COLLABORATION USING THE CM/GC PROCESS TO FIND SOLUTIONS FOR ACCELERATED BRIDGE CONSTRUCTION

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ABSTRACT

The Utah Department of Transportation has used alternative project delivery methods to deliver accelerated bridge construction projects. The Construction Management/General Contractor (CM/GC) method provides collaboration between the owner, contractor and engineer in finding solutions for accelerated bridge construction. The CM/GC project delivery method was used on the I-80; 1300 East to State Street project where seven bridges were moved up to 1.6 miles using self-propelled modular transporters (SPMTs). The I-80 project used a “bridge farm” to construct seven bridge superstructures which were then moved to the final locations. Bridges were driven over previously constructed bridges. The CM/GC project delivery method was used on the deck replacement utilizing full depth precast-deck panels on the 495-foot arch bridge carrying I-70 over Eagle Canyon. This paper will discuss the collaboration in finding solutions to these challenging projects and discuss the final solutions for each project.

INTRODUCTION

Construction Management/General Contractor Process

Construction Management/General Contractor (CM/GC) is a contracting method used by the Utah Department of Transportation (UDOT). The intent is to form a partnership with UDOT, the owner, the designer working for UDOT, and the contractor (1). This partnership is developed during the design phase to minimize risk, develop a project schedule, identify potential innovations, and develop a project cost model. The CM/GC process uses the skills and expertise of all three team members to:

- Identify and mitigate risks
- Participate in formal design reviews
- Participate in risk analysis workshops
- Provide informal input on constructability
- Develop a cost model to identify project cost, contingencies and budgets

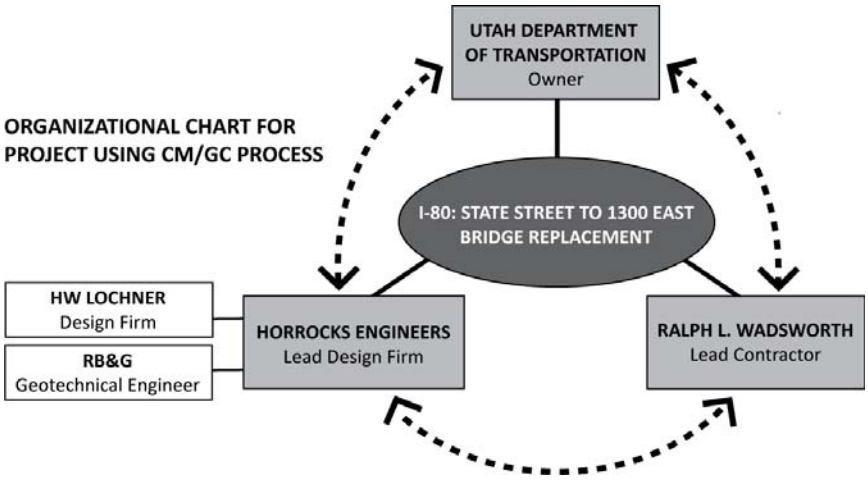
The goal of the CM/GC team is to deliver the project in less time and at a lower cost than design-bid-build construction processes. This paper discusses the collaborative efforts using the CM/GC process for the accelerated bridge construction (ABC) techniques for two case studies: including the I-80; State Street to 1300 East and the I-70 over Eagle Canyon in Utah.

CASE STUDY 1 – I-80; STATE STREET TO 1300 EAST

The I-80: State Street to 1300 East project is a major arterial along the Wasatch Front in Salt Lake City, Utah. The existing corridor carried six lanes, three eastbound and three westbound, with three interchanges and 17 bridges. A project map is illustrated in Figure 1. The existing corridor was in poor condition with deteriorating bridges and inadequate ramp configurations at the interchanges.

Figure 1 – Project Map

As indicated above, the goal of the CM/GC process is to form a cohesive team. The project team included the following partners:



The I-80 project replaced the existing bridges, added an additional general purpose lane, improved ramp geometry, and added an auxiliary lane. The project was completed in December of 2009. The final project consisted of the following structures:

- Mainline I-80 Bridges (7 pairs, 14 total)
- Ramp Bridges (3)
- Mainline Deck Replacements (2)
- MSE Retaining Walls (11)
- Modular Block Retaining Walls (8)
- Cast-in-place Retaining Walls (2)
- Sign Structures
- Noise/Retaining Walls
- Noise Walls
- Miscellaneous Drainage Structures and Canal Relocation

Accelerated bridge construction implemented on this project included:

- Moving six mainline bridges and one ramp bridge using self-propelled modular transporters (SPMTs)
- Precast bridge elements on one ramp bridge

Project Criteria for Bridges

The initial project criteria required the reconstruction of I-80 while maintaining three operational lanes in both eastbound and westbound directions. Additionally, UDOT required the project team to minimize the construction schedule and implement ways to accelerate the bridge construction in order to minimize impacts to the travelling public. In order to meet these criteria, collaboration between owner, contractor and engineer was required to find accelerated construction methods to construct the bridges. The CM/GC process was implemented to allow for this collaboration.

Collaboration

The CM/GC process is a constant collaboration effort between the owner, engineer and contractor. Although the list of collaboration items is extensive for the entire project, two key technical issues required collaboration for the bridges. These items included the methods for accelerated bridge construction techniques (ABC) and utilities.

Accelerated Bridge Construction

The project goal of implementing ABC required the collaboration of UDOT, the engineer and the contractor. John Montoya, UDOT Project Manager, said, “This project couldn’t have been done using any other method under the time and budget constraints, mostly because of the innovations of the bridges”(2). Very early in the design process, ABC workshops were held to brainstorm bridge construction techniques. Each bridge site was evaluated for ABC methods using transverse slides, longitudinal slides, moving superstructures with SPMT’s, and precast bridge elements.

After the analysis of each site, the team selected a final solution to use a ramp infield to construct all seven superstructures in what was termed the Bridge Farm (see Figure 1 and Figure 2). After each site was prepared, the superstructures were transported from the Farm to the bridge site using SPMTs. After the first structure setting, the linear nature of the project required that each successive superstructure be transported over the previous constructed bridges. Collaboration was required to identify methods of construction and mitigate risk.

Figure 2 – Bridge Farm

During the selection of the lifting and transporting methods, collaboration was required to match the design with the construction methods. Realizing that the ABC method selected required input from a heavy lift company, a bid package was generated that identified construction methods. This package was given to potential heavy lift contractors to provide technical information and pricing. Mammoet was selected as the heavy lifter for this project and became another partner in the collaboration process.

Meetings were held weekly to discuss all the issues with moving the bridges. The many issues included the temporary Bridge Farm, the travel path to each bridge, the carrying beams, the SPMTs, the skid rails, the jacking towers, and the temporary foundations. One of the key collaboration issues was moving bridges over bridges.

After all issues were resolved and a plan was determined, the team agreed upon a construction sequence. A highly simplified version of the construction sequence follows:

- Step 1. Construct temporary abutments in Bridge Farm.
- Step 2. Construct the bridge superstructures in the Bridge Farm (see Figure 1 and Figure 2)
- Step 3. Construct temporary foundations and supports for previously constructed bridges (see Figure 3)
- Step 4. Lift the bridge using SPMT's (see Figure 4)
- Step 5. Transport the bridge from the Bridge Farm to the bridge site
- Step 6. Transfer the superstructures from the SPMT's to the skid supports
- Step 7. Slide bridge longitudinally over the cross street (see Figure 5)
- Step 8. Transfer the bridge from the skid supports to the jacking towers
- Step 9. Jack the bridge down onto the permanent foundations

Figure 3 – Transport over Bridges

Figure 4 – Bridge on SPMTs

Figure 5 – Longitudinal Sliding

One of the most difficult tasks was transporting a bridge from the Bridge Farm down the corridor and over a newly constructed bridge as shown in Figure 3. Collaboration was imperative to eliminate and mitigate risk. In order to accomplish this task, the new single span bridges were temporarily supported at midspan turning them into two span bridges. Collective input was received from the heavy lifter for axle loads and load distribution. In order to reduce cost, the contractor provided a list of available materials to use to construct temporary supports. All this data was collected and the bridges were analyzed to support the loads.

Utilities

The project had both overhead utilities crossing I-80 and buried utilities at each cross street location. During the design, each utility was located and potholed, and a conflict matrix was developed to minimize impacts at all possible locations. Throughout the corridor each conflict was evaluated and in many cases relocation was avoided. Specifically at bridge locations, utility conflicts were evaluated for conflicts with foundation construction, pile driving, and ABC. An example of eliminating conflicts was at 900 East where a bridge foundation location was moved to eliminate an overhead conflict during pile driving.

In order to implement the ABC methods selected, the cross streets at each bridge location were evaluated for impacts. The ABC method selected required fill to be placed at each cross street which supported the equipment to slide and lower the bridges and support the temporary foundations to convert the bridges to two span structures as shown in Figure 3. An example of difficult utilities was a waterline at Highland Drive that was constructed in 1906. The team held workshops to review each utility and identify the potential risks and impacts. Examples of mitigation included installation of water valves on major waterlines for emergency shutoff, lining a sewer line to mitigate settlement impacts, and monitoring settlement of temporary supports at critical utilities.

CASE 2 – I-70 OVER EAGLE CANYON

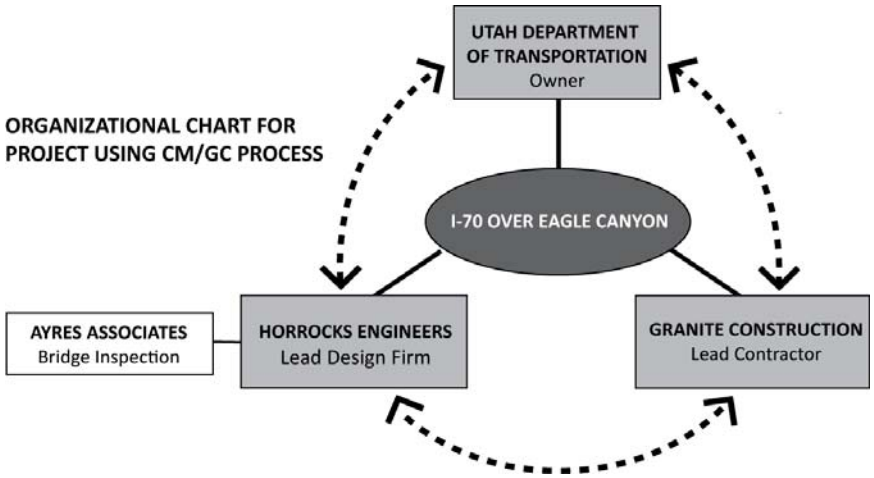
I-70 eastbound and westbound are carried over Eagle Canyon by steel deck arches and approach spans with a cast-in-place concrete deck constructed in 1965, as shown in Figure 6. The existing bridge has a 364-foot steel deck arch with approach end spans for a total structure length of 485-feet. The floor beams support non-continuous stringers that support the reinforced concrete deck. The reinforced concrete deck with asphalt overlay provides the driving surface over the entire length of steel girder approach spans and steel deck arch.

Figure 6 – Existing Bridge

A full inspection of the westbound structure, including arms length inspection of all bridge elements, was conducted as part of the project. The inspection report (3) prepared by Ayres Associates as part of the project reported the following conclusions:

Bridge Element	Conclusion
Deck	The deck is in poor condition. The underside of the deck has significant spalling with exposed reinforcing steel that has moderate corrosion. Other areas of the deck are heavily cracked with significant efflorescence.
Stringers	The Stringers are in good condition. There are few areas with peeling of the top coat of paint at the exterior faces. The Stinger connection details are in good condition. Some welds of the connections are of poor quality due to porosity and undercut but do not show signs of cracking.
Floor Beams	The Floor Beams are in good condition. The connection details are in good condition. Some welds of the connections are of poor quality due to undercut and porosity but do not show signs of cracking
Arch Ribs	The Arch Ribs are in good condition. At the splice connections there is pack rust between the connection plates and the rib segment. These areas have been filled with caulk to prevent water seepage into the arch.

Based on the conclusions in the Ayres report, UDOT decided to replace the deck on the arch and the approach spans. In order to minimize impacts to traffic along the I-70 corridor, it was decided to replace the existing concrete deck with full depth, post-tensioned, precast deck panels. Collaboration and feedback from the contractor was necessary to understand the equipment and construction methods that would be utilized. The project team included the following partners:



Collaboration

The CM/GC process is a constant collaboration effort between the owner, engineer and contractor. Again, the list of items requiring collaboration is extensive for the entire project, but for the bridges two key items were critical. These items included the deck removal and placement sequence and the deck panel details.

Deck Removal and Placement Sequence

The original bridge was a three pinned arch that was made continuous after steel erection. Structure stability during deck removal was a primary concern. Project team members held weekly meetings to discuss the methods of construction. A final deck removal and precast placement plan was developed,

and the structure was analyzed to determine the effects on the existing bridge and verify the stresses were below the allowable. The final sequence is illustrated in Figure 7. This sequence was designed using the equipment provided by the contractor for the removal process.

The original placing sequence developed for the deck replacement was to set the new deck panels with a crane placed on the existing deck. The contractor provided the equipment and outrigger loads for the crane. Due to the existing structure member capacities, the analysis for the specific equipment it was determined that no panel placement could be completed from the deck of the existing structure. As such, the final removal was by small equipment placed on the existing deck and a crane placed behind the abutments. The crane for removal was alos used for erection of the new deck panels. The crane was a 600 ton crane with 335 feet of boom. The crane had 220 feet of reach with 82,800 pounds. Part of the crane is shown in Figure 10.

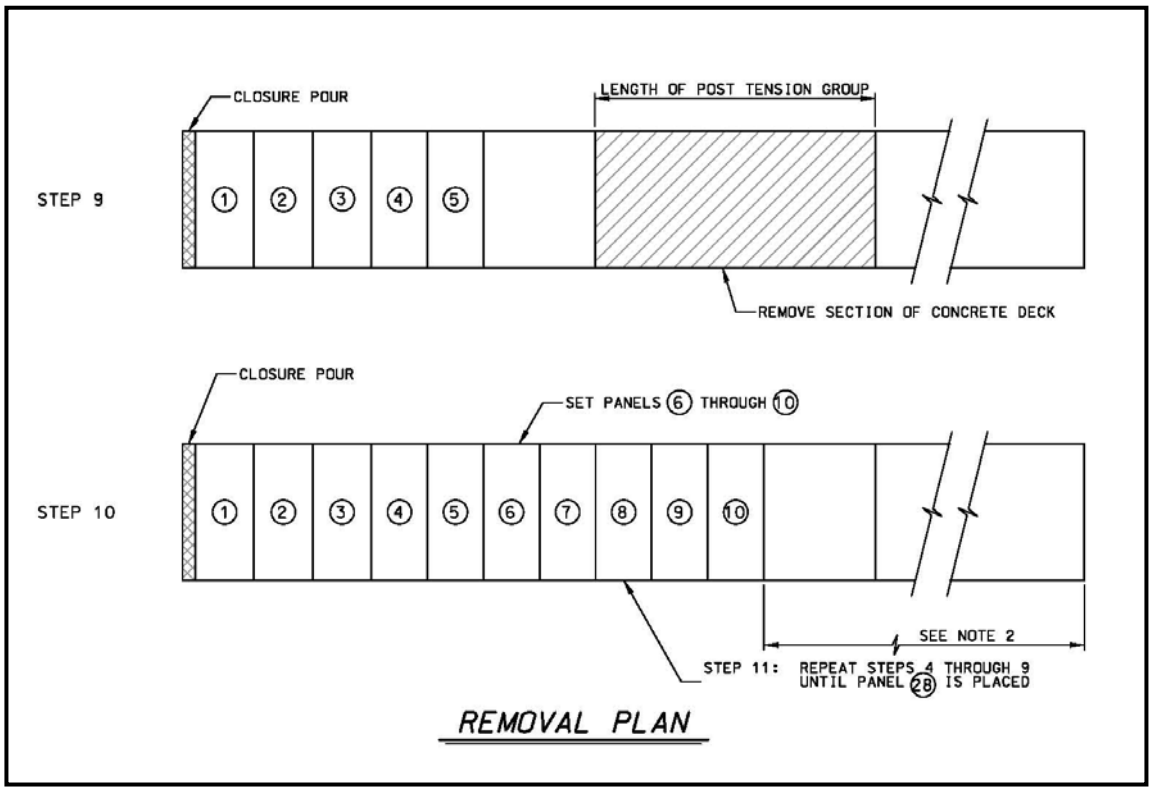


Figure 7 – Deck Removal and Placement Sequence

During the analysis to verify the construction techniques, four panel point locations showed inadequate load rating for live load. The columns at each panel locatoin required modifications to obtain adequate load rating.

Deck Panel Details

The existing bridge deck was non-composite with the floor beams and stringers. In order to match the existing conditions, a non-composite, full-depth precast panel was developed. A deck panel section is shown in Figure 8. The deck panel details were designed based on contractor equipment. The contractor had casting beds in their construction yard approximately 200 miles from the project site. The panels were designed for lifting and transporting to the site and erection at the site based on the contractor's equipment. Additionally, designing for the contractor's equipment provided control over handling, shipping, and erections stresses.

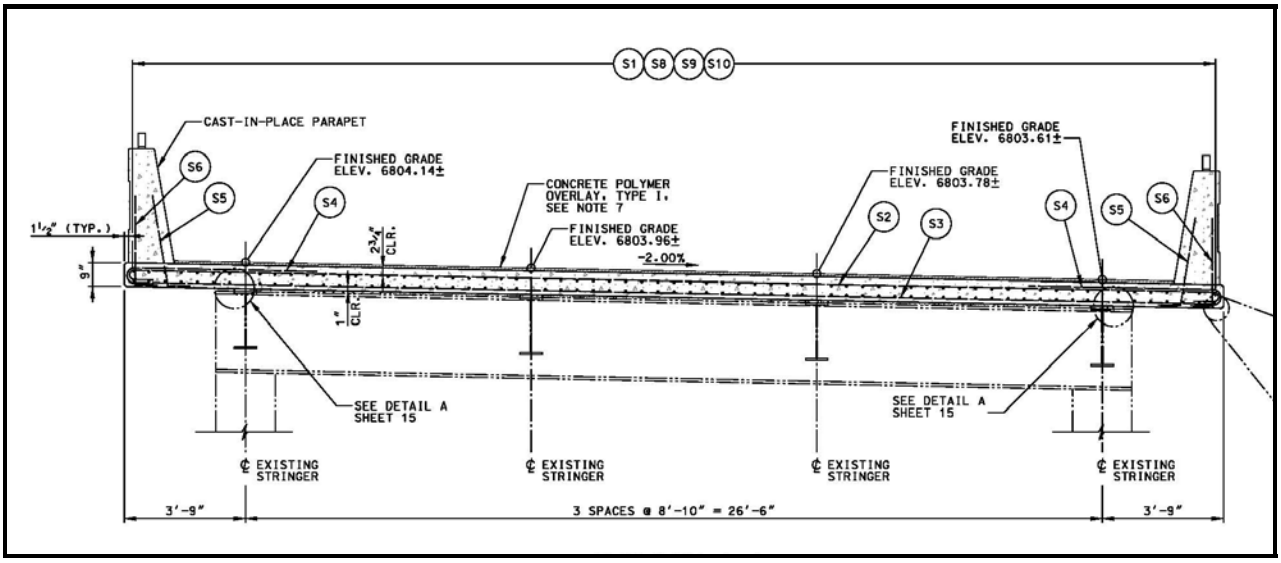


Figure 8 – Deck Panel Section

Without the addition of shear studs, a detail was used to develop the horizontal shear forces developed from the load groups (see Figure 9). The contractor provided the detail from a previous project whick was implemented on this project.

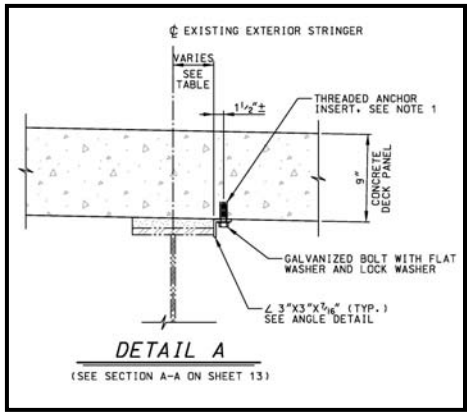


Figure 9 – Non-composite Detail

Along the length of the bridge there were seven panel groups post-tensioned longitudinally. The placing sequence is shown in Figure 7. The contractor provided input on the post-tensioning equipment, and the deck panel details were modified to incorporate the equipment. Each panel group was post-tensioned to the previous group to provide post-tensioning for the entire length of the bridge. The first panel group just prior to grouting the blockouts is shown in Figure 10.

Figure 10 – First Phase of Deck Panels

CONSLUSIONS

The CM/GC process is a project delivery method for technically challenging projects. This process allows the team to mitigate risk and project cost. In both case studies, the projects were complex and benefitted from collaboration between the owner, designer, and contractor during the design process.

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