capital costs; higher transaction costs - Lack of competetion due to long-term contracts - Cultural gaps between public and private deliveries	Cost-plus Unit price

Before state DOTs enter into contracts with designers and contractors, they need to understand the types of contracts available to protect their interests. Each of the three contract types examined in this paper has its own advantages and disadvantages, which are summarized in Table 5. The contractor and the state DOT equally share risks when using unit price contracts. The primary danger for the agency is the unknown final costs, whereas the perils for the contractor lie in the accuracy of the quantity of work estimated. However, the situation changes when lump-sum contracts are used. For instance, the risk level for the agency is low because the total project costs are readily known and a fixed price is guaranteed by the contractor, who assumes a higher level of risks. Unlike unit price and lump-sum contracts, state agencies assume higher levels of risks when using cost-plus contracts because the overall costs of the project are unknown. On the contrary, the risk assumed by the contractor is low because its costs plus profits (fee) are covered.

TABLE 5. COMPARISON OF CONSTRUCTION CONTRACT TYPES

					Financial Risk	
Contract Type	**Main Characteristics**	**Key Advantages**	**Key Disadvantages**	**Project Examples**	**State DOT**	**Contractor**
Unit Price	Unit of work can be defined; quantity of work required is unknown	Exact quantities are not needed	Total project costs are unknown	Highway construction, bridge projects, dam projects	Medium	Medium
Lump-Sum	Project scope and work are well-defined	Total project costs are known	Completion times are longer	Bridge painting, bridge projects (with minor excavation), fencing, guardrails, sidewalks, landscaping, lighting, resurfacing, signaling	Low	High
Cost-Plus	Project design is not complete; time pressure to start construction as soon as possible	Project timeline compression	Multiple change orders might be necessary; unknown final project costs	Clean-up/repair of damage by natural disasters (e.g. tornadoes, hurricanes, and floods)	High	Low

CONCLUSION

In this paper, we review delivery methods and contract types in public construction management from the perspective of state DOTs and the main focus is on the definition, use, as well as pros and cons of each of them. More specifically, the DBB strategy generally leads to a longer delivery period but fewer changes when compared with its DB counterpart. Interestingly enough, emerging delivery methods shift more responsibility and risk to the contractor but offer advantages for the state DOT not present in traditional delivery methods. On the other hand, unit price contracts are most appropriate when the scope of project is defined but the quantity of work is difficult to estimate. In contrast, lump-sum contracts are typically used if the design specifications and drawings are completed at the time of request for proposals. Finally, cost-plus contracts are limited to unusual situations with severe time constraints. We believe that Tables 4 and 5 summarizing the advantages as well as the disadvantages of all delivery methods and contract forms discussed herein will aid state DOT managers in selecting the optimal approach to completing projects efficiently and cost effectively. Thus, the paper achieves the first objective of the study, which is to provide linkage between delivery methods and contract types to facilitate better decision making in public construction projects.

In Tables 4 and 5, delivery methods and contract types are put into context of one another. By displaying the key advantages and disadvantages in each table, we have identified potential relationships that can be further tested empirically, which is the second objective of the present study. For instance, in Table 4, we can test the conjecture that lump-sum contracts work well with DBB projects. A researcher could operationalize the advantages and disadvantages to examine if these outcomes lead to better cost control and result in longer project duration. In a recent study that evaluates risk factors leading to undue costs in highway construction projects, Creedy, Skitmore, & Wong (2010) identify specific factors that could lead to overruns. Although some of the determinants appear to be associated with the delivery method, others are related to the contract type. However, what seems to be absent from these analyses is the consideration of causality. Do we know if the design/scope changes cause the tender prices to go up? It is not certain and additional empirical research is needed to examine more closely the reason for the price increases.

While the present study has addressed some important issues in managing public construction projects, it is not without limitations. Firstly, no empirical data is employed to support our findings on the use of different delivery methods or contract types. As a result, further investigation is needed, for example, to survey the current practices of the state DOTs to validate observations made in this paper.

Future research should attempt to synthesize terms used in project management, construction, and engineering to encourage a more cross-functional approach to construction practices. The disparate definitions amongst the different fields have resulted in a fragmented base of literature, which leads to scholarly works that lack generalizability across subjects. Construction management is clearly a field with pillars from engineering, construction science, and business. Future research should seek to better integrate these disciplines by converging on terms which transcends each of them. While our contribution posits relationships between delivery methods and contract types, we only scratch the surface of the potential that lies in this area. This suggests that the strength and direction of these relationships need to be tested sometime down the road.

Finally, an additional area for future research lies in the quest for an optimal approach for the state DOT to pay the contractor. Keeping all tasks on budget and on schedule are essential to successfully executing construction projects (Odeh & Battaineh, 2002). Therefore, it could be beneficial for the agency to make payments contingent upon key milestones or other criteria (e.g., quality of workmanship). Matching payment strategies with these objectives could motivate the contractor to more carefully assess the risk taken during the course of a project. As state DOTs are continually asked to do more with less, optimizing payments to contractors can benefit both parties.

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