

CMGC Process Report – Phase II
For
I-215; 4500 South Bridge Replacement
F-I215(126)13
Salt Lake City, Utah

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For

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Purpose

In accordance with the Memorandum of Understanding SEP 14 (MOU) for Alternative Contracting Process, the CMGC Phase II report is to address the following issues from Section 4.1:

- Discuss the evaluation criteria applicable to the project.
- A special focus of the innovations used and an analysis of the savings.
- Provide a comparative analysis between the project final cost and the Independent Cost Estimate (ICE).
- Provide project data that will aid in the formulation of the Annual Report of all projects to be submitted to FHWA.

Evaluation criteria as outlined in the MOU are as follows:

- A. Design and Constructability
- B. Innovation
- C. Project Schedule
- D. Risk
- E. Learning opportunities
- F. Environmental Stewardship
- G. Benefit to the Public

Furthermore, the Utah Department of Transportation (UDOT) has outlined additional information that is required in this report for internal evaluation. This information includes a discussion of change orders, a comparison of overruns and under runs, comparison of advertising date vs. the signed construction contract date, explanation of extensions of project scope.

This report focuses on the implementation of the CMGC process to the I-215; 4500 South Bridge Replacement; Salt Lake County project number F-I215(126)13, located in UDOT Region 2 area. This project constitutes the “bridge project” for this region in accordance with the Process (Section 3) of the MOU.

Project Overview

Located near Holladay, Utah, the project was to completely replace the 4500 South bridge over I-215. To minimize impacts to the public, the bridge deck was constructed completely outside of

the roadway, limiting impacts to drivers and reducing user costs. The bridge was constructed completely outside of the roadway, limiting impacts to drivers and reducing user costs. The bridge was moved into place in one weekend using Self Propelled Modular Transports (SPMT). The roadway impacts for a typical reconstruction process would have been approximately six months. Instead, the impacts were reduced to two and a half days.

UDOT contracted with Michael Baker Jr. Engineers in November 2006 to provide engineering services. Ralph L. Wadsworth Construction was selected as the contractor for both the design and construction phases. For the Independent Cost Estimation (ICE), UDOT contracted with Stanton Constructability Services.

This project began in early spring with the goal of completion by the end of the construction season. Soon after the designer and contractor were hired, a date for moving the bridge into place was set for late October. The CMGC process was critical for meeting this schedule because the contractor was able to begin construction and procurement activities before design was complete.

Construction Costs

The programmed budget for this project by UDOT was \$6,600,000.00. The total construction costs before accounting for overruns came to \$7,298,790.12. In order to meet the short timeline, the construction was broken into two phases. The contractor began phase 1 within one month of getting under contract. Phase 1 entailed procurement of the steel girders, and construction of the substructure. Phase 2 included the construction of the superstructure, moving the bridge into place, and demolition of the old bridge. Table 1 shows a summary of construction costs.

TABLE 1 – Total Project Construction Cost

Contract Amounts	Engineer's Estimate (EE)	Independent Cost Estimate (ICE)	Awarded Bid	% of EE	% of ICE
Programmed Amount: \$6,600,000.00					
Original Contract	\$4,036,311	\$3,984,584	\$3,995,048	-1.02%	+0.26%
Change Order 1	\$2,636,201	\$2,709,995	\$2,710,361	+2.81%	<1%
Change Order 2			\$570,440		
Change Order 3			\$22,940		
Total	\$6,672,512	\$6,694,580	\$7,298,790	+9.39%	+9.02%

Change order 1 was anticipated, and constituted phase 2 of the project. Because the change order was anticipated, and constituted a substantial portion of the construction, the bid process was followed for change order 1.

Project Goals

UDOT developed the following goals for this project:

- Replace the structure
- Minimize environmental and community impacts
- Prove that Accelerated Bridge Construction is a cost-effective solution (even with difficult geometric constraints)
- Make the best use of available funding

UDOT recognized that achieving the project goals required that the Contractor work closely with the design team during the design phase.

Applicability of the CMGC Process

In accordance with the original MOU between UDOT and FHWA, each project selected for the CMGC contracting process must evaluate how the criteria for selection were impacted by the project. It is important to note that in accordance with the MOU, additional characteristics that make the project a good candidate for the CMGC process can be justified by UDOT. The justification report indicated that this project was justified by the following criteria as outlined in the MOU: Constructability, Innovation, Project Schedule, and Learning Opportunities.

After the completion of construction, personal interviews with the project managers of each discipline were conducted to determine the effectiveness of the CMGC process. Persons interviewed included Lisa Wilson from UDOT, Wayne Bowden from Ralph L. Wadsworth Construction, and Michael Arens from the Michael Baker Corporation.

Design and Constructability

This project presented several design and constructability challenges, including:

- Schedule: need to design and construct the bridge in 8 months, then remove old bridge, and install new one in 58 hours.
- Grade issues: 4500 South is on a steep grade east/west and had varying cross slopes on the abutments.

- Abutments, including building the abutments with the old bridge in place, retaining the existing abutments, and designing and constructing temporary abutments for the new superstructure.
- Removing the old bridge and moving the new bridge into place in one weekend: this was the first time that UDOT had use the Self Propelled Modular Transporters (SPMTs)

A discussion of each of these issues and what was realized during construction is presented.

Confined Schedule

The use of the CMGC process allowed UDOT to benefit from the efficiencies of completing the bridge reconstruction in one construction season. Brining the contractor on board at the beginning of the project allowed for construction on the abutments simultaneously with the bridge deck design. In addition, UDOT was able to use the contractor to perform early procurement on the steel girders.

Grade Issues

Because the new bridge was constructed off site, then moved into place, it was critical that the bridge not only have the right dimensions, but that the slope and cross slope match perfectly. Some of the grade issues include: five percent elevation difference between the east and west ends, and twelve percent grade on 4500 South with varying cross slope, and four percent grade on I-215 with a two percent cross slope. Using the CMGC process encouraged dialogue and innovation in addressing these issues and assisted in the communication with the surveyors on the numerous checks and rechecks of their calculations. Figure 1 provides a perspective of the challenging grade issues.



Figure 1 Presence of Steep Grades

Abutments

Four sets of abutments were dealt with on this project: the abutments holding the old bridge in place, the permanent abutments constructed for the new bridge, and the temporary abutments for the construction of the new bridge and the removal of the old bridge. The following bullets describe the challenges associated with these abutments:

- Old abutments- needed to function in safe and proper order while the new abutments were being constructed around them.
- New abutments- needed to be built around the old abutments, which were still supporting the old bridge superstructure, which was still in use.
- Temporary abutments for the new and old structures- these abutments needed to be cost-effective, easy to construct and tear down, and have the ability to be transported

The constructability reviews from the contractor were invaluable in the design of these abutments. The contractor worked closely with the designer engineers to collaborate on what

could and could not be reasonably done with each of these abutments. Figures 2 and 3 illustrate the temporary and permanent abutments.



Figure 2 Construction of New Abutments Underneath Existing Structure



Figure 3 Temporary Abutments

Moving the Bridges

Because UDOT had never used SPMTs before, there were minimal protocols and precedents in place on the logistics of this process. The general contractor assisted in communications with the SPMT contractor to develop plans to execute the moving of the bridges in a safe and efficient manner.

Innovative Process

The concept of replacing a bridge in one weekend is an innovative idea which required the use of numerous smaller innovations to make it possible.

Innovation Used

This project incorporated the following innovations:

- Construction of new bridge abutments around the existing abutments
- Construction of temporary abutments to hold the new bridge deck while under construction and the removal and demolition of the old deck
- Use of empty cargo containers in temporary abutments
- Use of SPMTs
- Beginning the construction of the new abutments while the superstructure design was still underway
- Early procurement of steel girders

The entire project team worked together closely to develop and implement these innovations.

Impact to Schedule

This project began in spring of 2007, and construction was complete by November 2007, with a total project design and construction time of eight months – one construction season. Under a design-bid-build process, the design would have lasted until fall 2007, and preliminary construction could have begun in late fall 2007. The construction would have been complete in late summer/early fall of 2008, rather than November 2007. The result would have been a design and construction schedule of 16 to 20 months. The construction schedule was cut approximately in half.

Impact to Quality

There was no significant enhancement to quality of the final product as compared to if the bridge had been built using a different process.

Benefit to Public

The use of accelerated bridge construction (ABC) allowed for replacing the bridge in 58 hours, rather than impacting traffic for months. Using daily traffic volumes on 4500 South and I-215 from UDOT 2007 data, and assuming a user cost of \$15 per hour, the savings in user cost of using the accelerated bridge construction was more than \$40 million.

Project Schedule

Soon after initiation of the project, the date was chosen to move the bridge into place. The team chose late October, at the tail end of the construction season as the move date. Because this was the first accelerated bridge construction project in the state, and one of the first in the nation, the project drew a great deal of publicity and national attention. Once the date was set, numerous dignitaries and leaders set travel plans to be in attendance during the weekend of the bridge replacement. As a result of the desire to finish the project in one construction season, combined with numerous dignitaries planning their schedules around the move date, there was minimal flexibility in the schedule.

Because to the compressed schedule, the contractor was brought in at the beginning of design, rather than at 30% design. Within one week, the contractor had begun the procurement process for the steel girders, and within one month, the contractor began construction on the bridge substructure. Because construction was underway while the engineers were still working on the design of the superstructure, the team members said that the project had a similar feel to a design-build project. However, because of the CMGC process, UDOT had the benefit of being intimately involved in the decision making, which would not have been possible in design build (from interviews with Mike Arens at Baker and Lisa Wilson, UDOT PM).

Figure 4 illustrates the project schedule through both design and construction.

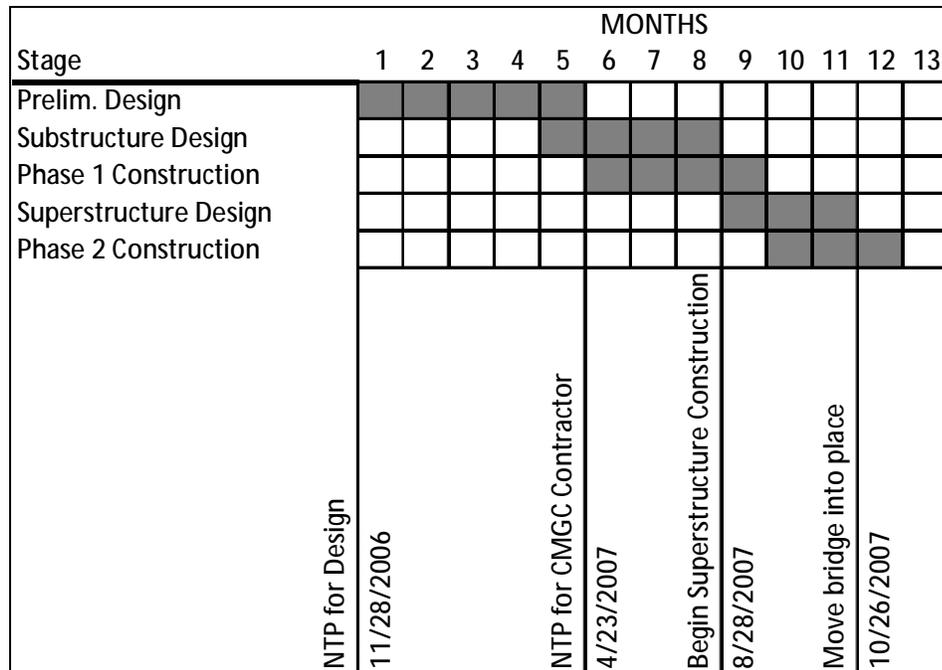


Figure 4 Project Schedule

Risk

Risks that were identified during the construction period included the following:

- Meeting the completion deadline
- Ensuring that the new bridge fit perfectly onto the abutments
- Safety
- Use of self propelled modular transporters (SPMTs) for the first time as a department
- Construction of temporary abutments

Because this was the first project of its kind, and because the contractor was brought on so early in the process, it was difficult to quantify the risk reduction because of the lack of a comparison case. However, there was a consensus among the UDOT project manager and the designer that without the contractor’s early involvement, they would not have been able to meet the constrained schedule, and that construction of the abutments would have been hampered with delays and cost escalation

Learning Opportunities

At the onset of this project, UDOT identified the following learning opportunities:

- Development and implementation of accelerated bridge construction (ABC)

- Use of SPMTs for the first time as a department

Throughout this project, UDOT, the design engineers, and the contractor all had the opportunity to learn from each other and set the precedence for the numerous other ABC projects that have followed.

Budget Analysis

Figure 5 below illustrates the costs through the development of the project, including change orders. The original programmed budget was \$6,600,000. The final project cost was \$7,504,596, including all change orders and overruns. The additional costs can be attributed to the fact that this was a showcase project with technologies which UDOT had never used before, and thus were challenging to estimate during the programming phase of the project. In addition, an area was graded, fenced, and re-landscaped to accommodate spectators and dignitaries. These costs are not typically associated with a construction project.

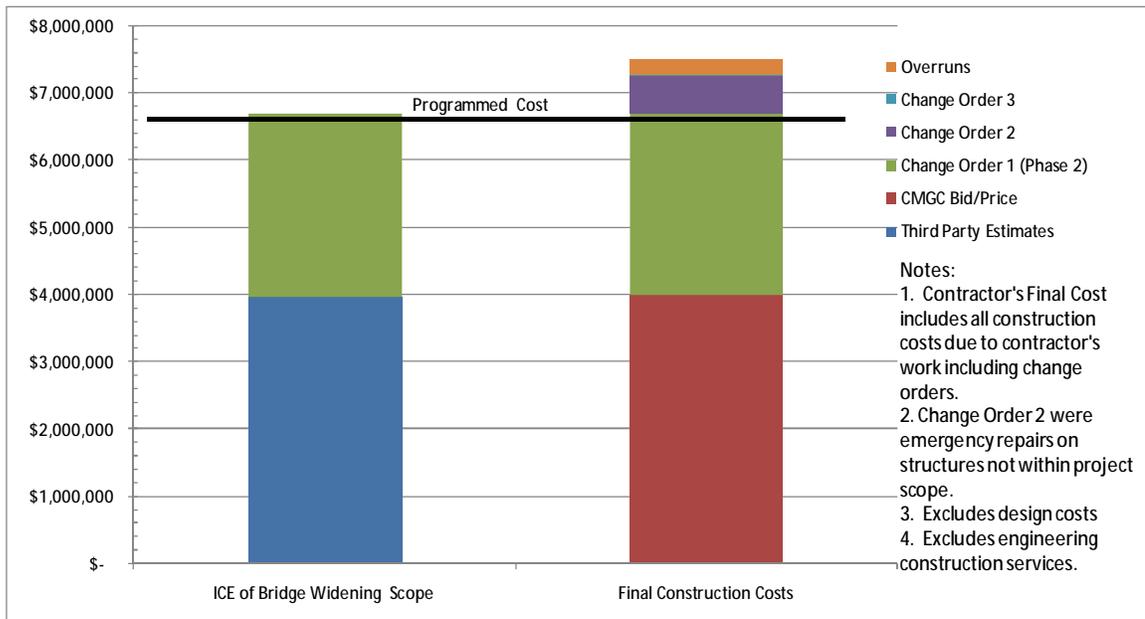


Figure 5 Construction Bid/Costs Comparison

Contractor’s Influence to Cost Control

The contractor played an important role during construction identifying risk and mitigating risks throughout the project. Specific areas where contractor involvement reduced costs include the development for a methodology for building new abutments underneath the existing abutments, and the use of empty cargo containers in the construction of temporary abutments.

Were Contractor's Prices Fair and Reasonable

All contract changes and Early Material Procurement (EMP) bid prices were compared with an Engineer's Estimate (EE) and an Independent Cost Estimate (ICE). For the original bid, the prices were remarkably similar indicating that the prices were reasonable for the work performed. Early procurement prices ranged significantly between the EE and ICE. With negotiated bid processes affordability is always questioned.

In order to uniformly evaluate pricing of CMGC projects the UDOT developed a ratio of comparison for project bid prices and change orders to the "Total Anticipated Cost of Project". This ration is called Ratio of Project Cost and is represented from the equation shown in Equation 1 below. For a complete discussion of the evaluation process and development of the associated equation please refer to Appendix B of this report:

$$R_{PC} = \frac{\left(1 + \frac{C_{O1}}{B_1}\right)}{R_{SB}(R_{CO} + 1)}$$

Equation 1 – Ratio of Project Cost to Allowable Cost

Where:

- C_{O1} = The sum of the unplanned change orders. These are change orders that were unforeseen at the time of design and resulted in added prices during construction (dollar value). \$593,380.29
- B_1 = The original base bid total, including any early procurement bidding (dollar value). \$6,705,409.83
- R_{SB} = Ratio of the State Average Price total to the Bid Price total using the same quantities that were outlined in the bid and using the state average unit prices for the year of the project, and the bid unit prices respectively. 1.401
- R_{CO} = State wide 10 year percentage rate of total change orders to bid costs for all projects from 1999 to 2008. Currently 0.0998

A value of R_{PC} above 1 suggests that the project was overpriced when compared to state average pricing data. Values under 1 suggest that the contractor's prices were fair and reasonable. The R_{PC} for this project was 0.71, suggesting that the contractor's prices were fair and reasonable.

Change Orders

Table 2 shows a breakdown of the change orders from this project.

TABLE 2 – CHANGE ORDER COST IMPACT

Ralph L. Wadsworth Construction Original Contract = \$3,995,048.48			
C.O. Number	Description	C.O. Cost	Current Contract
1	Phase 2: Bridge Construction	\$2,710,361.35	\$6,705,409.83
2	Temp. Demo Site, Asbestos Cleanup	\$570,440.29	\$7,275,850.12
3	Delineator, Ped Ramps, Drainage	\$22,940.00	\$7,298,790.12
Total		\$3,303,741.64	
Total Unanticipated		\$593,380.29	

Change order 1 was anticipated, and constituted phase 2 of the project. Because the change order was anticipated, and constituted a substantial portion of the construction, the bid process was followed for change order 1. Change orders 2 and 3 covered some unexpected issues that arose, including:

- The need to clear, grade, and fence an area for spectators to watch the bridge move.
- Removal of asbestos waste which was found during construction.
- Additional construction for pedestrian ramps, delineators, and drainage.
- Moving the temporary demolition site away from overhead power lines.
- Removal of asbestos waste which was found during construction.

In total, unexpected change orders cost \$593,380.29, accounting for approximately 8.1% of the total construction costs. The designers believe that they would have been able to work out nearly all of the risks, and therefore the change orders if there was more time allotted to design.

Reduction of Change Orders Due to Contractor’s Design Influence

The contractor provided design input on use of the SPMTs, construction of the temporary and permanent abutments, and general constructability reviews. Because to the high risk from the unknowns involved with the abutments and bridge moving, the designers felt that the likelihood of numerous change orders without contractor involvement would have been high.

Analysis of Performance Measures

Overruns and Underruns

The total project overruns for this project were \$205,806.22, which accounts for approximately 2.7% of the construction costs. These overruns were for:

- Steel
- Granular Borrow for Backfill
- Topsoil
- Broadcast seed

Because this project was the first of its kind, numerous spectators and dignitaries watched the bridge move from a nearby embankment. The project covered the majority of the costs associated with accommodating the crowds, including grading and re-landscaping the area. In addition, there were underruns for pavement markings and a concrete lines ditch that was shorter than expected.

Cost Comparison of ICE and Final Cost

The total construction cost including change orders and overruns was \$7,504,596.34. The combined ICE project for phase 1 and 2 was \$6,694,579.25. Not including change orders and overruns, the cost would have been \$6,705,409.83, which was approximately 0.2% higher than the ICE.

Lessons Learned

The following is a list of some of the lessons learned in this project:

- This project was successful because the contractor was very involved and engaged early on. Although not the case in this project, contractors have a tendency to not “scour” the design until they’re getting ready to bid/construct, and by then it is too late to make significant changes. The key to success is to push the contractor to be thoroughly engaged in preliminary reviews (Mike Arens).
- UDOT will often use CMGC as a way to accelerate design, but this acceleration increases risk, which will be demonstrated in the bids. If you use CMGC in a normal schedule, you can work more of the risks out of the plans prior to bid. You can’t have it both ways (Mike Arens).

- Never have the end date set before starting the project. A constrained schedule drives up costs (Lisa Wilson).
- We were able to learn some interesting new technology that has been used elsewhere. This project verified that this new technology really does work and that it's a benefit to the public (Wayne Bowden).

Conclusion

This project involved a new technology, high risks, and a compressed schedule. By bringing the contractor on early, UDOT and the designer were able to ground truth ideas and plans, procure materials early, reduce risk, brainstorm approaches to challenges, and improve constructability. Using CMGC allowed for reducing the project time by an entire construction season. All of the major players involved in this project agree that CMGC was crucial in the success of this project.

APPENDIX A – Personal Interview Notes

CMGC Interview Questions

UDOT Project Manager- Lisa Wilson

Project Description: I-215/4500 South bridge reconstruction

Pin: 4752

Project Phase: Phase 2

Constructability

<p>How was constructability improved by involvement of the contractor in design?</p>	<ul style="list-style-type: none"> • Having the contractor on board early was a “huge benefit” due to the unique nature of the project and the newness of the technology. It was essential to have the general contractor and the SPMT contractor involved in design (Mike Arens). • The contractor was pulled in at the very beginning of design, so the design was tailored around what the contractor could build. The general contractor was key in the communication with the SPMT contractor (Lisa Wilson). • We helped with the development of “how and where” to do construction, ensuring machine availability, and coordinated on constructing around the existing bridges. None of this was confirmed until we were brought on board (Wayne Bowden).
<p>How did constructability ideas introduced by the contractor in the design process get incorporated in the field?</p>	<ul style="list-style-type: none"> • Weekly constructability meetings were held. The contractor reviewed the design and looked for issues. Particular areas where they provided critical input was on the temporary abutments and the constructability of new abutments under the bridge. In addition, the SPMT contractor assisted in designing the travel path and in the logistics (Mike Arens). • All of the decisions were made with the contractor there, which made for a good transition for implementation in the field (Lisa Wilson). • Ideas presented in the design were incorporated ‘real well’ in the field. It helped to have a good relationship with the

	designer (Wayne Bowden).
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Project Schedule

<p>Was the construction schedule shortened by the design effort? By how much?</p>	<ul style="list-style-type: none"> • The schedule was probably cut in half, and felt almost like a design build atmosphere because the contractor was building abutments while Baker was still designing the superstructure (Mike Arens). • CMGC probably shortened the project (as a whole) by as much as a construction season (Lisa Wilson). • The project was shortened by 9 months (Wayne Bowden).
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Risk

<p>How did the team identify, evaluate, and track project risk?</p>	<ul style="list-style-type: none"> • While the risks weren't formally documented, there was a constant dialogue concerning risk. Risk was discussed at the team meetings, and for the final 1-2 months, weekly meetings were held with Jim M and Carlos B to strategize on risk reduction and mitigation (Mike Arens). • There was an open discussion of risks as the project went on. The contractor kept track of risks and contingency plans. This list was quite long by the time they were ready to move the bridge (Lisa Wilson).
<p>Which contractor suggestions helped you to reduce risk and control cost?</p>	<ul style="list-style-type: none"> • The contractor provided ideas for building the new abutments underneath the existing abutments and with the temporary abutment structures. The SPMT contractor assisted in the optimal use and configuration of SPMT equipment. Having these contributions early on reduced risk during construction (Mike Arens). • The individual cost and risk savings were hard to quantify since the contractor was so integrated in the design from the start (Lisa Wilson). • Letting out the construction in smaller design packages allowed for each one to be more complete and with fewer contingencies (Wayne Bowden).

Change Orders

<p>What was the total cost of Change Orders?</p>	<ul style="list-style-type: none"> •
<p>What change orders were unexpected and occurred because of design oversights or unseen risk and what is the dollar value of these change orders?</p>	<ul style="list-style-type: none"> • The need to provide an area for spectators was unexpected, and required a change order for the contractor to clear and fence an area (Mike Arens, Lisa Wilson). • Other change orders included the delineators and ped ramps, drainage, asbestos cleanup (some of which was repaid to UDOT from Questar), and having to move the demo site after realizing that the original site was under overhead power lines. These resulted in approximately \$600k in unexpected change orders (Lisa Wilson).
<p>What change orders were anticipated and occurred to meet design or scope and what is the dollar value of these change orders?</p>	<ul style="list-style-type: none"> • Phase 1 of the project covered the construction of the abutments and procurement of steel, and phase 2 occurred as change order 1. Change order 1 was the construction and mobilization phase of the bridge. The bid and ICE process were redone as part of change order 1 (Mike Arens, Lisa Wilson).
<p>How did having a contractor involved in design help to reduce change orders?</p>	<ul style="list-style-type: none"> • The contractor knew what the design was through the whole process, which eliminated nearly all unexpected change orders (Mike Arens). • Having the contractor on board early reduced risks substantially. The change orders would have been much higher without CMGC (Lisa Wilson). • CMGC created the ability for general buy-in with the designer on the plans by finding design and constructability issues early on, which reduced the contingencies and associated pricing when bidding (Wayne Bowden).
<p>How did you negotiate change orders?</p>	<ul style="list-style-type: none"> • Due to the pressure on schedule there were few negotiations on change orders (Lisa Wilson). • The markup was negotiated early on. After that everything was a “pass through”. No markups were negotiated as are typical in Design Bid Build jobs. (Wayne Bowden).

Environmental Stewardship

<p>How did bringing the contractor on early alleviate environmental concerns?</p>	<ul style="list-style-type: none"> • Environmental concerns for this project were minimal (Mike Arens). • Faster cleanup of asbestos (Lisa Wilson).
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Benefits to Public

<p>How did the public benefit from the CM/GC process?</p>	<ul style="list-style-type: none"> • Replacement of a bridge over an interstate with minimal disruption to traffic (Mike Arens). • This project paved the way for future accelerated bridge projects. (Lisa Wilson). • Construction of the bridge offsite eliminate the risk of constructing operations above public traffic (Lisa Wilson) • Construction of bridge offsite afforded the contractor better control of concrete placement because the concrete was placed on a flat surface rather than on the sloping conditions that occurred in place (Lisa Wilson). • The public benefited from an accelerated project, fewer traffic disruptions, and safer work environment for crews. Furthermore, the existing bridge was in a state of severe disrepair. (Wayne Bowden).
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Lessons Learned

<p>What did you learn in the CM/GC process?</p>	<ul style="list-style-type: none"> • This project was successful because the contractor was very involved and engaged early on. Although not the case in this project, contractors have a tendency to not “scour” the design until they’re getting ready to bid/construct, and by then it is too late to make significant changes. The key to success is to push the contractor to be thoroughly engaged in preliminary reviews (Mike Arens). • UDOT will often use CMGC as a way to accelerate design, but this acceleration increases risk, which will be demonstrated in the bids. If you use CMGC in a normal schedule, you can work more of the risks out of the plans prior to bid. You can’t have it both ways (Mike Arens). • Never have the end date set before starting the project. A constrained schedule drives up costs (Lisa Wilson).
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	<ul style="list-style-type: none"> • Don't change out the UDOT RE halfway through the project (Wayne Bowden). • We were able to learn some interesting new technology that has been used elsewhere. This project verified that this new technology really does work and that it's a benefit to the public (Wayne Bowden).
<p>What lessons did you learn from debriefing the contractor?</p>	<ul style="list-style-type: none"> • Innovations were developed and we were also able to verify claims of SPMT. The company selected for mobilizing the bridge claimed that it was there most difficult move to date. Mostly due to complex bridge/abutment geometry.

General Notes/Other Items

<p>How would you rate the CMGC process now that the project is completed?</p>	<ul style="list-style-type: none"> • Rating of 9 out of 10. It was almost essential to this project to use CMGC. Had the project been DBB, Baker would have likely been calling contractors anyway for advice. • It was a great experience (Lisa Wilson). • As one of the first CMGC projects, the RFP did not contain a price component. This was added to later projects. However, pricing control of the project was more greatly affected by compressed schedule than by any other issue. Overall the contractor's prices were fair and reasonable (Lisa Wilson). • Although it may have been possible for this project to be completed utilizing other construction processes, there was so much risk involved that delays would have ensued. The CMGC process enabled to move the project along quickly (Lisa Wilson). • Rating of 10 out of 10 (Wayne Bowden). • To evaluate the subcontractor that would be selected for the SPMT portion of the contract, Wadsworth interviewed 4 companies and evaluated them on both cost and experience. By bringing them on board early it reduced a lot of speculation on what could and could not be done.
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APPENDIX B – Development of Fair and Reasonable Pricing

Pricing Comparison Procedure

One of the difficult processes with the CMGC process is to determine if the bid price provided by the contractor is fair and reasonable. In order to address this issue in a standardized way, a proposed procedure that can be used to compare and rate CMGC processes is presented herein.

Assumptions

The following assumptions are applied:

1. Averages of historical data are the best representation for the projection of future data. It is understood that individual items will range drastically in the approach. However, the overall averages can help build a base line of what is “reasonable and fair”.
2. Average data presented on the UDOT website is utilized as the state average for the year in which the project took place.

Procedure

The proposed procedure simply compares the overall cost of the project (bid items and change orders) with a projected value that is based on the historic averages. A ratio of Project Cost to Allowable Cost is then determined. If the ratio is greater than one, the project was not cost effective, if the ratio is 1 or below, the project cost was fair and reasonable.

Steps

To illustrate this process the data for the Spanish Fork Bridge Deck Repair Project will be utilized.

Step 1 - Calculate the Total Project Cost

The total Project Cost (P_C) for comparison is the Base Bid (B_1) cost plus the “unplanned” change orders (C_{O1}). Please note, that planned change orders are essentially additional phases as the same project. Early procurement items are handled the same way but supplying and installing fees must be added together prior to comparison. Unplanned change orders are addressed later, it is assumed that the same pricing methods are utilized for change order payment as with the base bid data.

$$P_C = B_1 + C_{O1}: \quad \$ 7,298,790.12 = \$6,705,409.83 + \$ 593,380.29$$

Step 2 – Determine the Ratio of State Anticipated Price to the Bid Items Price

This ratio is obtained by matching the current bid items unit price from the bid abstract to the average state prices for the same bid item. The totals of the corresponding prices based on the different unit prices are used to make the ratio. Please note that typically only about 50% of the items will match. It is important that the comparison is done between data of the same description and unit of measurement. The rest of the data is discarded. The data of comparison is attached. The Ratio of State Anticipated Price to Bid Item Price is:

$$R_{SB} = 1.401$$

Please note that R_{SB} values above unity indicate that the bid unit prices were typically below the state average unit prices for the items compared.

Step 3 – Determine the Anticipated Bid Price

The Anticipated Bid Price (A_{BP}) is the anticipated price of the project if the state averages could have been applied to the entire list of bid items. Assuming that the compared data is similar to the unmatched data A_{BP} is simply the bid price (B_1) multiplied by the R_{SB} :

$$A_{BP} = \$6,705,409.83 * 1.401$$

$$A_{BP} = \$9,396,190.15$$

Step 4 – Estimate the Anticipated Change Orders of the Project

The Anticipated Change Orders (A_{CO}) is determined by multiplying the Anticipated Bid Price (A_{BP}) by 10 year average of change orders per project at UDOT (1999-2008). This data is found on PDBS and is 9.98%.

$$A_{CO} = \$9,396,190.15 * 0.0998$$

$$A_{CO} = \$937,739.78$$

Step 5 – Find the Total Anticipated Cost of Project

The Anticipated Cost of Project (A_{CP}) is simply the sum of the Anticipated Bid Price (A_{BP}) and the Anticipated Change Orders (A_{CO}):

$$A_{CP} = \$9,396,190.15 + \$937,739.78$$

$$A_{CP} = \$10,333,929.92$$

Step 6 – Find the Ratio of Project Cost to Allowable Cost

The Ratio of Project Cost (R_{PC}) determines if the project was fair and reasonable. If the value is over 1 the contractor's prices were not fair and reasonable. If the value is 1 or under the contractor's prices were fair and reasonable. The value is determined by dividing the Total Project Cost (P_C) with the Total Anticipated Cost (A_{CP})

$$R_{PC} = \$7,298,790.12 / \$10,333,929.92$$

$$R_{PC} = 0.71 \quad (\text{project was fair and reasonable})$$

Summary Equation

The steps outlined above can be summarized in one equation:

$$R_{PC} = \frac{\left(1 + \frac{C_{O1}}{B_1}\right)}{R_{SB}(R_{CO} + 1)}$$

Where:

C_{O1} = The sum of the unplanned change orders. These are change orders that were unforeseen at the time of design and resulted in added prices during construction (dollar value)

B_1 = The original base bid total, including any early procurement bidding (dollar value).

R_{SB} = Ratio of the State Average Price total to the Bid Price total using the same quantities that were outlined in the bid and using the state average unit prices, and the bid unit prices respectively.

R_{CO} = State wide 10 year percentage rate of total change orders to bid costs from 1999-2008 (currently 0.0998)

Issues

The following issues are recognized with the analysis:

- Mobilization fees were not included in the analysis as there is no correlation between mobilization fees and the cost of the project. It should be noted that the project had higher than the average Mobilization fees.
- Some of the bid items that the analysis does not address are large specialty items which do not have a comparable counterpart in the state data. It should be noted that large lump sum specialty items may mask actual cost results that this process can not address. These bid items should be addressed with the Engineer's Estimate and the ICE at bid opening.
- The State Averages used for comparison are from the UDOT website for the year the project was bid. There is no verification as to if the data had been cleaned up or if significant outliers may affect the results.