Implementing a Working BIM Model Halfway Through a Public CM Multi-Prime Project: A Case Study

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The development of a BIM (building information model) model is a standard practice in today's construction world. While the process of model adoption nearly has a written formula, implementing a BIM model in the midst of a project is a rare occurrence. This paper will examine the implementation of a working BIM model halfway through a public multiple prime contractor project managed by a construction manager (CM) in California. The project cost is roughly $20 million and of moderate complexity. This paper will outline the factors leading up to the ultimate decision of creating a working model, the process of getting all relevant team members involved to create the model, and the final takeaways once the model was finished. The excessive amount of RFI's and drastic MEP (mechanical, electrical, and plumbing) coordination clashes left the team no choice but to create a model after weighing the cost of the model against potential change orders. The construction manager stepped in to quickly set precedents for model creation responsibilities, utilizing their in-house BIM expert which ended up being invaluable for a variety of reasons. All parties created their specific models within the time frame given, followed by a series of successful BIM coordination meetings featuring all parties involved. Had the construction management firm not been so well versed in technical construction solutions, the model may have been outsourced to a company unfamiliar with the project and team or worse, never suggested at all. Since the CM was also a company that performs general contracting works, their in-house BIM capabilities, project coordination skills, and building knowhow provided the means to escape this potentially costly situation.

Key Words: CM Multiple Prime, BIM, Implementation, Model Adoption, Public Project

Introduction

The construction industry is infamous for project schedule and budget overruns. While unforeseeable natural causes can be at fault, the usual cause for the extended time and dollar value is either incompetent project management or unbuildable contract documents. Project managers can only do so much to keep the project on the right path when all of the pieces don't fit in the box per the directions.

The lack of coordination between the drawings, especially MEP scopes, is nothing new to the industry, but rarely do the teams involved in the project identify the clashes early on enough to consider creating a model. As a result, the adoption of a model implemented halfway through a project by all teams is a topic few have experienced and documented. BIM models are commonplace in today's construction world where the MEP contractors are involved in the design process, resulting in an early understanding of the project by the key team players.

The aim of this case study analysis is to discover the challenges and effective techniques when introducing a model during a real life project. After a string of serious MEP coordination issues discovered five months into a sixteen-month schedule, the client, architect, and construction manager decided the cost to create a working BIM model would be outweighed by the potential change-order dollars over the course of the second half of the project. This case study covers months two through nine of the project from the initial thought of implementing a BIM model to the final product.

CM Multi-Prime in the Industry

Dating back to the late 1960s, CM multi-prime emerged in an attempt to address the challenges posed by the traditional design-bid-build delivery system. The public sector was facing projects being bid over budget, finished behind schedule, and an increased number of claims. As a solution, the new delivery system, still complying with existing public procurement law, emerged aimed at providing the owner with the cost benefits of directly procuring the prime trade contractors while utilizing the construction expertise of the construction manager. Acting in the owner's best interest, the CM manages the prime contractors contracted by the owner without the risk, making it a win-win situation for both parties.

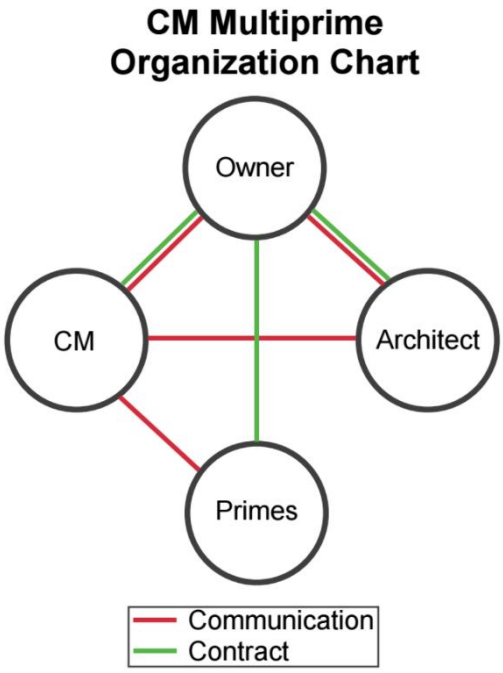

Figure 1: The Organization of the CM Multi-Prime Delivery System

As with all project delivery systems, the benefits can only be maximized when the capabilities of all parties match the requirements of their role. Unlike the role a CM agent plays for the owner when managing a general contractor, the CM position in the multiple prime method demands the building knowhow of a general contractor coupled with the ability to think and act on behalf of the owner. Playing this dynamic role can be challenging to firms signatory to the GC or CM side, yielding a project gone awry in the case of a more CM inclined firm or a disgruntled owner fighting the hand they are feeding in the case of a GC-minded firm (Kluenker, 2009).

Lessons Learned from the Industry

Seeing that this circumstance is so specific, no information was to be found on the subject of implementing a BIM model in the midst of a CM multi-prime project, public or private. This is no surprise as the case is rather extreme and other more moderate solutions are usually applied when teams face 'standard' drawing coordination issues. This case of creating a model during a project of this type will serve as a reference to other industry members who may encounter a similar situation.

Red Flags Leading to the BIM Model

Unrelenting RFIs, change orders, and coordination challenges are commonplace within a project, which made it hard to decipher whether a BIM model was necessary. By the 6th month of construction, 300 RFIs had already congested the drawings, making as-builts evermore important. As the structural system was nearly completed, the MEP prime contractors had begun a more in-depth analysis of how their scopes of work were going to piece together. The construction manager's superintendents were simultaneously performing the same analysis after

several months of intensive underground and structural constructability reviews. From these reviews came swarms of RFIs, triggering serious concerns from one of the superintendents with nearly 45 years of experience. This concern developed into a meeting with the architect, owner, and construction manager to discuss the severe coordination issues found from the reviews. Among the coordination issues including fire sprinkler mains running through beams and plumbing mains running through ductwork, which was certainly sufficient cause to start looking into a model.

New Knowledge

Since the use of a BIM model in a public CM multi-prime project is uncommon to begin with, the knowledge gained from implementing a model in the middle of this type of project sits itself in a small niche. In this particular project delivery system, the successes in a streamlined development and implementation of the model can be directly attributed to the construction manager having an effective, in-house BIM expert. The modeler not only brought high-level coordination skills to the table, but also a fresh perspective. It appeared that the project team had not only been viewing different revisions of the drawings, but the plumbing prime contractor didn't have any plans showing the exact location measurements. Creation of the model pinpointed the exact dimensions of the plumbing runs to be transferred onto a 2D set by the designer to be used in the field.

Methodology

The objectives of this case study are as follows:

- To highlight the red flags that may point to need for a BIM model during a project.
- To provide one potential methodology for creating a BIM model.
- To highlight the challenges and successes of that specific method of implementing a model.
- To highlight the lessons learned from implementing the model
- To provide solutions for avoiding the situation altogether

The methodology for this case study is entirely qualitative. The study was completed while on site for a minimum of two days a week for 8 months. Interviews were conducted of the entire construction management team in order to gain different views from a management perspective. From this data, conclusions were formulated as to point to the most successful or ineffective techniques in implementing the model. In addition to interviews, summaries of BIM coordination meetings and owner-architect-contractor meetings were developed to produce key takeaways and closely monitor the process of idea inception to final implementation. From these meetings, the perspective of the owner, architect, consultants, prime contractors, construction manager, and BIM expert were gathered in order to divert from the sole perspective of the construction manager. Specifically from the BIM coordination meetings, the sequence of progress meetings and deadlines were recorded to track responsiveness of the team.

Case Study

The following information covers the project specifics, steps taken to create the model, and the final steps taken to outfit the team with the required materials.

Project Specifics

The project featured roughly 40,000 square feet within a structural frame design considered to be above average complexity by the superintendents and a 'standard' MEP system containing nothing out of the ordinary. During the first six months of the project, progress was as expected considering the outside-the-box structural design and varying soil conditions. The prime contractors were mostly smaller local firms new to the CM multi-prime project delivery system, but this foreign team setup contributed to very few problems since their job was the same at the root. Essentially serving as a general contractor, the primes determined their own means and methods to the chagrin

of the superintendents staffed by the construction manager. This relationship between the superintendents and primes slowly developed since each side was hesitant to trust due to the unfamiliar delivery system and the 'out-of-town' construction management firm. Once the primes realized that the construction manager's team was overly qualified in the realm of technical building, the change orders noticeably lessened and the jobsite culture improved.

Model Formation

The formation of the model was spearheaded by the BIM expert of the construction manager who served as the sole point of contact for model related activities. This sole point of contact established order and ensure that everyone was on the same page, receiving the same information and immediate responses. The process of creating the model can be broken out into four different phases as highlighted below:

1. Get the main players on board. The owner must understand the cost of the potential changes versus the model development cost. When it comes to major coordination issues such as plumbing mains running through beams and fire sprinkler mains running through ducts, the potential for high-dollar change orders is enough of a threat to spend the roughly $30,000 required to model a project. Communicating this information effectively to the owner from the standpoint of a builder and an advisor, a good construction manager can put the situation into simple terms and make it a no-brainer. While of lesser importance than the owner in terms of project standing, the architect must also fully understand the situation. They are a key part of the team no matter what delivery method it is and maintaining a good relationship with them is vital in the culture of the project. For this particular project, the construction manager presented a few initial major clashes found in a constructability review and was able to convince the architect that this was just the tip of the iceberg. These clashes were beyond what could be considered 'contractor coordination items' and had to be sorted out by the consultants. Now that the owner and architect were on board, we could proceed with rolling out the plan to the prime contractors.

2. Assign a deadline. After a review of the schedule, our team came up with a date for when each party's scope of work had to be modeled by. This decision was made at an all-hands meeting including the prime contractors when we announced that creating a model was necessary for the job. The prime contractors were neutral on the idea since the change orders would have meant bigger profits and a model meant a smoother process. During that meeting, it turned out that some of the primes had already modeled their work in Tekla as a standard practice. Scopes like fire-sprinklers and structural steel are commonly modeled, so from this point on the team was focused on the remaining pieces of the model. The deadline was two weeks from the date, during which the BIM expert of the construction manager assisted the prime contractors. After the two weeks, all of the primes had completed their respective models on time, which could be attributed to the reasonable time frame given and assistance of a BIM expert.

3. Assemble and fix. Now that all of the different scopes had modeled their work, the BIM expert compiled the files to create the complete, but imperfect model. A coordination meeting was scheduled two days after the model deadline, when the entire team including the primes met up to solve the existing clashes. All sitting at a big conference table in the job trailer, the BIM expert linked his computer to a large TV monitor on the wall for all to view and problem solve. The technical building knowledge of the prime contractors' foreman and the superintendents of the CM were able to agree on feasible solutions at each clash, while the architect and consultants weighed in. The prime contractor's set all differences aside to collaborate in the process and come up with solutions that worked for everyone. This inclusive process was key in coming up with 'one and done' solutions that everyone could agree on. Addressing each clash with the team was a somewhat tedious process, but vital in ensuring everyone was on the same page. The clashes requiring further coordination from the consultants due to design loads and angles were saved for a separate discussion.

4. Create new 2D drawings for field use. With the completion and correction of the model, the prime contractors needed new plans to go off of in the field. The old sets became obsolete in exception to the site plans and could not be relied on. Since the field guys are still relying on paper drawings instead of a model on an iPad, the 3D model from Tekla had to be converted to a 2D set. Tekla's ability to convert 3D drawings to 2D sets created serious value for our project, saving the architect time and further rationalizing the decision for

modeling a project. Once the sets were printed, the prime contractors were equipped with drawings they had contributed to and had a sense of pride in.

Results and Discussion

Overall there were very few, if any, hiccups in the process of creating and implementing the model. All teams were efficient and responsible, realizing the future of the project laid in the hands of a model. The capabilities of the CM were instrumental in the success of the process, first realizing that a model was needed then taking charge of the situation with an in-house BIM expert. The expert assisted the primes and served as a neutral party with surface-level knowledge of the project. Since he was in-house for the CM, a reasonable deadline was able to be determined, where an outsourced BIM firm would have been hesitant to assign project deadlines. These reasonable expectations kept the project running smoothly with all involved parties anticipating a streamlined project following the modeling process. The owner may not have been so pleased with their architect, but that's not for here.

Project Culture

This culture of this project would have been a lot more hostile had a model not been implemented. The change orders would have had all parties holding a hard line, especially when the dollar amounts kept rising. Creating a model not only avoided the future headaches, but also brought the team closer together as everyone sat down to come up with solutions for the existing clashes. This process created a sense of teamwork among the prime contractors and attributed to the success of model creation. CM Multi prime is supposed to avoid the contentiousness while still being low bid, and in this instance we were able to keep it that way.

Lessons Learned

The lessons learned from this unique project will serve as a valuable resource for future project teams that face a similar challenge:

1. A construction manager with modern technical building capabilities provides a lot more value than the typical CM. Since the CM in this case was a capable builder, they had an in-house BIM team and staffed the project with superintendents to quickly solve on-site challenges. They were able to foresee expensive future change orders and determine when it was time to build a working model for the job. Had the CM not been so building-savvy, the model may never have been suggested or it would have been outsourced. Outsourcing this module creation would only create more communication routes, potentially further complicating the current state of the project. Additionally, outsourcing would have likely extended the time to create the model as well as higher costs.

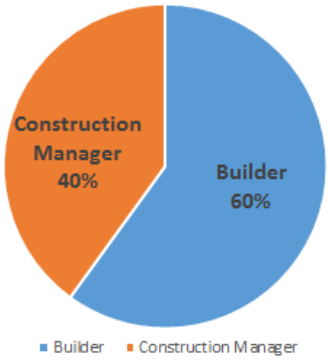

Figure 2: An Advantageous Makeup of a CM Firm in the CM Multi-Prime Delivery System

2. The utilization of a BIM expert from the construction manager is extremely valuable. Since the job is likely undergoing a phase of coordination problems, a fresh perspective and professional modeling capabilities can clear up the confusion and piece things together. The project team often gets their heads too wrapped up in a job after hundreds of RFI's, making it hard for them to realize solutions that came as obvious to someone introduced to a project halfway though. Additionally, having this team member serve as the sole point of contact for the model is key. That person serving as the BIM expert for the team holds everyone accountable and is tuned into all of the changes that have occurred. When prime contactors inevitably end up trying to coordinate with each other rather than the project team as a whole, they often complicate things despite their good intentions. Having one BIM expert work with all of the primes keeps the process linear, essential when the project can seem chaotic.

3. Get the superintendent of the construction manager involved in the clash detection process. They are coordination experts that are often thinking about how to solve problems instead of sleeping at night. Having a superintendent from the construction manager is beneficial since they are not looking for the quick and dirty approach to solving problems, but rather what is the right way to build it.

4. A model serves as cheap insurance. Modeling the project from the beginning to avoid the situation altogether. With projects becoming increasingly complicated, the initial investment in a model goes a long way when all is said and done. Change orders can easily exceed the $30,000 required to build a model and increase the likelihood of a negative project culture.

Conclusions and Future Research

The process of implementing a BIM model halfway through a public CM multi-prime project has provided valuable information regarding the unique challenges that can arise in this endeavor. Construction managers, prime contractors, architects, owners, and consultants can now gain an insight into successful strategies can be utilized when faced with a similar situation. This case study found ways to streamline the modeling process, avoid miscommunications by implementing specialized personnel, and maximize the utility of each team member involved in the project. With so many construction management and general contracting firms now utilizing in-house BIM experts, this information will be evermore relevant. Especially in the increasing complexity of buildings, it is possible that as an industry we continue to see an intensified need for superior coordination at all stages of a project. This case study serves as just one example showcasing an approach to implementing a BIM model halfway through a project, but when analyzed alongside other similar situations, a more finely tuned process can be developed to serve as a new industry standard.

Although a project team would never go into a project planning to create a BIM model in the middle of a project, the scenario of a construction manager with no BIM capabilities having to outsource a BIM model during a project would add to this realm of information. The challenges posed by outsourcing the model are something that this project did not encounter, but would have applied had the CM not had those capabilities.

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