ATINER CONFERENCE PRESENTATION SERIES No: CIV2018-0089

ATINER's Conference Paper Proceedings Series
CIV2018-0089
Athens, 12 September 2018

Best Practices for the Design Process for the Construction-Manager-as-General-Contractor Delivery System

Edward Minchin, Giovanni Migliaccio, Lourdes Ptschelinzew, Yuanxin Zhang, K. E. Atkins & G. A. Hostetler

Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10683 Athens, Greece

ATINER's Conference Paper Proceedings Series
CIV2018-0089
Athens, 12 September 2018
ISSN: 2529-167X

Edward Minchin, Professor and Interim Associate Director, M.E. Rinker School of Construction Management, University of Florida, USA
Giovanni Migliaccio, Associate Professor, University of Washington, USA
Lourdes Ptschelinzew, Graduate Research Assistant, University of Florida, USA
Yuanxin Zhang, Assistant Professor, Guangzhou University, China
K. E. Atkins, CEO, Strategic Solutions Partners, LLP, USA
G. A. Hostetler, Senior Vice President, Infrastructure Engineers, Inc., USA

Best Practices for the Design Process for the Construction-Manager-as-General-Contractor Delivery System

ABSTRACT

In the 1990s, the American public began insisting that planned highway and bridge projects be completed quicker than possible using the Design-Bid-Build (DBB) construction project delivery system, which had dominated the US industry since the 1930s. This led state Departments of Transportation (DOTs) to look into fast-track methods of construction. The Intermodal Surface Transportation Efficiency Act, passed by the US Congress in 1991, established, among other things, Special Experimental Projects Program 14. This allowed DOTs, which had previously used state funds for fast-track highway and bridge construction to apply for federal funding for construction projects using the Design-Build (D-B) delivery system. The D-B system has proven to be very effective and popular; however, that delivery system is not without its downsides. Many design professionals are uncomfortable being subservient to the contractor instead of their traditional position under the owner. Some owners complain about the lack of control over the design process that they experience with DBB. These and other problems have, once again, caused public transportation agencies to search for another delivery system that might mitigate or eliminate those concerns while providing many of the advantages of D-B. Early in this millennium, a solution was offered in the form of Construction-Manager-as-General-Contractor (CM/GC), a fast-track system that allows, and most often compels, the Construction Manager to self-perform a portion of the work. As D-B and CM/GC evolve, it is obvious that the Design-Builder and the CM are both faced with challenges related to managing the design portion of their duties in these fast-track contracts. Design

Management has become such a challenge that the National Cooperative Highway Research Program sponsored a research project that delivered a guidebook to help DOTs handle the DM challenges when delivering transportation construction projects via the D-B or CM/GC delivery methods. This paper gives the highlights of the CM/GC portion of the research.

Keywords: Construction Manager, Design-Build, Delivery Systems, Design Management, Integrated Project Delivery.

Introduction

For over 50 years, the Design-Bid-Build (DBB) delivery system was practically the exclusive delivery system utilized by state Departments of Transportation (DOTs) to bring about the construction of highways and bridges in the US. By the 1990s, however, the pace of life had become too fast, and the travelling public too impatient, for the exclusive use of DBB. Drivers and taxpayers demanded that highway and bridge projects be delivered quicker, and the politicians sent the DOTs in search of a better way to delivery their projects.

The Intermodal Surface Transportation Efficiency Act (ISTEA), passed by the US Congress in 1991, established, among other things, Special Experimental Projects Program 14 (SEP-14). SEP-14 made it possible for DOTs to apply for federal funding for construction projects using a fast-track, integrated project delivery system long popular in the building construction industry called the Design-Build (D-B) (ISTEA 1991). The system was called "fast-track" because portions of a project designed first could be under construction while other portions of the project were still being designed. This decreased the amount of time between conception and operation, sometimes by substantial measures. The process was called "integrated" because the contractor, long shut out of the design process, was given a seat at the table, so to speak, in the design of a project. Theoretically, the contractor's involvement in the design would bring expertise and innovation long missing in the process.

The D-B system has proven to be very effective and popular, with forty-two state DOTs and numerous county and municipal transportation agencies now using the system. However, D-B has its own set of challenges. After years of currying the favor of owners, many design professionals (DPs) are uncomfortable being subservient to the contractor instead of the owner. Some owners complain about the lack of control over the design process that they experience with DBB, while some contractors denounce attempts by some owners to interfere with the design process. This has, once again, caused public transportation agencies to search for another delivery system that might mitigate or eliminate those concerns while providing many of the advantages of both D-B and DBB.

The Construction-Manager-at-Risk (CMR) delivery system offers a direct contractual relationship between the owner and the DP, which solves both problems. However, CMR has not achieved the popularity of D-B, mainly because contractors do not trust a system that forbids them from performing work themselves, as some agencies prefer, or that forced them to bid against a list of qualified subcontractors for any work that they wanted to self-perform, as called for by other agencies.

Another option was offered by CM/GC, a system modeled after CMR except that it allows, or in most cases compels, the construction manager (CM) to self-perform a portion of the work. This mollified the contractor groups somewhat and, along with the FHWA's Every Day Counts (EDC) initiatives, gave CM/GC a boost in popularity among public transportation agencies.

The US National Cooperative Highway Research Program (NCHRP) sponsored research that produced a guidebook for DOTs to use in establishing their DM processes when using D-B or CM/GC to deliver their highway and bridge construction projects (Minchin et al., 2014). This paper reports on the highlights of the CM/GC portion of this research.

Literature Review

There has been an extensive amount of research done on the comparison of DBB, D-B and, to a lesser extent, CMR and CM/GC - most focusing on the performance of each method in regard to the aspects of cost, time, and quality. Ibbs et al. (2003) used sample case studies to present a result that confirmed one of D-B's key advantages, in that D-B does perform more efficiently with respect to time than DBB.

Doren et al. (2005) discovered valuable statistics regarding CMR. In that study, 35 percent of project owners believed that CMR provided them the "best value", followed by 23 percent for D-B. Yet, the traditional system of delivery (DBB) is employed most frequently. Doren et al.'s research combines data from the areas of vertical and horizontal construction. According to him, government agencies that have experience with an alternative method consider CMR and D-B as the "best-value alternatives". Doren et al. (2005) believe that CMR has the potential to become the leading method of delivery, due to positive experiences reported by so many agencies. This research was conducted before the advent of CM/GC.

Gransberg and Shane (2009) conducted extensive research on the topic of CMR project delivery for highway programs and reported that Utah's DOT (UDOT) has the most experience with this method. At the time the research was conducted, 13 CMR projects had been completed, and 16 projects were in the planning. UDOT confirmed the system's ability to fast-track projects, which can result in the decrease of project cost. States like Alaska, Arizona, Florida, Oregon and Utah all had experience with CMR as the method of delivery on transportation projects at the time of Gransberg and Shane's report (2009). The city of Phoenix has had more than 200 projects completed by CMR (including both vertical and horizontal projects). Local transportation projects in Michigan and Rhode Island were also using the CMR delivery system. Florida used CMR on projects of multiple scales, from minor local projects to a 1.3 billion dollar intermodal center. Alaska tends to use CMR on projects that have a significant portion of vertical component build-in. Even though Oregon's DOT has limited experience with this system, an interstate bridge that was completed by CMR has been a successful project, and they do plan to employ the CMR system in future projects.

Ghavamifar and Touran (2006) investigated all the regulations that had been set in place by states' legislations regarding public transportation projects. Ghavamifar and Touran listed the states that have statutes that address D-B,

CMR, and public/private partnerships. That information has confirmed some of the data that were collected in this research project.

The foundation of the DBB system is the principle of selecting designers according to set qualifications (Brooks Act, 1972) and selecting contractors per competitive sealed bids, with award going to the lowest responsive and responsible bidder, usually based on 100% Plans, Specifications and Estimates (PS&E) (Scott, 2006). Over the decades, this system has provided taxpayers with adequate, safe, and efficient transportation facilities while helping to prevent favoritism in spending public funds. However, DBB did not always provide the best value to the owner for all project circumstances or types.

Mounting pressure to expedite projects while maintaining quality prompted the call for highway agencies to review and evaluate alternative procurement and contracting procedures. DBB was pretty much the exclusive project delivery method in transportation projects in the US from the 1930s until the introduction of D-B. In 1996, the Federal Acquisition Reform Act authorized the use of D-B for federal projects (FARA, 1996), and then in 1998 the Transportation Equity Act for the 21st Century allowed federal funding for DOTs to award D-B contracts if enabling state-level legislation was in place (TEA-21, 1998). Some states subsequently passed new legislation and codes to allow the use of alternative project delivery methods (Minchin et al., 2014).

An obvious drawback to D-B was less agency control over design. Since the single design-builder entity often contracted out the design services, the management of design was substantially different from what DOTs were accustomed to under DBB. Furthermore, the line of communication between DOT and DP had to go through the same design-builder, which was often a contractor or joint venture of contractors and DPs (Minchin and Li, 2011).

These concerns motivated DOTs to seek alternatives to DBB, D-B, and CMR; and CM/GC offered expedited project delivery while allowing the DOT to retain control of design. Previous studies also found that adding CM/GC to a DOT's delivery toolbox provided several benefits (NCHRP, 2009; NCHRP, 2010). CM/GC provides DOTs with a conservative option when D-B and DBB are unable to satisfy contrasting project objectives. As illustrated by UDOT's use of CM/GC, that delivery system was perceived by those who used it as a less radical shift in procurement culture than D-B (NCHRP, 2010), and was used to initiate change in transportation agencies that had not adopted D-B (Alder, 2007).

Exhibiting an integrated team approach, CM/GC applied professional management during the planning, design, and construction of a project. As with DBB, the owner contracts separately for design and construction, but the CM is best retained around the same time as the DP by means of a best-value or qualifications-based selection process (Minchin et al., 2014).

The CM acts as a consultant to the owner during the pre-construction phase through a pre-construction services contract, assisting with constructability reviews, estimates, scheduling, and budgeting in addition to non-standard duties such as helping to secure financing or aiding in the selection of DPs. During the construction phase, the CM is "at risk" and

functions similar to the general contractor on a DBB project (Minchin et al., 2014).

Subcontracts made under CM/GC can be fixed-price, cost reimbursable, or guaranteed maximum price (GMP). When bound to a GMP, a CM/GC's relationship with the owner has changed, as it manages construction costs to keep them below the GMP. Additional design advantages to using CM/GC over D-B, DBB, or both include:

- Early innovation and constructability recommendations
- Significant control over design by the agency
- Fast-tracking early construction components prior to complete design, resulting in time savings
- Earlier, more accurate cost estimate by the designer
- Design accomplished in priority order by construction needs and budget constraints (Alder, 2007; Alder, 2010).

Wisely selecting between implementing a D-B or CM/GC program requires understanding certain general concepts. A change in design philosophy from traditional DBB projects is necessary to successfully implement a D-B or CM/GC program. DOT DM practices must be adjusted to educate the design community while creating and maintaining a collaborative culture among all participants. Under CM/GC, early and continuous value engineering (VE), right-of-way (ROW) phasing, real-time pricing, and accelerated design may require additional education or shifts in responsibility for full project schedule and budget management. Successful implementation also requires a project be broken up into multiple phases to allow for early starts, early product or material procurement, or working around ROW, permitting, or utility relocation challenges (Minchin et al., 2014).

Methodology

The motivation behind the research was that a comprehensive delivery toolbox which includes the CM/GC method would require the utilization of new practices for DM than with DBB or D-B. Once an agency has decided to pursue the implementation of a CM/GC program, there are certain broad concepts that must be understood by all parties involved. Successful implementation of a CM/GC program in many cases requires a significant and aggressive change in the culture and philosophies of the parties involved from that of traditional DBB projects. In terms of DM, the standard design methods, schedules, and plans review stages frequently used in designing DBB projects may prove inadequate or insufficiently accelerated to realize the advantages of this alternative delivery method, making the task more challenging for DPs and agency staff.

Initially, the research team contacted, by telephone, every state DOT in the country (52 including Puerto Rico and the District of Columbia), plus 13 non-

DOT public transportation agencies, and conducted an initial round of phone interviews with the personnel identified by the agency as the individuals most knowledgeable about that agency's design process, as well as experiences with CM/GC. This first round of interviews (Level 1) was performed using a structured questionnaire that included strategic, exploratory questions regarding the agency's recent experience with design services under CM/GC. Most DOTs do not have experience with this system, but an organization potentially may have sound and effective design practices in place that could serve as building blocks for strategies of some value to the final products of this research.

The agencies with the most experience and information to offer were identified and asked to participate in a second round of in-depth interviews (Level 2). Agencies participating in the second round took part in a second telephone interview and were asked additional (supplemental) questions by e-mail. Level 2 participants were asked to provide answers to more in-depth questions, as well as for data from their projects and documents. Eighteen agencies took part in Level 2. From the in-depth questions, critical assessments were made regarding the relative merits of alternative approaches to managing key aspects of the design that affect implementation, project scope, quality, and cost.

The results of these Level 1 and Level 2 surveys guided the selection of case study programs and projects that were selected to provide an in-depth diverse portfolio of sample implementations of DM procedures. Agencies chosen for case studies were visited by one or two team members. During these visits, the team conducted detailed interviews and gathered specific information from various parties, including agency staff and consultants, DPs, and contractors. Between six and 20 individuals were interviewed at each of the 10 programs visited. The Guidebook produced by the research includes synopses of many case studies that were conducted (Minchin et al., 2014).

Findings / Results

The nature of CM/GC contracts especially affects DM. In the scope of this research, the researchers have defined DM as the approach used by agencies to organize and oversee the process of designing the transportation infrastructure. Under CM/GC, the researchers found that it is often impossible to completely separate the design process from the construction process, since the two are more closely intertwined and dependent on one another than in any of the major delivery systems. Therefore, many of the recommendations for organizing DM under CM/GC can be easily considered as actions necessary to successfully implement CM/GC at large.

The most important advantage offered by CM/GC is the innovation possible through the pre-construction services of the contractor in the role of CM. The second-biggest advantage of CM/GC is the flexibility it grants the participants, before and during the project, in assigning risk to the different

parties in the optimum proportions for project success. Everything should be done to retain the CM as early as possible. It is important that the design process enable the team to permit and design the project in small "mini" phases, and that this process be tailored to begin construction early. It is important to educate DPs and contractors that have never worked on CM/GC projects that the culture of CM/GC is different than those of DBB or D-B, and to teach them the CM/GC culture. For CM/GC to work, especially early in the life of a program, complete support from upper management is essential, as is the education of the surrounding counties, municipalities, supplier networks, subcontractors/specialty contractors, permitting agencies and utility companies. Constructability Reviews and VE are considered part of the fee the CM receives for pre-construction services, and therefore an expected part of the normal process, without ever being identified as such.

The research team executed two case studies that focused on UDOT. UDOT has long been the greatest proponent and leading exploiter of the advantages of CM/GC. One of these case studies was on a construction project that used the amazing flexibility afforded by CM/GC to extend a highway project by 17.5 miles just by using the funds saved through that flexibility. In the execution of the Mountain View Corridor (MVC) project, UDOT and their CM/GC team continually shifted risk between the parties in a way that saved millions of dollars–enough to buy the ROW and extend the construction by 17.5 miles. Another case study analyzed the UDOT CM/GC program as a whole. The personnel interviewed for both case studies made the point that UDOT requires "105% plans"–a very intensive design effort, greater than that found on DBB projects so that problems may be avoided in the construction phase, cost estimates can be more accurate, and so that risk may be more accurately allocated. Another case study focused on the "Osceola County Miracle," where the Public Works Director of Osceola County, Florida was faced with a seemingly impossible situation. In that scenario, the new Director was told on his first day in the position that unless he could get seven large highway and bridge projects under construction within one year, he would be terminated. He was inheriting a program that had gotten two such projects underway in the last five years, and everything was at a dead standstill. The Administrator, an author of this paper, was able to meet his deadline by risking everything on the use of a construction project delivery system that he had only heard of–CM/GC. By telling the DPs that he wanted them to work with the CMs to produce only the bare essentials in their designs and work together to ensure success at every stage as the projects progressed, he got nine projects started in that first year; and two more were started in the months that immediately followed, much to the shock of everyone. The outcome of that case study was that an advantage of CM/GC was the reduced design effort necessary, and thus reduced design cost, when using CM/GC, compared to DBB. Could the CM/GC teams in Utah and Florida both be right? Absolutely. And that points again to one of the biggest strengths of CM/GC–its flexibility.

Those were two very different programs, with very different needs that both found what they needed with CM/GC. UDOT was an established

program, a world leader in the use of CM/GC. Contractors, subcontractors, suppliers, local government agencies, permitting agencies and utility companies all understood, accepted and mostly embraced CM/GC there, especially people within UDOT. UDOT's major consideration was cost. Even their striving for proper risk allocation had at its base, cost. They have found that the "105% plans" helps them lower cost by identifying and assigning risk, which helps the process of innovation. Meanwhile, the Osceola County program was brand new. A recently-elected County Commission had hired a new County Manager and handed him a broken highway construction program that had been collecting money for years from a tax increase for the expressed purpose of building roads. They had amassed several years' worth of highway tax money, and a record of starting virtually no highway construction projects. The previous two County Managers had been fired because of this. After the ultimatum from the Commission, the need that this program had was speed - speed in design and speed in starting construction. Every decision was made to meet the goal of getting as many projects started as possible, as quickly as possible. This was accomplished by co-locating all key parties to a contract, doing away with traditional sets of plans and designing the project through a seemingly endless series of meetings of the decision-makers from all the parties, around a large conference table. Their design goal was to produce just enough design for the CM (contractor) to get started and then keep the design process just enough ahead of the construction so as to not slow down the prosecution of the work. CM/GC was just as successful at meeting Osceola County's goal as it was in meeting UDOT's goal.

Thus, the two most important advantages that CM/GC offers over DBB and D-B are related – Innovation and Flexibility. D-B offers more opportunity for innovation than DBB for sure, but not as much as CM/GC. It was through the flexibility to assign and re-assign risks among the parties as the project progressed that allowed the CM/GC team on the MVC project the freedom to use multiple innovations in saving enough millions of dollars to extend their project by 17.5 miles. It was the flexibility to reduce the size and scope of the design package required to get started that allowed the Osceola County CM/GC team to meet the seemingly impossible demands of the County Commissioners and get those 11 projects under contract so quickly; and only through one innovation after another did the projects all come in on time and under budget.

Most advantages of CM/GC are derived from the fact that a CM should be involved in the design and decision-making process early in the project. These include the most important general advantages of 1) Freedom to innovate design and construction practices; 2) Flexibility to allocate risk, and then to reallocate risk, and continue to re-allocate risk throughout the life of the project; 3) Potential for great cost savings through innovation and optimum risk allocation. A comprehensive list of advantages of CM/GC specifically involving design includes the following:

- Innovation and constructability recommendations early in the design phase
- Flexibility in the assignment of risk, reduction of risk and improved project decisions as a result
- Agency retention of substantial control over design
- The DP works to coordinate contract documents to the contractors' needs
- Cost savings by identifying real-time project costs throughout the design process
- Potential for time savings by fast-tracking early components of construction prior to complete design in phased packages
- Rapid adaptability to changing conditions and additional project requirements during design
- Ability for the DP to develop a more accurate cost estimate earlier
- Allowance for the design to be accomplished in the priority order in which the phases are needed for construction and budget constraints
- Close coordination of third-party issues (utilities, ROW, permits, etc.).

Note that the legal status of CM/GC for public construction projects varies from state to state. In some states, it is not legal for public construction projects at all. In other states, it is legal for public construction of vertical facilities, but not for horizontal construction like highways and bridges. In still others, it can be used for all public construction.

Discussion

If the design phase of a CM/GC construction project could be perfectly executed, the construction phase would be completely free of the problems, challenges and difficult decisions so common in a traditional highway construction project, save force majeure, unforeseen conditions, and human error. This statement cannot be made about any other system, and points to the importance of DM under CM/GC. The goal of this section is to help the decision-makers in public transportation agencies establish and apply this unique and effective system in the most ideal way to their specific, individual circumstances, and to make CM/GC a powerful tool in their project delivery toolbox. If some of the methodologies discussed in this section seem unrealistic or unattainable, the agency should strive to follow them as closely as possible. If they do this and have high-quality, competent people that believe in the system and are willing to work diligently to see the system work and the project or program succeed, things are very likely to go well.

Successful use of CM/GC expedites project delivery, while allowing the agency to retain full control of the design; and positioning the DPs where they are most comfortable-directly responsible to the owner. An integrated team approach that applies professional management during the planning, design,

and construction of a project, CM/GC incentivizes innovation to a greater extent than any other delivery system. In fact the system allows for, encourages, and even requires, innovation during the design process.

The core of a CM/GC team consists of the owner, the DP, the CM, the sub-DPs and subcontractors. The CM is best retained about the same time as the DP, typically through a qualifications-based or best-value selection process. Any agency considering using this system must understand that they are trading off a measure of control over the process in favor of speed, innovation and flexibility.

Typically, preconstruction continues until the last work package is approved and released for construction. Of course, by this time the construction phase is well underway. During preconstruction, the CM acts as an advisor, providing professional services to the owner. A CM performs constructability reviews, cost estimates, construction phasing and schedules, and budget recommendations to assist in determining the best options for the owner, based on the project budget. The CM also may perform duties not typically performed by contractors, such as assisting in securing financing, or selecting or helping in the selection of DPs. The CM's greatest contributions during the design phase (and construction phase, for that matter), are to generate and create innovations to better perform work tasks, either from a methods standpoint or through a scheduling or financing standpoint.

Once construction begins, the CM becomes the General Contractor (GC). This phase typically begins when the project team releases its first work package for construction. The CM awards subcontracts in a fixed-price, cost-reimbursable, or GMP contract. When a CM is bound to a GMP, the most fundamental character of the relationship is changed. In addition to acting in the owner's interest, the CM must manage and control construction costs to not exceed the GMP (Migliaccio and Minchin, 2016).

Under CM/GC, the intensity of the design effort shifts from traditional plans production to team project planning–that is, critical design decisions are made during regular meetings with all decision-makers present. Although some agencies demand it, CM/GC projects do not need a fully developed design package, as with DBB projects, or a complex performance specification as with D-B projects. CM/GC creates an environment where the owner, or owner's agent, must be more involved; for instance, CM/GC gives the owner the ability to get what they want from the contractor and price items accordingly. Also, since the parties are co-housed, it is simple to gather the parties together and have an impromptu meeting if something happens on the project that warrants such a step.

If executed properly, CM/GC offers the fastest way for a construction project to progress from conception to completion. It also offers the fastest way to get multiple projects designed and under construction.

Conclusions

Any state transportation agency that cannot legally use CM/GC should work within their legislative process to achieve legislation necessary to legalize its use. Like every other delivery system, it is not the optimum choice for every project; however, it has been shown to be effective on a wide range of projects and in a variety of applications. Several ways of applying the advantageous characteristics of CM/GC will be discussed here.

Standard items under the DP's oversight, such as utility coordination and permitting during design, partially transfer to the CM due to the need to accelerate utility relocations, advance-order long-lead items, and/or have one "point" of responsibility with the utility companies, permitting agencies, etc. These shifts in responsibilities often are needed for the CM to take responsibility for the overall project schedule and budget.

Well thought-out and finely crafted specialized and hybrid contracts—i.e., with the CM, DPs, consultants, etc.—must match perfectly the goals and objectives of the program/project. For best results, the contracts should require aggressive delivery, streamlined plans, innovation-mandatory goal percentages, advanced coordination, sufficient time for production meetings, principal involvement, strict adherence to the schedules and budgets, coordination, etc. Failure to put this language in the contracts will require asking for volunteer participation, which is much more challenging.

When one compares the means and methods of CM/GC to those of other delivery systems, it is easy to grasp the importance of understanding and embracing the culture of CM/GC. For instance, the duties of the design team—such as permitting, project management, utility coordination, overall project schedules, and owner's representative duties—should be handled from the beginning by the whole team. Traditional duties are redistributed among the team, not handed off after the phases are complete. The CM should take over project administration as soon as possible and through construction; while many of the duties that would be led and handled by the DP (such as utility coordination) are redistributed to the team.

Some risk and effort traditionally borne by the DP in the design phase can be lessened or even eliminated through not requiring quantity takeoffs, computation books, and bid summary sheets.

Some or all of these items can now be assigned to the CM as part of the GMP. Making quantities the responsibility of the CM enables the DP to strictly design instead of being concerned with plan matrices, quantity take-offs, etc. This practice also reduces the DP's scope and the cost of design; and converts the design plans to construction plans rather than bid plans. Streamlining the plans and scopes is a key principle in keeping the costs of CM/GC under control, and one of the best ways to do this is to eliminate some activities that are not as necessary as in the past, let the CM handle more of the activities for which they are better positioned to handle, and then not replicate or duplicate effort by having the DP or Construction Engineering and Inspection (CEI) consultant perform some of the same functions.

Please note that some of the details of the process currently outlined are geared toward the program just getting started, or whose over-riding consideration is speed—speed from conception to construction or merely from design to construction. If an agency is more concerned with, say, risk identification, risk balancing, risk allocation, more complete sets of plans may be necessary. UDOT has long used CM/GC to shift risk among CM/GC team members for cost advantage as seen in the MVC project, and they demand extensive plan sets.

Key CM contributions to the design of a CM/GC project include innovation, motivation and a sense of urgency, thus getting utility companies and permitting agencies moving toward project goals. These functions are just as, or even more, valuable than more apparent and acknowledged contributions, such as plans reviews and constructability/biddability reviews. Of course a CM must perform constructability reviews, cost estimates, construction phasing and schedules, and budget recommendations to assist in determining the best options for the owner, based on the project budget; but the sense of urgency that the contractor brings is to be valued by the agency.

Discuss with all stakeholders, prior to kicking off the program, the purpose of CM/GC and the goals and objectives to be met for the project to be considered successful. As appropriate, include in the training / education effort all relevant utility companies, ROW agents, permitting agencies, subcontractors, CEI firms, municipalities, counties and other local governments, owners, internal departments, procurement personnel, contractors, subcontractors, DPs, sub-DPs, law enforcement, citizens' groups, press, surveyors, attorneys, political figures, upper administration, CMs, and (most importantly) internal owner staff, leadership, and subordinates.

It is recommended that the principals of the DPs and all other professional services be required to be present and represent their teams in regular design production meetings; and the process works best if the owner’s senior leadership—i.e., people with binding, decision-making authority—are actively involved in all design production meetings. All PMs and subordinate staff should also be required to attend these meetings, which should be a regular part of the schedule for participants from the beginning of the scoping of the projects to the completion of construction. This requires a tremendous effort and investment for all parties concerned. The costs for these efforts must be made up through innovation produced as a result of the meetings. No one member dominates the team, although the Project Leader facilitates the meetings. Also, it is wise to have a partnering retreat early in the process to introduce each member and build positive relationships. The partnering meetings also can be used to train team members in the nuances unique to CM/GC, such as responsibilities and lines of communication.

Owners must be willing to make a significant investment—more than with any other delivery method—in leading these projects, to ensure success. This is not a passive delivery method for the owner. Ceding control of certain aspects of project management (mostly in the construction phase) to other parties does not equal less involvement. Poor engagement by the owner almost always

leads to poor results. The owner must be the hardest-working member of the team—either actual owner personnel or the owner's assigns, or agent of the owner.

The emphasis on teamwork and the contractor's involvement in the design and decision-making process early in the project is an aspect of CM/GC that brings important benefits. The CM (contractor) can be brought on to the project at any time during the design phase; however, there is a strong consensus that the earlier the better. The earlier the CM is retained, the more time there is to develop synergy with the DP and the rest of the team; and the more time and opportunity to enjoy the most important benefit of CM/GC—innovation. Innovation in project design, traffic control design, the NEPA (National Environmental Policy Act) process, permit application, utility relocation, schedule of activities, ROW acquisition, construction methods and many other items are essential for the most successful execution of a CM/GC project. The CM is the single most important team member as far as innovation is concerned, and every day that the CM is part of the team is a day in which the full team can work toward time- and cost-saving innovations. On the MVC project, for example, the CM saved substantial money and time by eliminating the need to relocate a large set of gas lines traversing the project; and this was just one of the innovations on that project that saved millions of dollars.

The budget can be affected significantly by the CM's arrival if ROW, survey, permits, etc., are just beginning. Bringing in a CM, regardless of the timing, significantly reduces changes, delays, constructability issues, and schedule challenges, while increasing ease of contracting and procurement. Permitting agencies and utility companies almost always respond more favorably and more quickly to a project team's requests and applications after the contractor is on board. These organizations will see the CM as a contractor even though the contractor is still officially serving in a consultant capacity during preconstruction; and experience and research show that permitting agencies and utility companies change their attitude about a project when there is a contractor present. According to the City of Phoenix, suddenly the project that was a "paper project" becomes a real project as soon as the contractor arrives on the scene. The administrators of the Osceola County program inherited projects at every possible stage of development, and observed that changing from DBB to CM/GC and immediately procuring the CM (contractor) improved every project instantly, regardless of its stage of development.

Lost in the amazing story of the project that just kept growing in size (the MVC) is the fact that to grow like that, the project had to experience substantial cost savings. In fact, MVC data show a 27% reduction in expected cost over the design period of the project. This is unheard of on a major highway construction project. In fact, costs generally increase during design. UDOT, in their public release of information has noted this savings in several of their documents. Similarly lost in the amazing story of how the CM/GC program in Osceola County got nine projects designed and under construction in one year was the amount of money that was saved in the process. To save

substantial money, the owner must understand the risk and know how to manage that risk. The owner cannot be totally risk-averse and save money. Risk management and cost savings go hand in hand. Risk management also affects quality and schedule. This is why CM/GC is more work for the owner. It takes more owner knowledge, time, and skill, but it pays big dividends. The owner that has the ability and desire to manage risk gets the reward.

The most successful CM/GC projects are those that take advantage of the most important opportunities offered by the CM/GC delivery system. Only the opportunity for innovation is a bigger advantage than the flexibility to assign and re-assign risk during a project.

"Schedule and budget drive the project, not vice versa"—this principle is critical to controlling costs, as the administrative overhead is most expensive among the three primary delivery methods, and if not controlled will cause the project to fail. Due to the high overhead, the program must be resource-loaded up front, including how many staff to bring on, how many hours they need to work during the project, and when they need to cut back on their hours to meet budgets and staffing requirements. This needs to be understood clearly by all team members to avoid causing any friction due to unmet or colliding expectations. If GMPs are employed, costs of all cumulative GMPs should be calculated as accurately as possible prior to starting early work packages or mini-GMPs.

DPs must budget additional funding and management personnel for frequent team meetings and binding decisions while working with both the owner and contractor (CM). DPs that have not worked within CM/GC before probably will need to be educated in the process of receiving real-time input from the constructor as well as being flexible in modifying standard items such as traffic control plans to best fit the chosen approach to construction.

Once the project budgets have been determined, require the professionals to agree to them—i.e., design fees, CM fees, CEI fees, geotechnical fees, survey fees, overhead, and construction costs as well, as the overall project budget and schedules should be specifically broken into design, construction, survey, permitting, and ROW. Identify clearly all targets. For the project to succeed, costs cannot exceed the agreed-upon budget for all GMPs combined, regardless of the circumstances and problems encountered. If total project costs ever exceed the agreed-upon budget for all GMPs combined, it sets a very dangerous precedent for the program.

References

Alder, R. UDOT Construction Manager General Contract (CMGC) Annual Report 2007, Salt Lake City, UT, 2007.

Alder, R. Construction Manager General Contract Utah Annual Report 2009, Salt Lake City, UT, 2010.

Brooks Act. Pub L. No. 92-582. 40 U.S.C. § 11101 (1972).

Doren, D., M. Bridgers, and M. Napier. FMI/CMAA Sixth Annual Survey of Owners, Construction Management Association of America, McLean, Va. 2005.

Federal Acquisition Reform Act of 1996 (FARA). Pub L. No.104-106. Div. D (1996).

Ghavamifar, K., A. Touran. "Alternative Project Delivery Systems: Application and Legal Limits in Transportation Projects," Journal of Professional Issues in Engineering Education and Practice, ASCE, 2006.

Gransberg, D. D., Shane, J. S., "Construction Manager-at-Risk for Highway Construction Programs," NCHRP Synthesis 402; Washington, DC, 2009.

Ibbs, C. W., Y. Kwak, and A. Odabasi. "Project Delivery System and Project Changes: A Quantitative Analysis," Journal of Construction Engineering and Management, ASCE, Vol. 129, No.4, 2003, pp. 382-387.

Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Pub L. No. 102-240 (1991).

Migliaccio, G. C. and Minchin, R. E. Editors: Jefferies M.C. and Rowlinson, S. *New Forms of Procurement: Public Private Partnerships and Relational Contracting in the 21st Century*, Chapter 6, "Design Management of Infrastructure Projects: A Comparative Case Study Analysis of Design-Build and Construction Manager / General Contractor Projects in the US"; Routledge/Taylor and Francis; 2016; pp. 95-116.

Minchin, R. E., Li, X. X. Performance of Construction Manager-at-Risk for Highway and Bridge Projects in the Southeastern United States, Balfour Beatty Research Report No. 1, Miami, FL, November, 2011.

Minchin, R. E., Migliaccio, G. C., Atkins, K., Warne, T., Gatti, U. (g) Ptschelinzew, L.(g) Hostetler, G., Asiamah, S. "Design Management Guide for Design-Build and Construction-Manager-as- General-Contractor Projects", Transportation Research Board of the National Academies, Washington, DC; 2014, ISBN978-0-309-30805-2.

National Cooperative Highway Research Program (NCHRP). (2009). NCHRP Project 20-68A, Scan 07-01: Best Practices in Project Delivery Management. Washington, DC.

National Cooperative Highway Research Program (NCHRP). (2010). Synthesis 402: Construction Manager-at-Risk Project Delivery for Highway Programs. Washington, DC.

Scott, S., III, NCHRP Report No. 561: Best-Value Procurement Methods for Highway Construction Projects, TRB, Washington, DC, 2006.

Transportation Equity Act for the 21st Century (TEA-21). Pub L. No.195-178 (1998).