Building Information Modeling for Nonresidential Construction—An Industry Perspective

Matthew CASH¹, En-dong WANG¹,* and Xiao-ni WANG²

¹University of Tennessee-Chattanooga, 615 McCallie Ave, Chattanooga, TN, U.S.A.
²Xinda Engineering Designing Company, Weifang, Shandong, China

*Corresponding author

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Abstract. More than traditional computer-aided design (CAD), Building Information Modeling (BIM) can include a lot of additional information about the various products and systems in the design. It was noticed that BIM had unbalanced applications among different types of construction. BIM has been shown to provide a significant cost savings to the design firms and clients by its use in residential construction. Yet, it has limited use on a very small number of industrial construction projects. Rather than performing a theoretical cost analysis on BIM usage to prove that it could save project cost, this paper explores the specific benefits that BIM provides from an industry perspective, and see how they would translate to the industrial construction sector. To do this, BIM users in industrial and commercial construction are surveyed. The first-hand survey results revealed that the two biggest benefits to BIM are clash detection and the large amount of information it can provide to the entire stakeholder in the project. Comparing these benefits to the current practices used in the industrial engineering and construction field leads to the conclusion that, BIM usage is probably not worth the cost investment for these firms. There are some additional considerations as to why including BIM capabilities in a company’s profile would be a good option, but cost savings is not the most important.

Introduction

BIM is being increasingly adopted by residential and commercial sectors in the U.S. due to the versatile functions and interoperability embedded in the technology. Based on National BIM Standard-United States® [1], a BIM is “a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onward.” This definition identifies the core technology functions of visualization, parameterization, and informatization. With these technical functions, BIM has been widely used for designing, estimating, scheduling and life cycle analysis for both residential construction (e.g. dwellings) and commercial projects (e.g. campus buildings) [2,3,4]. Industrial construction consists of engineering and design of power plants, chemical facilities, and refineries, etc. Though they all have the same basic steps to completion as residential and commercial projects, they vary in the implementation of those steps. The 3D modeling software has been used in industrial facility design for decades, but it was almost solely as a space management tool. Technologically, BIM is more than just space management. The physical building properties can be shown by BIM as in traditional models. Also included are the facility systems and their relationships with design elements. These systems and relationships have an influence on the facility not only in the construction phase, but also over the life cycle of the plant. This adds two dimensions to the standard three in traditional models [5]. These five dimensions are length, width, height, time, and cost. The five-dimensional models of facilities provide a clear and understandable way of relating all the impacts of project decisions for all of the project’s stakeholders. It also ensures that all parties have the same information and understanding.
If there are all of these theoretical benefits to using BIM, why then would industrial facility engineering and design firms not use this powerful process? The main goal of this paper is, from an industry perspective, to determine why BIM is not used in a broader scope, as well as determine the cost benefits of using BIM in design and construction. Especially, the viewpoints of commercial and industrial practitioners are investigated.

**Methodology**

The goal of this project is to determine not only the cost savings of using BIM on nonresidential projects, but also the major benefits and obstacles in the utilization of this technology. Especially, it is to understand the reasoning for industrial engineering and construction firms not to utilize BIM in their project execution. In order to perform the analyses, a usage survey was conducted with current BIM users in large Engineering, Procurement, and Construction (EPC) firms for industrial and commercial projects. The survey needs more than just designers or constructors, as the intent is to determine the overall cost benefit of BIM technology. As such, an attempt was made to contact several different engineering and design firms with experience not only with using BIM in design, but also in construction as well. The survey response provides qualitative information on BIM usage by individuals who have experiences with this technology. The below shows the seven major questions on the questionnaire:

- Can you give a brief description of your occupation, company, and work history?
- How much experience have you had with BIM?
- What is the biggest benefit that you see with the BIM as it is currently set up?
- What is the biggest drawback to using BIM?
- How much experience do you have with traditional CAD? If so, what would you say is the biggest difference between the two systems?
- Do you have any experience with different BIM software packages? If so, can you elaborate on any differences and how they might affect different construction sectors?
- Are there any additional comments you would make regarding BIM usage in the industrial construction environment?

There are some issues with this population, which limits the results for the survey responses. Firstly, the number of surveys sent out is limited by both the authors’ contacts and the number of companies that perform industrial construction. Only the results of those who could be contacted and responded were used, as this was a survey-driven project.

**Survey Results and Analysis**

Creating the survey pool was a challenging task, as there are not a large number of BIM operators in the industrial construction sector. Using a contact list, we reached out to several different commercial and industrial EPC firms. We were able to get five responses from BIM operators (Table 1). From Table 1, all the interviewees are at higher technical director positions with an average of 14 years working in EPC. They are familiar with the mainstream BIM tools, especially Revit. It means that, all the interviewees own enough capabilities in assessing BIM technology for the interview. Several of the people who responded also provided additional feedbacks, in both print and through phone conversations. The obtained responses are summarized as below.
Table 1. Qualifications of the interviewees.

<table>
<thead>
<tr>
<th>Responder</th>
<th>Occupational role</th>
<th>Work history</th>
<th>BIM tools used</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Virtual design and construction lead</td>
<td>25 years</td>
<td>Revit, Navisworks</td>
</tr>
<tr>
<td>B</td>
<td>Part of practice technology group</td>
<td>11 years</td>
<td>Revit</td>
</tr>
<tr>
<td>C</td>
<td>Director of virtual technology group</td>
<td>11 years</td>
<td>Revit</td>
</tr>
<tr>
<td>D</td>
<td>BIM manager</td>
<td>9 years</td>
<td>Revit, Navisworks, BIM 360 Glue</td>
</tr>
<tr>
<td>E</td>
<td>Director of virtual design and construction</td>
<td>15 years</td>
<td>Revit, Navisworks, Bentley Microstation</td>
</tr>
</tbody>
</table>

Based on Responder A, the biggest benefit from BIM is the ability to visualize work, especially in resolving coordination issues between disciplines. BIM helps with estimating, as they come with an ability to extract quantities. This saves estimators time in preparing bids. Throughout vast experience, Responder A continues to notice how clash detection has been able to save money. Responder A only sees two small down sides, and one is the small lost productive time as new users learn the technology and its updates, which can also be found in Bouška (2016) [6]. The other is that there can be some difficulties in getting all the information to the users due to the fact that the companies don’t have the same technological compatibilities. Responder A notices that on projects, the design hours may not be affected by the different software used, but the better coordination that comes from using BIM results in savings in the construction phase.

Responder B has been involved in projects that have taken full advantage of BIM capabilities. The system has the ability to integrate all the information and data from a project in one place, but it is difficult to utilize it in constructions phases. This could be due to access to the technology or general resistances in the industry to change the way things are done. Responder B has experienced a multitude of savings on projects as a result of utilizing BIM methods, but there are no standard metrics for those savings. Those savings have been in design hours due to a reduction in the need to check/re-check work as all disciplines work is combined into the same model. Responder B believes that BIM is a tool for aiding in project execution but is not a magic fix for all the problems in the industry.

Responder C works on both industrial and commercial projects in chemical, pharmaceutical, manufacturing, pulp, and nonwovens markets. For Responder C, the biggest benefit to using BIM is the ability to modify and use the information in the model based on the needs. It can eliminate design conflicts, coordinate construction activities, generate cut sheets for fabrication, as well as digital hand off for future needs. Responder C does provide an example of an industrial project, where BIM saved money. As machinery was being dismantled and relocated to a new facility, the company put the field measurements into BIM to construct the new facility where the machinery was headed. The coordination led to there being minimal construction conflicts, which resulted in savings for the company and the client. Due to extensive work history, Responder C has seen more drawbacks. The biggest issue is the misconception of the efforts required to utilize BIM. It can be a time consuming and intensive process.

Responder D has worked on various commercial projects including healthcare, higher education, and office spaces. Responder D sees three big benefits to BIM, covering resolution of clashes in design phase, design confirmation, and plan visualization. If a client can confirm that the model reflects their intents, then there are no surprises during construction and closeout. The ability for the construction team to visualize the work can help them to formulate a better execution plan based on the added information that comes with BIM. The biggest issue that Responder D sees is that there is a lack of experienced professionals to operate BIM.

Responder E believes the biggest benefit to BIM is the great amount of information and collaboration. As more stakeholders and design disciplines are involved, the earlier potential issues and conflicts are resolved. Responder E echoes previous responders’ belief that the only drawback to BIM usage is its lack of total embrace by the industry. There are not enough professional users, and not enough companies have the capacity to use BIM. As far as the economic benefit is concerned,
according to Responder E, the average duration was reduced by 20% for the entire division. For them, many jobs contain a large amount of pipe design and routing through a facility. The company used a three-dimensional CAD for those projects and spread to other divisions for consistency. There was no need to spend capital on rolling out and training for BIM.

From the above results of the survey, overall, the responders are positive and reflect what has been consistently shown through research, and that is, the benefits of using BIM outweigh the costs for commercial contractors [7]. The major benefits include clash detection, duration reduction, coordination benefits, and cost saving. For example, according to Responder D, by looking at the routing of ducting, piping, electrical raceway, and lighting, the constructors can coordinate their plans and prefabricate the installed materials. Labor costs are lower on shop fabricated items versus those built in the field. The commonly mentioned drawbacks are related to learning curve effects, limited technological capabilities, general resistance, and time-intensive BIM process. However, most responses are from commercial sector and have limited experiences in industrial sector affecting the ability to extrapolate the results. Responder A does call attention to the ability of three-dimensional modeling to help with conflicts and making changes earlier in the project timeline. Likewise, the experience and anecdotal evidence from Responder B does not provide any new information related to the industrial construction sector. Responder C echoes previous sentiments, that the BIM model is limited by the technical capabilities of each user. Contractors and clients might not have the software to be able to utilize all the information that could be put into the model, which may also apply to the industrial sector. During discussions with Responder E, it becomes clear that large industrial design firms have been using three-dimensional modeling as long as the technology had been available. As the use of the model in design has grown, so too has its use in construction. These industrial construction firms have already been developing their construction execution plans with the model. Responder E’s company have plans and procedures in place that were built around the utilization of these models, and these plans and procedures have let the projects to being successful in the project execution.

Summary
A multitude of theoretical studies showed how beneficial BIM could be to not only a client’s bottom line, but all the stakeholders in the projects. Since this information has already been available to the industrial firms, a question becomes why they are not utilizing the technology. Utilizing a survey of professionals in this environment, this paper attempts to determine what the users feel are the biggest benefits and barriers to BIM utilization, as well as ascertain their thoughts regarding applications for the technology in industrial field. Overwhelmingly, the most the responses to the surveys indicate that the early clash detection is of the greatest benefit to the design teams. The ability to show all the aspects of the project and their spatial relationships, will give the design team the ability to make corrections and adjustments before the project has moved to the construction phase. This saves all stakeholders in a project both time and money. However, this benefit is not unique to BIM and it also applies to traditional 3D models. Industrial design and construction firms have already used the traditional 3D CAD models. This means that there is no benefit for these companies to invest in BIM products. The other benefit to BIM is the ability to include additional information about building systems for future use. While this benefit is very helpful in many commercial applications, the complexity of systems in industrial facilities impacts the benefits to BIM. Most industrial projects will have engineers and designers working to integrate equipment, instrumentation, and individual systems into a single process that meets clients’ needs. This can include not only the materials of construction, but also the specifications for instrumentation, equipment information and capabilities, process flow rates, power and cable requirements, as well as a large amount of other information that is not necessarily included in all the commercial buildings. As helpful and beneficial that BIM has been shown to be, there is a cost impact to adding this technology to industrial EPC firms’ capabilities. This is currently viewed as an unnecessary cost, as the major cost savings that BIM can
provide have already been utilized through the standard three-dimensional CAD models and standard engineering processes in these firms. Moreover, technical difficulties are also being faced by construction firms which could be another barrier for the wide application of BIM technology.

References


