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Abstract: A recent NCHRP study found that seven state DOTs have some type of experience using Construction Manager-at-Risk (CMR) (also termed Construction Manager/General Contractor or CM/GC) project delivery. This project delivery method's major advantage was found to lie in the collaboration between the designer and the builder during the preconstruction phase, which was found to reduce delivery time and project costs. Preconstruction collaboration does not happen automatically by merely deciding to use CMR project delivery. To be effective, the requirement to collaborate must be included in both the design and preconstruction services contracts. This paper reports the changes to DOT design contracts that were successfully employed in CMR transportation projects. It concludes that an agency's standard design services contract must be modified to directly coordinate with the CMR preconstruction services contract to maximize the benefits associated with this project delivery method.

INTRODUCTION

Construction Manager-at-Risk (CMR) (also termed Construction Manager/General Contractor or CM/GC in several states' enabling legislation) project delivery method is an integrated team approach to the planning, design, and construction of a project, to control schedule and budget, and to assure quality for the project owner. The team consists of the owner, the designer, which might be an in-house engineer or a design consultant, and the at-risk construction manager. A CMR contract includes preconstruction and construction services. The CMR is usually selected early in the design process and collaborates with the owner and designer during all phases of the project, including but not limited to planning, design, third party coordination, constructability reviews, cost engineering reviews, value engineering, material selection, and contract package development. The CMR and the designer must commit to a high degree of collaboration. A guaranteed maximum price (GMP) is established when the design of a specific feature of work is nearly complete (progressive GMP) or when the entire design is at a point where the CMR can reduce the magnitude of necessary contingencies. The CMR warrants to the owner that the project will be built at a price not to exceed the GMP. The CMR thus assumes the risk of meeting the GMP. After design is complete, the CMR acts as the general contractor during the construction phase of the project. Strang *(1)* describes the relationship change like this: "The construction manager is an agent of the Owner in managing the design process, but takes the role of a vendor when a total cost guarantee is given."

A number of state and local transportation agencies have undertaken or experimented with CMR project delivery. These include the Alaska, Arizona, Florida, Oregon, and Utah Departments of Transportation (DOTs). Additionally, Maricopa, Pima, Pinal and other Arizona counties as well as the Arizona cities of Flagstaff, Glendale, Phoenix, and Tempe have implemented CMR project delivery on major transportation projects. The Michigan and Rhode Island DOTs have overseen CMR projects for local air and sea port authorities. The California DOT is looking at CMR as a potential project delivery method and has completed a study of the method *(2)*. CMR is widely used in the airport, transit, and water/wastewater industries as well as in the building construction industry where it first evolved. Several transit megaprojects in Utah and Oregon have been successfully delivered using CMR *(3)*. Large and small airport projects in Colorado, Florida, Georgia, Massachusetts, Ohio, Tennessee, and Texas have also been delivered using CMR *(4)*.

In a 2008 presentation to the Western Association of State Highway and Transportation Officials (WASHTO) by Jane Lee of the Oregon DOT, she expresses her agency's essential motivation by listing Oregon's six reasons for using CMR project delivery:

1. "Collaboration and cost control
2. Concurrent execution of design and construction
3. Well suited for complex projects, tight time frames
4. Owner, A/E [architect/engineer], CM/GC [CMR] have mutual project goals
5. Risk management: Team identifies - Owner controls
6. Collaborative process minimizes risk of construction and design disputes" *(5)*

Lee uses the words "collaboration" and "control" twice in her description. The Utah DOT confirms Lee's focus on collaboration and control and adds "to introduce innovation and new technologies"

as another reason for using CMR *(6)*. Previous research has found that owners in the transit and airport sectors choose CMR project delivery for the same three reasons *(3, 4)*. The aspect of owner "control" usually extends to the three salient aspects of project delivery: control over the details of design (i.e. quality), cost control, and schedule control *(7)*. One early study of alternative project delivery methods found that owners' main goals for using design-build (DB) project delivery were compressing the schedule and controlling cost *(8)*. However, another study found that DOTs were often reluctant to use DB project delivery because they lost control over the details of design *(7)*. Taking the facts from these four studies and combining them with Lee's reasons for using CMR project delivery leads to the inference that CMR may furnish a project delivery method that satisfies owners' need for control over cost and schedule without losing control over the design. Additionally, the collaborative nature of CMR may provide added value through the fundamental structure of the contractual relationships. One report states that this value is usually in the form of risk reduction to the owner:

> "The collaborative approach of CM/GC also reduces risks to the owner. The CM/GC firm becomes an ally of the owner through independent evaluation of project costs, schedule, and overall construction performance, including similar evaluation of changes. Additionally, the structure of the CM/GC process offers a system of checks and balances to assure that owner's decisions and the decisions of the A/E are prudent" *(9)*.

METHODOLOGY

The need to coordinate the design and preconstruction services contracts was uncovered during case study data collection in conjunction with NCHRP Synthesis 40-02, *CM-at-Risk Contracting for Highway Projects (10)*. In the project, structured interviews of transportation agencies with CMR experience were used to collect the majority of the data. Each case study was centered on a single CMR project. However, the interview was broadened to include a more general set of policy, procedure, and effective practices for those agencies that had completed several CMR projects. A total of ten agencies were interviewed either face-to-face or telephonically. The total value of the case study CMR projects associated with these agencies is $2.3 billion. Table 1 shows the salient information of the case study projects.

TABLE 1 Agency Structured Interviews

Agency	CMR Experience (# projects)	Case Study Project	Location	Size ($)	Primary Type
Alaska DOT&PF	2	Fairbanks Intl Airport Expansion	Fairbanks, AK	$99.0 million	Building
Florida DOT	9	Miami Intermodal Center	Miami, FL	$1.3 billion	Building, Rail, Road, Bridge
City of Glendale	18	Glendale Pedestrian Improvements	Glendale, AZ	$16.2 million	Road, Utilities
Michigan DOT	1*	Passenger Ship Terminal	Port of Detroit, MI	$10.0 million	Building, Marine, Utilities
Oregon DOT	1	I-5 Willamette River Bridge	Eugene, OR	$150.0 million	Road, Bridge
Pinal County Public Works	5	Ironwood-Gantzel Road (US 60) Improvements	Florence, AZ	$63.7 million	Road, Bridge
Utah DOT	13	I-80 State St to 1300 East. Reconstruction	Salt Lake City, UT	$130.0 million	Road, Bridge
Non-Highway Case Study Agencies					
Memphis Airport Authority	25	Whole Base Relocation	Memphis, TN	$245.0 million	Runway, Building

Utah Transit Authority	4	Weber County Commuter Rail	Salt Lake City, UT	$241.0 million	Rail, Road, Bridge, Building
Texas Tech University	40+	Lanier Law School Center	Lubbock, TX	$13.7 million	Building
*Oversight on behalf of another agency responsibility only					

As part of the case study data collection, copies of design and CMR preconstruction services contracts were obtained and the interviewees were asked to identify how the design contracts were modified to facilitate CMR project delivery. Three conditions were found to exist. First, agencies that were in the process of their first CMR projects made no alterations. Next, several agencies merely stated that the design work would be done in conjunction with CMR delivery of the construction. Finally, the remainder modified the traditional design contract used in design-bid-build (DBB) projects to coordinate the design process with the preconstruction services process. For those with design contract modifications, the various CMR-specific clauses were identified using content analysis and categorized to permit a comparison with preconstruction services specified for each case study project. The results are reported below.

DESIGN RELATED PRECONSTRUCTION SERVICES

NCHRP Synthesis 40-02 *(10)* found that the willingness of the designer to actively and willingly participate in the CMR preconstruction process was key to realizing the method's potential benefits for the DOT. The most significant lesson learned in this study is the agency's need to ensure that the designer has an opportunity to appropriately price its work by modifying the design contract to reflect the change in effort that CMR project delivery entails*(10).* This is not to say that the synthesis found that design costs increase with this form of project delivery method. In fact, the finding is just the opposite. The Utah DOT realized savings in design costs on the order of 40% in its first set of CMR projects *(6)*, and the Corps of Engineers reported that it also realized a savings in design costs that was directly related to CMR project delivery *(11)*. To realize these savings, the agency must understand that the CMR design process proceeds in a different manner than in a DBB contract *(12)*. One case study interviewee likened it to a tennis match where the designer and the builder take turns evaluating and improving the design. One contract document stated it like this: "the CMR will function as one of three key team members."

A second difference is the need to directly correlate the design packages with the subcontractor bid packages, especially if the project will be fast-tracked or if early bid packages are desirable to mitigate escalation risk. The Utah, Pinal County, and Oregon case studies did this and found it greatly improved the savings possible during preconstruction. Thus, the designer must evaluate a sequence of work that is different from the one it normally follows. To bring a bridge design to a level where the CMR can order the structural steel as soon as possible may necessitate assigning the consultant's most senior structural engineers early in the design, which may create conflicts with other design projects the firm has underway that are following its standard work flow. It might also require the consultant to assign more engineers to the steel design to complete it as quickly as possible. Finally, early bid packages can often require engineering disciplines not directly involved with a specific package to accelerate their work in order to furnish supporting information.

Design Contract Modifications

The solution to ensure collaboration is to modify the design contract to facilitate CMR project delivery. Doing this makes preconstruction collaboration enforceable and gives the designer the opportunity to appropriately price the activities that do not occur in a DBB design project. The synthesis found that five of seven highway agencies and all the non-highway agencies modified their standard design contract in some form. The two agencies that used the same design contract in both DBB and CMR were the Utah and Michigan DOTs. During the interview, Utah stated that they inform the design consultant of the project delivery methods the department is considering for a given project and expect the consultant to account for the possibilities in their proposals. Given the fact that UDOT has institutionalized CMR project delivery and routinely uses it on a variety of projects *(6)*, the consulting community has no doubt adjusted its proposal preparation process to account for the eventualities. Michigan is overseeing its first CMR project for another agency and has no programmatic requirement to address this issue in their design contracts.

Table 2 shows typical changes to design contracts found in the case study projects and their frequency of use by the eight agencies that reported them. By inspection, the top four modifications all deal with coordinating the efforts of the designer and the CMR during preconstruction. The coordination of the design and construction work packages introduces efficiency to the joint work effort and ensures that the bids received from subcontractors are as accurate as possible by largely reducing the scope risk for the subcontractor. A well-coordinated package will give the subcontractor all the technical information it needs to furnish a competitive price and eliminates the risk of having missed some scope that is displayed somewhere else in the construction documents as happens in DBB *(13)*.

TABLE 2 Design Contract Modifications to Accommodate CMR Project Delivery.

DBB Design contract modification	**Number (out of 8)**
Coordination of design packages with construction bid packages	6
Joint coordination with third parties during design	6
Facilitate CMR design reviews	5
Joint value engineering with CMR	5
Design milestones specified to match preconstruction services	4
Mandatory budget review points	3
Requirement to respond CMR comments and incorporate as appropriate	2
Requirement to notify CMR of major design changes	2
Allow the CMR to assist in material selection decisions based on market surveys	2
Design in accordance with CMR designated means and methods	2
Pass design changes through CMR for cost/schedule impact validation	1
Over-the-shoulder review of construction submittals with trade subs	1
Expedited review of construction submittals at CMR's request	1
Design fee at risk for design quality	1
Collaborate with CMR on cost model development	1
Participate in joint scheduling conference	1
Collaborate with CMR to define required right-of-way	1
Provide CMR design products to facilitate CMR-obtained permitting	1
Furnish graphic design support to CMR public relations effort	1
Joint planning and participation in public outreach meetings	1

The second contract modification, joint coordination with third parties addresses the risk that the design will not accurately reflect the scope of work necessary to satisfy third parties such as utilities and permitting offices. By bringing the contractor in during design, the agency can assign the responsibility for quantifying the third party impact to a project by locating and coordinating with the third parties and assisting the designer in furnishing solutions to meet their requirements. Third party issues can be show-stoppers and as a result are typically addressed as soon as they are identified. The Utah DOT case study interview indicated that permitting agencies are more willing to expedite their process if they are dealing with a contractor because they believe the chance of significant design changes has passed when a contractor has been selected *(6)*. The Oregon DOT interview confirmed this when they indicated that the CMR was able to obtain a permit in three months that historically took a consultant a year. One author believed that the construction manager was better suited than either the consultant or the owner to deal with permitting agencies, utilities, railroads, and other third parties simply because it is a daily part of their work, and they have organized themselves to efficiently satisfy these entities *(14)*.

The next four items in Table 2 deal with activities undertaken to keep the project on budget throughout the design phase or to bring it back into budget if it strays. This requires a spirit of collaboration and partnering that can be enhanced through clear direction to the designer in its contract. The designer produces the design products necessary for the CMR to undertake the different types of reviews it is required to do in its preconstruction services contract and the design contract specifies the schedule on

which these are to be complete. These range from purely design reviews to checking constructability or offering possible material substitutions based on a market survey to administrative reviews of biddability. This clause is typically linked with a compatible clause in the CMR's preconstruction services contract so that the contractual requirement to "work friendly" runs both directions. Often the budget review points are scheduled to fall at the same time as the design milestones. The purpose of both of these clauses is to impose a scheduling discipline on both the designer and the CMR. Often the CMR is assigned the responsibility to establish the preconstruction sequence of work for the team and identify opportunities to reduce risk by locking in material and subcontractor pricing through early work package awards (UDOT and Memphis case studies). Thus, the budget review points may be better set to fall after the pricing is fixed. This then allows the team to evaluate its impact on the project's contingency pool and invoke value engineering if necessary or release pricing contingency to the owner to enhance the project's design.

The remaining design contract modifications in Table 2 are essentially "work friendly" clauses that seek to codify the behavior of the design consultant in a manner that makes it a contributing rather than reluctant member of the CMR project delivery team. The Oregon DOT interviewee stated "I want them [the engineer and the CMR] to be friends but not close friends. Creative tension between the two enhances the project's quality." The Memphis case study found that the consultant initially viewed the CMR reviews as unwelcome and unnecessary interference by an unqualified entity and as a result, was less than cooperative in facilitating design and constructability reviews by the CMR. The agency modified the design contract for the next phase of the project to put 10% of the design fee at risk for the final quality of the construction documents (5% for design quality and 5% for construction issues due to design quality problems) as well as codified design milestones, budget review points, a requirement to coordinate the design work with the construction work packages, and mandated joint coordination with third parties. This created a different environment where the consultant saw the CMR reviews as another layer of design quality control and the cooperation required to successfully complete the CMR project happened. A portion of the CMR design contract design quality clause is as follows:

> "The 'Milestone QA' services will be earned following each milestone submittal for the construction documents. The value of the 'Milestone QA' is set at five percent (5%) of the lump sum design fee for each Task [design package] … The 'Milestone QA' … will not be payable until the written review comments on each milestone submittal have been resolved by the ENGINEER following the guidelines in the Quality Assurance Plan. The amount of the invoice that is approved for payment will be based on the … thoroughness of the ENGINEER's responses [to review comments] and the effective resolution of the review comments." (Memphis Case study)

A similar clause is included that rates the outcome and resolution of construction problems, such as change orders and delays that result from poor design quality control. Memphis has since adopted this clause for all its CMR projects and believes its real value is not in the penalty it imposes on the designer but on the collaboration that it encourages between designer and builder. This arrangement creates pain and gain for both parties and an incentive to mutually contribute to the design quality control program. A good example of a CMR design contract clause that is designed to require mutual collaboration is used by Arizona State University. The cogent aspect of this clause is the way it includes the CMR's product as a part of the designer's product and asks the designer and builder to present the design submission as a joint product.

> "The Design Professional shall submit to the Owner all required Design Submission Documents to describe the Project's essential elements….. The CMAR shall submit to the Owner detailed Construction Cost Estimates *as part of each design submission*. At the time of each scheduled submission, the CMAR, Design Professional and Owner shall meet and confer about the submission. During the meeting, *the CMAR and Design Professional* shall identify, among other things, the evolution of the design and any significant changes or deviations from previously submitted Design Submission Documents and any changes in the CMAR's Construction Cost Estimate." *(15)*.

The Utah DOT uses the concept for identifying the amount of required design effort as an "appropriate design." UDOT's definition of design appropriateness is one that is taken to a point where the CMR can confidently generate a GMP. To achieve this requires the CMR to be heavily involved in the design process and again highlights the need for rich collaboration. Essentially, UDOT asks the CMR to track design progress and literally tell the designer when it has enough design detail to adequately develop subcontractor bid packages and to be able to commit to a GMP for a given feature of work. UDOT also

uses a progressive GMP to further facilitate this process and allow the department to negotiate the allocation of risks on a package by package basis before the final GMP is established.

DESIGN COST IMPACT

The first question most upper managers in transportation agencies ask when considering a change to their procurement program is: How much is it going to cost? CMR project delivery adds a fee for preconstruction services. The case study interviews and literature indicated that those services reaped savings in both design and construction costs. One of the commonly cited advantages of CMR is the reduced design cost. This is confirmed by project owners interviewed during this study. A UDOT progress report on its CMR program described the reasons it was paying less for design like this:

> "The CMGC process has reduced the schedule for most projects. Part of the reason for this is the time saved in the design effort. The contractor's participation helps to identify solutions quickly and speeds up the design process. Their participation also reduces the detail that must be communicated to the contractor in drawings and specifications" *(6)*.

The interview with UDOT indicated that since the 2007 report that the trend of design cost savings continued and appeared to be around 40% savings to date.

CONCLUSIONS

The primary conclusion is that preconstruction services received in a CMR project are a distinct benefit to the project's cost, schedule, and ultimate quality. "The City of Portland reported that the contractor's early involvement with design review, value engineering, and risk analysis prior to design completion contributed to significant cost and schedule savings on the West Willamette River project" *(16)*. UDOT expressed the same sentiment in its report: "The CMGC process gives the contractor more time to understand and improve the design and to learn new construction methods not used before. Constructability is continuously reviewed in the design phase so the design is optimized for construction and project costs are reduced. The contractor is able to inform the team what construction methods would simplify construction and reduce cost and schedule" *(6)*.

To capture this benefit, agencies must modify their standard DBB design contract to make it compatible with the preconstruction services contemplated in a project delivered using CMR. Both the designer and the CMR should have "work friendly" clauses in their contracts. The Memphis case study solution not only created an enforceable contractual framework for collaboration but it also created an incentive for the designer to actively collaborate with the constructor for the benefit of the project. Open collaboration does not automatically occur because the agency has selected CMR project delivery. Collaboration must be "engineered" into the preconstruction service process through carefully written contracts for both the designer and the builder.

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