Discovering the Benefits of Integrating BIM Workflows into Residential Construction Estimating

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As Building Information Modeling tools become increasingly more prevalent within the construction industry, primarily the commercial sector, it is important to recognize how it can impact and/or improve other sectors of the industry. This paper will focus primarily on residential construction and the potential cost benefits that could be achieved with the implementation of model-based estimating. Other benefits that the commercial sector currently thrive on will also be noted and explained for potential implementation for residential construction. The project explained in this paper has a dual purpose; which is to discover if both cost and time benefits can be developed with the implementation of model-based estimating to a residential general contractor's workflow.

Key Words: BIM, Estimating, Residential, Construction, Model-based

Introduction

Technology within the construction industry has become widely accepted in the turn of the 21st century. Many developments in equipment and software have promoted this greatly. However, certain sectors of the industry have resisted to incorporate these new technologies, which leads to question why? The U.S. Census Bureau reported that in March alone, $1.3 Trillion was spent on construction in total. 42% of that was residential construction, (U.S. Census, 2018). The commercial sector of the construction industry has been a leader in adopting and utilizing new technology but this sector accounts for much less than residential construction in overall construction work. Residential construction, being the largest sector of the industry, should be the one leading innovation but it is not. Is it because of tight cost margins, resistance to change and adoption of new processes, or lack of knowledge about newer technologies? That is what this case study is out to discover.

According to a survey conducted by the National Association of Home Builders in 2015 "on average, 61.8 percent of the sales price goes to construction costs," (Taylor, 2015). Most residential clients will only build one home in their lifetime so providing the client with the best possible value is imperative. Building Information Modeling software has been available since the mid 1980's and is a great visual tool for clients, such as the majority of residential clients who may be novice to the construction industry. If the client can visually see what their home will look like before it is built they will know what they are paying for and can make effective decisions before it will end up costing them later on in both time and money. Not only will the visualization help the owners but it can help the contractors. According to a conference paper on BIM in Education, "BIM estimating methods help estimators visualize real world conditions through a virtual three-dimensional construction of the building," (Sylvester, 2010). Also, with the inclusion of quantifying engines incorporated into the software, BIM tools greatly benefit any contractor that may have to make quick adjustments to estimates and or schedules due to design changes or coordination issues. However, "…well-analyzed, well presented, and well-disseminated information is not always available. 'If people cannot get to the information they need, it does not achieve its intended purpose'," (Xu, 2013). Fully investing into the use of BIM requires a lot of behind the scenes work that is required to use it on a professional level. Most commercial contractors create their own historical cost data bases that work directly with excel sheets that they use to produce their estimates with in coordination with their model-based quantities. Because the new software is becoming more and more robust it is necessary to know how to extract just the data that the contractor is interested in. With the limited financial resources that a residential contractor might have available, what workflows would work best for the small scale builder? This paper will review one in particular which utilized three programs: Excel, Bluebeam Revu, and ArchiCAD.

Methodology

A Case Study approach was chosen for this particular project. The center of focus was specifically residential general contractors, however, this does not mean any results realized from this study cannot apply to all other sectors of the industry. Results were collected through delta measurements of data provided by the contractors and then a cost analysis of that information was performed.

For the case study at hand, 3 residential general contractors were provided plans for a 1600 sf house from an architect local to their region. They were asked to provide a rough framing estimate as their deliverable in whatever format or document type they would normally use for their projects. The rough framing estimate included, but was not limited to: Framing, Roofing Materials, and the Exterior Enclosure. These items were chosen specifically because all three contractors, which participated in the case study, self-perform that type of work.

While the estimates were being prepared a BIM model was produced of the same structure in the Graphisoft ArchiCAD 21 platform. This particular software was chosen due to its relatively low price and quick quantifying and exporting engine. ArchiCAD has the ability to export all model information directly to an excel sheet. With that information, and a well set up spreadsheet that has the capability of talking with the exported ArchiCAD sheet, an estimate only took a few minutes versus an industry standard of two weeks.

Case Study

Participating in this case study were three contractors from Sonoma County of northern California. All three contractors work on similar types and sizes of projects within that region. However, the contractors have varying years of experience in the industry with a range from 6 to 34 years. This seemed suitable, though, as they might have varying methods for estimating their projects, which they did.

- Contractor A, with the most experience, did hand take offs and formatted all of the information in a well-developed and easy to read excel spreadsheet for their deliverable. To quickly read and search the plan that were provided Contractor A also utilized a pdf viewer.
- Contractor B, with about 25 years of experience, required a paper plan set also did hand take offs with a note pad. They then transferred the data to a Microsoft Word document and submitted a paper copy for their deliverable. No other software was used.
- Contractor C, with the least experience, utilized Bluebeam for both pdf viewing and estimating procedures. An excel sheet, that was exported directly from Bluebeam, was submitted as a deliverable.

The material takeoff quantities provided from the contractors' estimates were compiled into a single spread sheet for a quick comparison of numbers against those obtained from the ArchiCAD quantity export. Due to materials that were left out of the contractors' estimates, and 4 quantities that were extremely erroneous, those particular line items were removed from the delta analysis process leaving 14 material types to compare out of the original 24 line items.

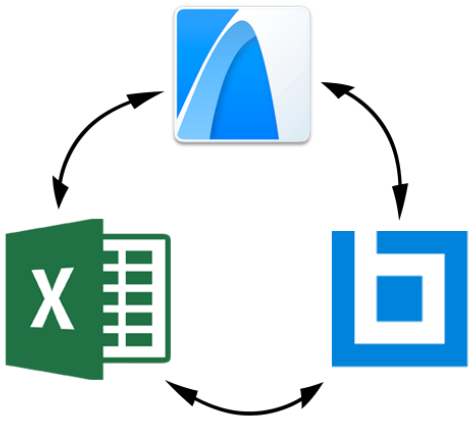

Figure 1: Workflow Utilized to Create Model Based Estimate

The workflow utilized with the ArchiCAD platform is as follows. Plans provided by the architect were reviewed and marked up in Bluebeam with notes for modeling. Those notes were flattened onto the pdf file, was imported into the 2D modelling dimension of the ArchiCAD platform, and then scaled to accurate dimensions. All of the notes added in Bluebeam appeared and eased the modeling process by eliminating the need to cross reference outside of the modeling software. The modeling of the building was straight off the plans which increases the accuracy and speed greatly. After all the 6 hours of modeling was completed the task was to create a spreadsheet that communicated with the property values exported from ArchiCAD. This process was a lot of trial and error but turned out to be successful. The ultimate goal would be to set this sheet up as a live sheet that tracks model changes and effects the estimate as they take effect. However, that was not accomplished with this project but others such as John Hallgarth of 3D Constructor are working on that effect with his ContraBIM theory, (Hallgarth, 2018). This theory is the simplification of BIM processes and ContraBIM is looking at the same workflow that was utilized with this project but from a commercial standpoint.

Results and Analysis

The Excel spreadsheet that was developed to communicate directly with the values that ArchiCAD exported. This spreadsheet automatically calculated totals for all material types that were needed for the comparison in this project. A study done at University of Nebraska reported "…current BIM applications are able to generate fairly accurate physical quantities of materials used in the design. However, due to the lack of context for construction methods and procedures, these material quantities cannot be used directly to generate labor and equipment quantities," (Shen, 2010). This fact is true, however, with a spreadsheet like the one that was created, quantities will associate directly with costs, consumption, waste factors, and labor rates. The best part is that they can be quickly and easily adjusted

Figure 2: ArchiCAD Rendering of the Modeled House

assuming everything is formatted well. A spreadsheet similar to this can be created for any type of project that a contractor may choose to use this software for. It took about 4 hours total to create the spreadsheet itself but taking the time to create it saves hours and even days when it comes to estimating. The overall time it took to do the model based estimate (including modeling) was 6 hours. Contractor A completed their estimate in 12 hours, Contractor B in 20 hours, and Contractor C in 14 hours. Even though the model-based estimate was much quicker than the contractors, one point to keep in mind is if the contractors were to implement this software they first would have to pay for the software and partake in training courses to be able to utilize the tool accurately and efficiently. Once having knowledge in how a software such as ArchiCAD exports its material quantities, they could then create a spreadsheet to communicate with it or utilize one such as those available from ContraBIM (Hallgarth, 2018).

All of the contractors said, in a follow up informal interview, that they would consider using newer technology. However, they were leery about time and financial commitments that would come with incorporating this technology into their workflow. A software like ArchiCAD (which costs $5000) could seem daunting to a small scale residential builder but the benefits might not have been expressed to them, or rather they simply haven't been exposed to it. *Figure 2* below shows quantities by material type from the model-based export and all of the contractors. The quantities were actually fairly close. ArchiCAD matched closest to the contractor with the most experience which made the numbers obtained through the software seem credible. The house that this project was based around was actually built a few years ago but information on material quantities for the actual project is no longer available. Out of interest, and being confident with the information, ArchiCAD was set as the constant and the contractor quantities compared directly to it.

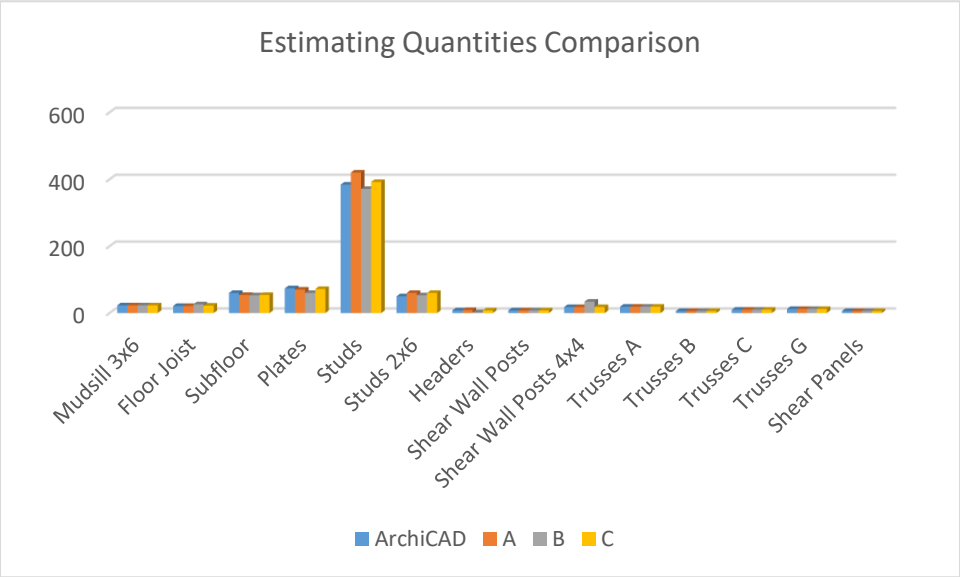

Figure 3: Estimating Quantities Comparison

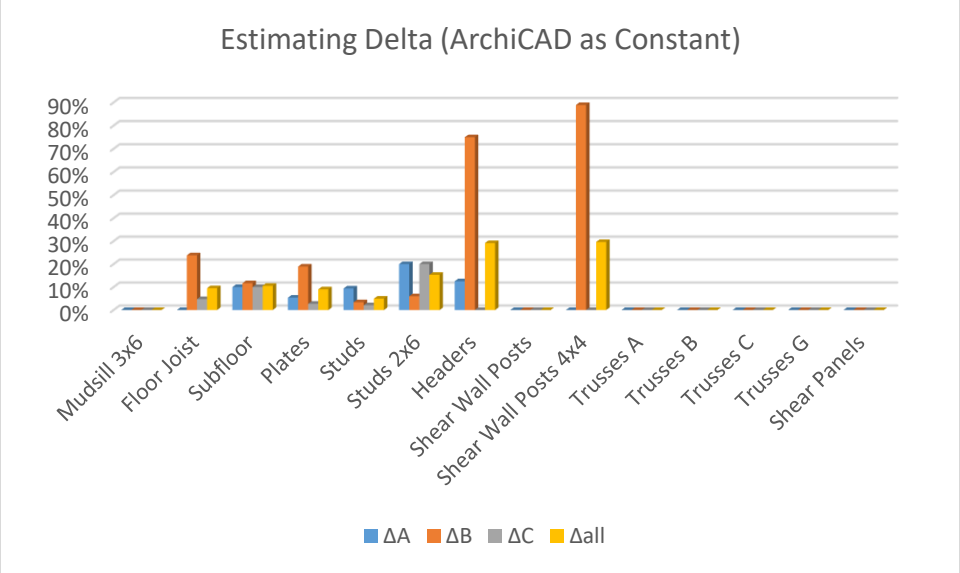

Figure 4: Estimating Delta (ArchiCAD as a Constant)

Figure 3 represents the delta between quantities, still holding ArchiCAD as a constant. The larger deltas were more closely associated with materials that had less quantities. However, generally the materials that have lesser quantities cost more. To view the actual error with a monetary value, cost was established based off of Home Depot online

prices as of May 2018. The following chart, Figure 4, show the materials with an associated cost attached to them. There are both over and under costs. These over/under estimates could simply be an estimating error, or too high of a waste factor. For example, the spreadsheet that was created for this ArchiCAD export may have had too high of a waste factor which caused the other subcontractors estimates to be low for the subfloor plywood. However, that seems to be the only ironic value in the graph. On the far right it shows the Total Difference of all estimated values which is fairly close to the ArchiCAD export. Even though the contractors are within $200 for the entire project, looking at individual elements, for over/under estimates they will have to take into account restocking fees, shipping costs, and labor to install or remove these materials. $200 can quickly amount to a few thousand dollars once all of those elements are included. If the estimated quantities from ArchiCAD are correct the software could have paid for itself with this job alone.

Unfortunately, without the actual data of how much of each material was used to construct the home it is difficult to confirm any cost savings or loss by using a model based estimating program such as ArchiCAD.

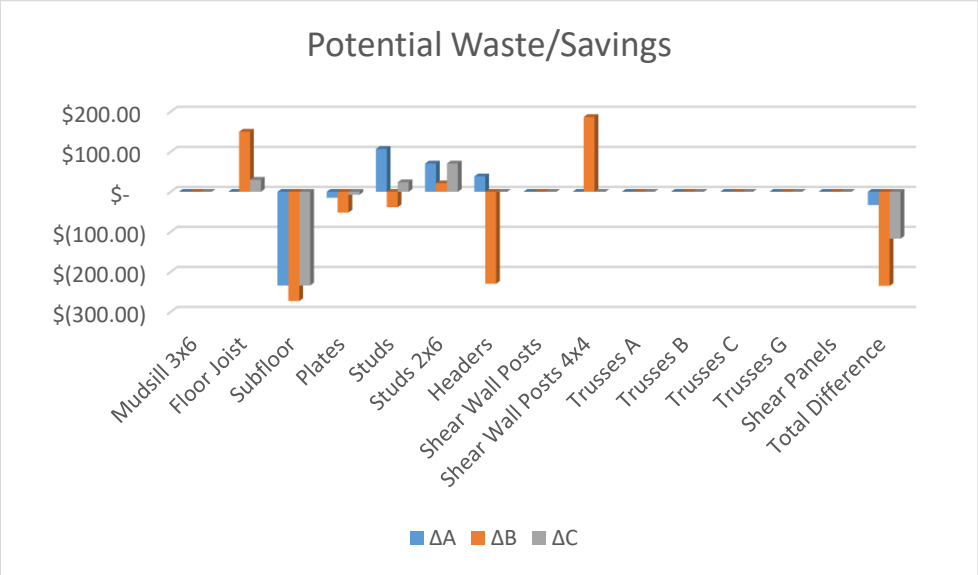

Figure 5: Potential Waste/Savings with ArchiCAD as a Constant

Conclusions and Future Research

A surprising fact that I came across when recruiting contractors for this case study is that most residential contractors have their lumber supplier do the QTO and that is what they use for their estimate for the job. Of course, if that lumber supplier is used for the project, the cost of the QTO is free. This system obviously appeals to most contractors because all they have to do is add their labor and overhead onto the results of the suppliers QTO. However, two of the contractors mentioned the inconsistency of the take-offs done by suppliers, and deliveries with improper materials for the job. These issues could not only delay a project but also cost the contractor a great deal of labor with no progress because the materials that were supplied were wrong. The supplier will have to cover the cost of their error as well, so maybe they would consider a model-based QTO in the future.

An improved version of this project would be to use a project with an accurate material list to test accuracy of the model-based export. However, I feel this was a good starting point on research in this area. The other potential benefits of BIM for residential contractors are not only utilizing visuals from the 3D model, primarily for owner's reference, but to also determine early coordination issues can reduce changes or scope conflicts during of the project. Overall, this project discovered fair accuracy for model-based estimating, the fact that the cost of the software is reasonable for a contractor due to potential savings in cost and time, and that the visual element of BIM can greatly assist their preconstruction efforts. The only question left is what is holding residential contractors back?

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