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Building Information Modeling (BIM) and Construction

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The term Building Information Modeling (BIM) is nothing new to many architects and design professionals. The adoption of this design process has skyrocketed in the past decade. It is becoming the new industry standard, and soon will completely replace the traditional 2D (CAD) design process. One of BIM's biggest advantages is that it allows the design team to identify and correct problems in the Schematic Design and Design Development phases, thus reducing the number of problems that may arise during construction. The design team is able to use BIM software to see a virtual model of a building, with all of the major building systems incorporated, on the computer screen prior to construction. While the concept of BIM is truly remarkable, the implementation of this relatively new technology by design professionals is far from perfect. It seems there is a disconnect between how BIM is used during design and during construction. Despite all the time and effort spent in the design phase (with BIM, the design phase is typically longer than with traditional 2D CAD) and the number of clashes found during construction don't seem to be decreasing. Based on my experience, construction cost savings as a result of BIM are far less than what owners have been led to expect. This leads to the question: What went wrong?

BIM modelers

Since BIM is complicated and relatively new, many architectural firms often hire BIM modelers to do the digital modeling. These modelers are usually talented young architectural interns trained in a variety of sophisticated 3D modeling tools. However, they rarely possess the experience or knowledge needed to solve technical architectural problems encountered during the design phase. As a result, many of the design models contain constructability problems. These problems are often not caught by project architects (who are overwhelmed by their many other tasks) and are carried into construction. Here's a real-life example: A BIM modeler with no prior construction experience located the exterior metal balloon framing studs against the edge of the second floor concrete slab, with no gap between the backs of the studs and the slab edge. In California, such a gap is required to allow seismic movement between the slab edge and the stud framing, not to mention that the slab edge will not be perfectly straight so a gap is needed to allow for industry-standard construction tolerances (the cost to achieve zero tolerance construction is enormous). Fortunately, the problem was discovered during the shop drawing process. However, valuable time was wasted during construction to reissue all of the slab plans with adjusted dimensions.

A successful BIM project relies on the level of technical knowledge the BIM modeler possesses. To take another example, BIM software models steel columns as perfectly plumb. A BIM modeler without any construction experience might think that a 6" metal stud wall is wide enough to conceal an HSS 6" x 6" column. However, in reality, steel columns are never erected perfectly plumb in the field. A construction tolerance, usually 1/2" for every 10'-0" of column length, must be accommodated when designing the stud framing around the column. One common way to address this problem is to add 1" furring channels to the metal stud wall to conceal the 6" x 6" column. BIM software is not capable of identifying issues like this, and since BIM won't identify it as a clash, the problem cannot be easily detected by the architect during the design phase.

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Consultants and level of detail

Even when architects manage to flawlessly supervise their BIM modelers, they often have little control over the models produced by their consultants. Despite spending numerous hours coordinating all the consultants' models so that clashes are removed from the design model, the architect must then sit in the contractor's BIM clash-detection sessions during construction and repeat the coordination effort. What happens is that the models produced by consultants often do not reach the level of detail adequate to identify all the problems. Another real-life example, also in California: An inexperienced BIM modeler in the mechanical engineer's office didn't model the interior lining of the supply ducts (since duct sizes are usually specified without including the thickness of duct lining). Also, the design model supplied to the architect included gravity duct supports, but none of the code-required seismic bracing. More than five hundred clashes were detected and a major delay claim was filed by the contractor. The result was catastrophic.

Not all building components are modeled during the design phase even per the national BIM standards. Just one component not modeled in the design phase could potentially have a huge impact during construction. Even more than with the traditional 2D drawings, the design team needs to have the proper knowledge to spatially identify all the components.

Construction BIM and Cost

Typically on a project using BIM, subcontractors are required to model their systems independently, based on the contract documents. The general contractor's BIM manager is responsible for putting all these models together for clash detection. He or she may also be required to model other components, such as building foundation, floor slabs, etc., based on the contract documents, to create a complete building model for construction. Unfortunately, not all subcontractors (or contractors) are BIM-capable, and requiring contractors to provide full BIM service could drive up the construction cost tremendously. One more real-life example: To save money, the owner decided to omit the requirement that the metal stud framer provide BIM services during construction. One result of that decision was that the king studs at the doors were not modeled. The mechanical ducts were installed before the studs were erected, and the design team had to adjust about 50% of the door locations to avoid conflicts between the king studs and the mechanical ducts above. This illustrates how important it is to correctly implement the BIM process from the design phases all the way to the end of construction.

Moving Forward

Despite these negative aspects, in most cases the cost of requiring contractors and subcontractors to produce a building information model is offset by the money saved during construction, as long as the BIM process is implemented correctly by all parties. Additionally, a BIM model completed in the early design phase helps the designer to visualize the design concept before committing to expensive 3D rendering services. Another feature of BIM is that it allows architects or cost estimation professionals (or contractors when they are preparing bids) to quickly extract critical information, such as room square footages and material quantities. BIM models are also widely used by mechanical engineers and energy consultants to perform energy analyses and sun path studies.

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In conclusion, I believe that detailed national BIM standards are required to guide architects and contractors in their use of BIM during design and construction. Education that trains architects and contractors, and even owners, in the proper uses of BIM (as opposed to marketing pitches to sell BIM) is needed to clarify some of the misleading expectations of this new process. After all, BIM is not a magic wand that architects and contractors simply wave to eliminate coordination problems and guarantee change order–free construction. Further emphasis should be placed on training design and construction interns to become architects and contractors who understand the realities of construction. As crucial as it sounds, the success of BIM depends on the thorough understanding of the process and on its proper implementation during the design and construction phases.

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