Stacy Meyers
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Honors Paper

Building Information Modeling Software

Construction is a constantly evolving industry which is largely controlled by the economy. The economy is not doing very well right now which is causing construction industry professionals to work twice as hard in order to estimate more accurately, negotiate more carefully, and take more risks to acquire work. Professionals in the construction industry are innovative and hardworking people who are always ready to work harder and smarter when times get tough. In order to help combat these hard times along with helping move the construction industry into the 21st century, this article is going to evaluate the use of Building Information Modeling o(BIM).

"Building Information Modeling is the digital representation of the 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 lifecycle from inception onward."[1] BIM has been around for quite some time, however, it has not caught on and been used to its full capacity within the construction industry. BIM when used as a Virtual Design and Construction tools, allows the user to simulate the construction of a building in the virtual world before it is constructed in the real world. The 5-D model consists of the normal X, Y, and Z dimensions along with time as the 4th and cost as the 5th dimension. The ability to view many of these unknowns in a digital format before any ground is broken is only half the beauty of BIM. The ability of the user to extract quantities from the model for estimating purposes and also the ability to simulate the schedule is the other half of its invaluableness to the user. When created correctly and accurately, the model allows the user to estimate large quantities of building materials such as concrete, rebar, and drywall as well as the smallest components such as welding plates and bolts. However, this is prefaced with the caveat that the estimate is only as accurate as the drawings. The ability to estimate this project is useful for both the preconstruction process and the as-built drawings. The use of an as-built set of drawings to generate an estimate can help both the construction team and the owner. Having estimates from as-built drawings will help everyone involved see what the building should have cost compared to how much it was built for and where the differences within cost might have come from.

Scheduling within BIM is a more sophisticated way of showing an owner a typical construction schedule by showing what the schedule will look like in comparison to the construction process. This means that within a certain piece of software used for BIM (e.g. Navisworks) one can link the construction schedule to the final model and watch a simulation of the building being built day by day in real time.

As noted in the previous section, the entire BIM process can help the industry become more efficient in several ways. Outside of estimating, scheduling, and clash detection, the process of Building Information Modeling encompasses many types of

software that improves the construction process. This article is going to discuss some of this software along with their pros and cons.

The first two software packages this article is going to discuss are Autodesk Revit Architecture and Bentley Architecture. Both programs are widely known throughout the construction industry. Keith Bentley founded Bentley Systems in 1985 and produced the first CAD software called Psuedostation in 1986. Over the years, Bentley software evolved and by 2008 Bentley released its first software package that could view real time plans, sections, elevation and clipping plans.[2] Revit is a software program an Autodesk, a company established in 1983 when AutoCAD was first released. AutoCAD evolved throughout the years and acquired Revit in 2000.

Bentley's software is based on a file-centric idea. Each project created within Bentley is broken up into several files and coordination amongst those files occurs when the user chooses to collaborate using them. In regards to response time, drawing in Bentley software is like drawing in 2D, whereas, Revit is a database-centric program where anything drawn within Revit is coordinated with a database. This causes Revit to have a slower response time and very advanced hardware requirements. However because of this database system, Revit has the ability to link all components within a model. In describing the parametric features of Revit, Bill Koster, a principal at MVE Institutional noted, "And as we make changes, it updates all the different components at the same time. It works the way architects work." [3] This feature makes Revit a very popular software package. By completely changing its interface in 2010, Revit's user friendly feature provides for a wider use of the software in the architecture, engineering and construction (AEC) industry. Revit Architecture 2010 now contains a ribbon interface much like what is used by Microsoft Office 2007. Also, the tabs within Revit are task-based and self-explanatory. For example, the home tab has everything needed to create a new model and the insert tab has tools for the ability to add and manage things such as images and CAD files. This allows for quicker learning which has lead to a wider acceptance among the construction industry. Conversely, Bentley has a more complex system based on their believe in "not starting over" with a new solution when they came out with their new V8 software. As a result in order to use Bentley's architecture software, the user must learn how to use the architecture specific software along with their existing MicroStation platform and Triforma extension. Based on this information, it seems that the learning curve for Bentley Architecture is steeper than the learning curve for Revit Architecture. Therefore, it is more likely for Revit to be used more often as it continues to be improved. User friendliness seems to be one of the main reasons for choosing and learning a new software because time is money and nobody wants to waste time learning new software. Based upon this information, it seems that Revit Architecture is a more superior software choice than Bentley Architecture.

The next two software applications that this article is going to discuss are Autodesk Ecotect and Autodesk Green Building Studio. Using BIM simplifies the entire design process, however, it does not end there. Using one simple computer file allows one to have access to a complete set of electrical, plumbing, mechanical, and structural files off of one architectural model. The architectural model can be

modified to construction specs allowing for things such as wall types and their materials to be modeled exactly how the final product will be built. After all of this information are inputted, schedules and quantities can be generated allowing for a more precise shopping list for purchasing materials. The ability to generate schedules and quantities is where the sustainability aspect of BIM becomes important. Less construction waste on a job can be a direct benefit of using BIM.

Ecotect is a piece of software created by Autodesk that performs sustainability analysis on BIM models. "Energy Analysis requires spatial information – it is essentially a simulation of energy movement in, out, and through rooms and volumes within a building." [4] This shows which surfaces are exposed to sunlight and how much heat is gained. A few things must happen in order for the sustainability analysis to be most advantageous. First, create a Revit model early in the design process. Second, model floors, slabs and ceilings in addition to walls and windows. Lastly, make sure to connect all walls, roofs, slabs and ceilings. [4] Ecotect will then analyze the building and study the shading effects of the building components. Ecotect software only analyzes sunlight and the effect of natural lighting in a building. AECOM architecture used Ecotect on the NASA Research center at Moffett Field and agreed that the use of the software cut down on costs and materials used. "We were able to optimize the day lighting, making sure that what we created worked for the benefit of the building from both an engineering and cost stand point. Ecotect Analysis helped us study the impact of potential design changes faster, more effectively, and earlier in the design process." [5] Another sustainability software that Autodesk has on the market is Green Building Studio. Autodesk Green Building Studio links the architectural model and other 3-D CAD designs in order to analyze energy, water, and carbon consumption. This piece of software is especially easy to use and has been catered to architects who may not know much about green building. This web-based service was created in 2004 and by 2007 it had met all AHRAE 140 standards and was certified by the United States Department of Energy. [6] This energy analysis is based on the building's size, type, and location. The service will then determine the best material, construction system, and equipment by using regional standards and codes. Using drop down menus, architects can change any of these aspects such as building orientation and window U-values. Green Building Studio uses hourly weather data, as well as historical rain data that are within nine miles of the buildings location. [6] This web based program will then compute within minutes the building's carbon emissions, estimated energy, and cost summaries. The output will also show water usage and costs and electricity and fuel costs.

Between these two pieces of software, Green Building Studio seems to be the more rounded piece of software. Each piece of software is equally easy to operate. However, Autodesk Ecotect only analyzes day lighting while Green Building Studio analyzes water, energy, and carbon uses; thus making Green Building Studio the better software of the two for analyzing sustainability within BIM.

The next two sets of software this article will analyze has to do with operational management. During the process of construction, many transitions occur. From design to procurement, to construction, to turning the building over, information gets lost along the way. "In a 2004 National Institute of Standards and Technology study undertaken to estimate the efficiency losses in the United States

capital facilities industry, it was reported that the annual cost (in 2002) associated with inadequate interoperability among computer-aided design, engineering, and software systems was 15.8 billion." [7] Data quality is often glossed over and brushed of; however, when handing a building over to a non-sophisticated owner, accurate user manuals are needed. The number one quality of Building Information Modeling is the ability to produce coordinated, consistent, computable information about a building. Therefore, the first program to analyze is FM Interact Workplace Management Suite by FM Systems. With FM an organization can:

- Manage a facility across multiple locations
- Access property information with a simple point and click map-based interface
- Run live reports, view floor plans, search archived drawings and critical documents
- Share facility data with management, partners, and internal customers via your corporate intranet
- Dynamically search for employees and related information
- Streamline the help desk, work order and move processes
- Provide responsive and efficient service to the organization [8]

FM has three main modules consisting of:

- Space Management which allows the user to view each space within a building, check its occupancy, and manage your ability to make a profit off of each space in your building.
- Strategic Planning which allows the user to enter estimates such as a headcount and space needs. Then the Strategic Planning module will create "what if" scenarios to show the owner what could happen to their real estate in the future.
- Asset Management which allows the user to track multiple types of assets – office equipment, furniture, lab equipment, or corporate artwork.

FM also has many interactive extensions consisting of Move Management, Real Estate Portfolio Management, Facility Maintenance Management, Project Management, and Sustainability.

The next piece of software to analyze for operations management is Bentley's Facility Planner. Facility Planner is a powerful piece of software for facility managers and owners. Facility Planner has the ability to:

- Calculate area based on floor plan data
- Provide scenario planning for both graphical and database information of spaces and assets
- See and quantify the effects of changes without altering the as-built data [9]

Bentley Facility Planner also has an add-on called Facilities Inquirer which allows you to share information through the web. This gives you the opportunity to edit and change facilities data, publish floor plans, locate equipment, and submit work orders.

Both pieces of software are incredibly useful for managing a building once construction is complete. In this situation, it is hard to choose which piece of software has better performance. FM is more useful for a commercial building that

is going to be rented for a profit. FM has more capability to access each space individually, monitoring its occupancy, and choosing how to better invest one's space for more profit. Bentley's Facility Planner is a program that would be more useful for University buildings or facilities of this nature. The ability to view the equipment within the building, submit computerized work orders, and view floor plans along with the 3-D models is an extremely useful tool. If future expansion or renovation is likely to take place, the ability to view the as-built drawings is very handy with FM.

  The last two pieces of software this article is going to analyze deal with mechanical, electrical, and plumbing systems. The MEP systems within a building are the most important systems and the cause of most change orders. Usually the MEP system within a building has to fit in a very tight space. The problem is that each system must closely coordinate with other systems to figure out which subcontractor will hug the ceiling and which will be the closest to the floor. However, because subcontractors usually just want to do their part and get paid, there is not a lot of communication among trades. This causes change orders in the field, time wasted, and extra money spent. However with the use of BIM, all of the coordination can occur in the preconstruction stage with one meeting while looking over a 3-D model. With the use of MEP software, the MEP systems can be modeled and checks for clashes can conducted before they occur in the field. This allows more coordination between the subcontractors before anyone enters the jobsite.

  The first software to be discussed is Bentley Hevacomp Mechanical Designer V8i. Mechanical Designer allows you to "calculate peak loads, generate schedules and material lists, size pipe and duct systems, and choose the correct equipment." [10] Mechanical Designer is an intuitive, easy to use program. There is a database in which you choose all the components and place them into the model. This allows for ease-of-use and accuracy in choosing the right equipment.

  The second piece of software is Revit MEP. Revit MEP enables a holistic design approach where the electrical and mechanical design systems "talk" to each other. The Electrical Engineer can look at the mechanical drawings and track the electrical requirements needed for the HVAC equipment. Revit features automatic sizing and system layout tools along with flow calculations for maximum performance and efficiency. Another advantage is avoiding interferences between the architectural, structural, and MEP models. All of these features make the construction process more accurate and fluid.

  Based on the analysis of these two pieces of software, they both seem to be comparable with each other. Both Hevacomp Mechanical Designer and Revit MEP software have a database along with the ability to size and choose the correct equipment needed for the building. Hevacomp and Revit MEP both have the ability to produce an equally useful model and thus both are a good choice when constructing an MEP model.

  BIM is a powerful tool when used to its full potential. The software has become widely used and is more frequently used on the West Coast than the East Coast of the United States. However as time passes and owners require stricter deadlines and tighter budgets, BIM will be used more often. BIM allows architects, engineers, and construction firms to communicate earlier on in the construction

phase which causes less adversarial relationships along with a more fluid construction process. Many large firms are already implementing this software into their everyday contracts. Multiple large projects such as the Minnesota Twins Ballpark in Minneapolis along with the Baltic Arena Sports Stadium that will host the 2012 World Cup Championship used BIM to ease the construction process of these elaborate projects. There are many software packages to choose from to create a Building Information Model. Some are more useful than others and some have a steeper learning curve than others. However, it is to every construction firm's advantage to learn the software and process of BIM and use this ability as a marketing advantage for acquiring future projects..

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