Feasibility Analysis of Initiating Building Information Modeling (BIM) for HVAC systems by General Contractors

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Abstract:

The construction industry is ever-evolving and consistently using innovative approaches to improve the construction delivery process. This research investigates the viability of using Building Information Modeling (BIM) by the General Contractor (GC) to detect potential construction errors or clashes, and to improve the project scheduling. The object of this study is to demonstrate the practicality of initiating a BIM model by the GC to identify potential clashes between the different building systems (mechanical, structural, and architectural). A team of researchers from Southern Polytechnic State University (SPSU) collaborated with a GC to study the feasibility of initiating BIM models by General Contractors. A faculty member and a graduate student who both have extensive experience in using BIM created a BIM model for a portion of a hospital project. They used AutoCAD construction drawings as a base for the BIM model. The BIM model will be used to coordinate between the Architecture, HVAC systems, Fire Fighting systems, plumbing systems, and medical gas lines. While BIM was proven to be useful in detecting design conflicts, this study made it clear that with the absence of this model during the design phase, the amount of time and effort required to develop an accurate BIM model is excessive, and might not justify the efforts involved in developing the model. Due to the nature and complexity of the task, developing BIM models took approximately 120 hours to create. In addition, this research proved that, if developed accurately and with detail, a BIM model can be used to in lieu of shop drawings. However, such a model requires extensive knowledge on the different specialty trades to meet the technical specifications and technical detailing that goes into the shop drawings. This means that one designer cannot have adequate enough qualifications to develop the BIM model for all trades. The outcome of this research

demonstrated the need for a new approach to using BIM in construction. In this approach, all trades involved in the project should have the technical BIM capabilities to collaborate, ensuring the accuracy of the BIM model. This allows all parties to use a BIM model during the duration of the design and construction phases as well as the operation and maintenance phases. This approach will also help in sharing the responsibilities of generating and using the BIM model.

Introduction:

The construction industry today seeks ways to assign information needed for projects where the information obtained provides a sustainable approach to the design process. Building information modeling (BIM) is a great tool in coordinating the different disciplines of the design. BIM is proven to be most effective especially in the commercial side of construction. Construction teams embracing BIM, along with virtual design and construction software, are discovering that these tools enable sustainable construction management (Diane Green 2009). Subcontractors can also benefit from BIM by using it to coordinate their work with other trades on a daily basis. BIM has many advantages that help trades who want to implement the Virtual Trade Coordination process on their project. This study is related to designers/drafters who would like to develop the drawings of a project on BIM to the construction process. Major BIM vendors are working on interoperability standards and are acquiring analysis software with an eye toward developing integrated suites of services (Diane Green 2009). The objective of the challenge was to demonstrate the capabilities of the proposed BIM software to identify any potential clashes of materials with the structure of a building to reduce change orders and to improve scheduling. BIM provides a shared and integrated resource for all members of the project team, facilitating visual decision-making and fostering collaboration (Diane Green 2008). The BIM design software allows you to identify interferences between the architectural, structural and MEP elements to minimize conflicts in the field. Ilana Hellman, a mechanical engineer with the U.S. General Services Administration in Washington DC, suggests that, "Visually modeling a project early in the design process promotes stakeholder participation and better communication between owners, the design team and other stakeholders in the process," (Diane Green 2008). Most General contractors would like to add their construction project schedule into BIM which makes BIM favorable when compared to other 3D software products available on the market (Joe Florkowski 2008). By linking the BIM model to the construction

schedule, a project team will able to visualize the workflow and optimize the installation sequencing.

Assumptions/ Methodology

Literature reviews were conducted in relation to the benefits of BIM and the coordination needs for developing a successful and green design. This study focuses on the significance of utilizing the clash detection capabilities of BIM and the benefits of linking a project schedule to BIM. The study also assumed that resources are allocated to develop, implement, and incorporate BIM into the design process. However, the study assumed that one designer is sufficient to develop the 3D drawings and that the participation of specialty trades and consultants play no role in the design process. An existing 2D drawing in AutoCAD was obtained from a general contractor for the purpose of developing a 3D drawing. A medical building was assigned for the proposed objective. Revit Architecture and MEP were the softwares used to translate the existing AutoCAD drawings into a 3D model along with the information associated with the 3D model. The primary focus of the design of the medical building was on the mechanical, plumbing, and structural part to analyze the different components and run the clash detection software. Revit Software from Autodesk was used for BIM. In order to interpret the different components considered for design, a literature review was undertaken. Then special building components (component library) were developed in Revit to have the elements necessary for the assigned medical building design. A schedule was established for the medical building for the purpose of linking the schedule to the Revit model to assure adequate sequencing of project activities.

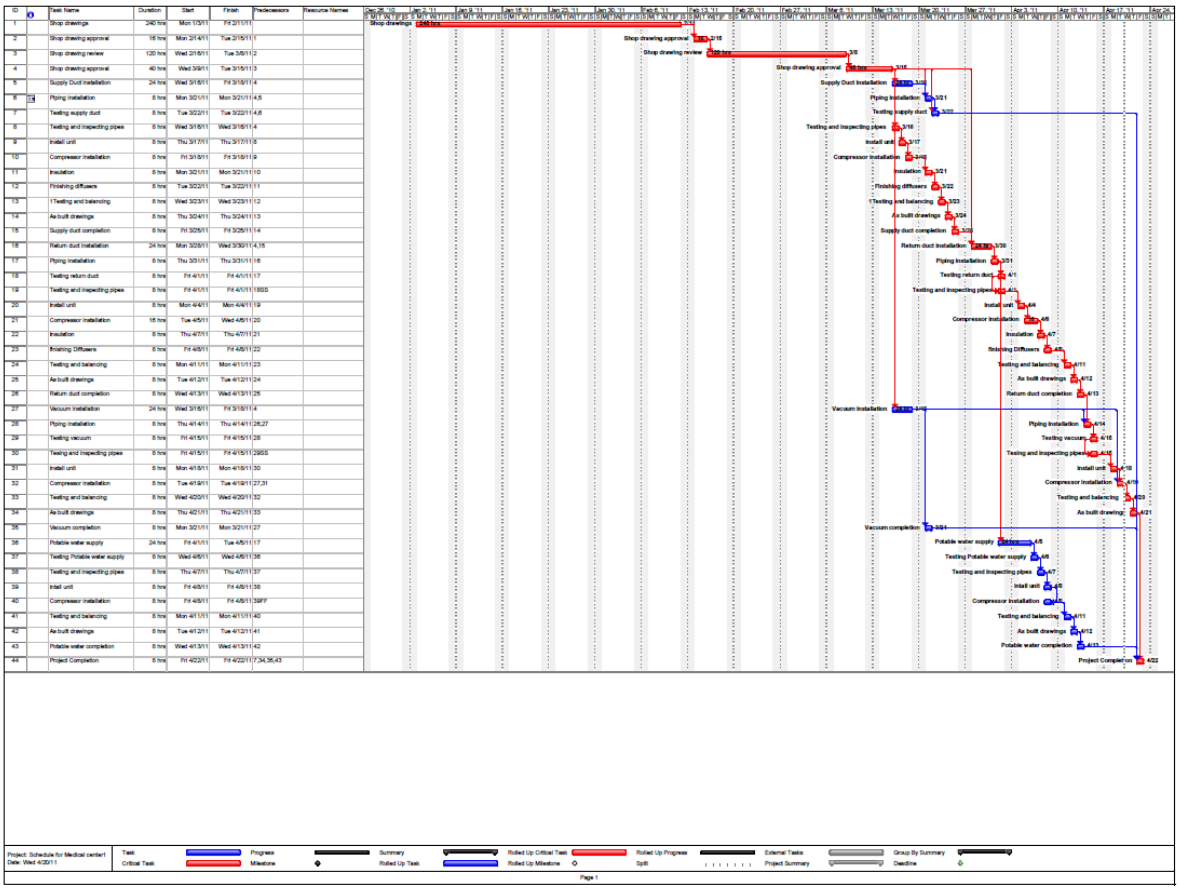

Figure 1.4: Project Schedule

Navisworks software was utilized for the clash detection and schedule sequencing processes. Navisworks allowed me to run the clash detection then print a report that documented all clashes that occurred in the design. Navisworks also was used to import the schedule and link it to the Revit 3D model. Figure 1.6 shows the view of the structural elements clashing with the mechanical components prior to running the clash detection process.

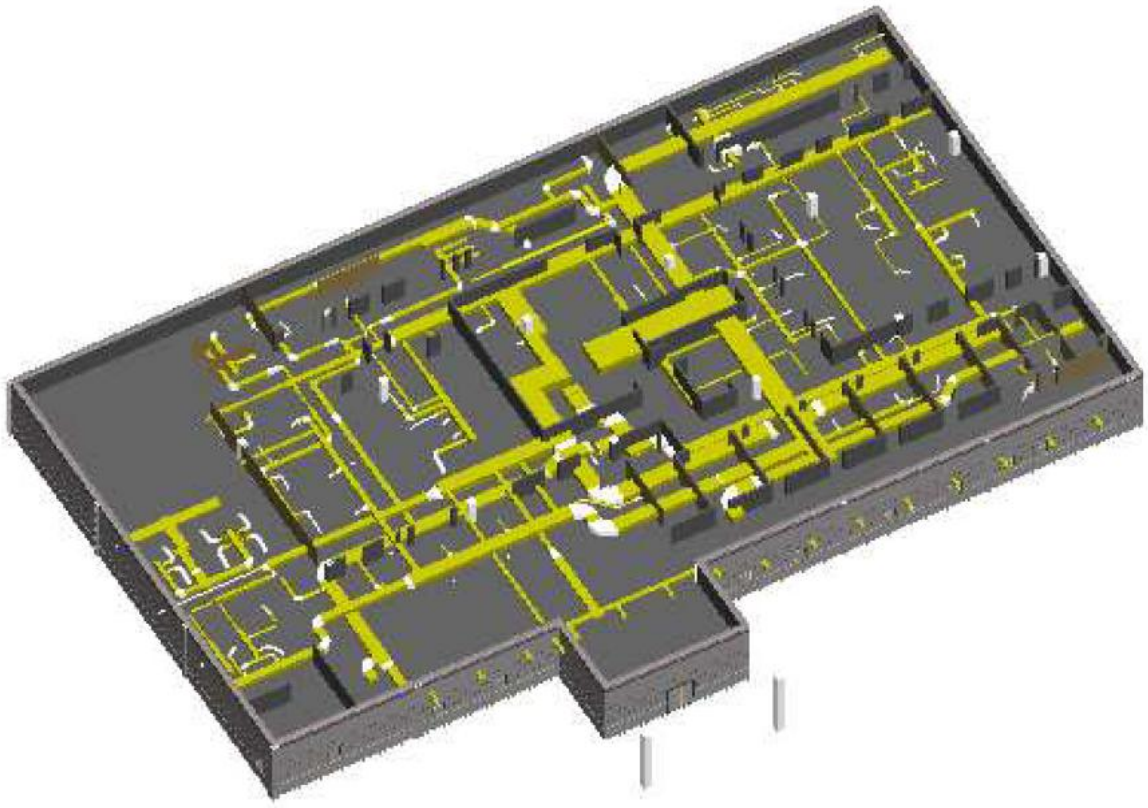

Figure 1.6: View of structural and MEP in Navisworks

Analysis and Results

The idea of being able to develop a 3D model which can help the design and construction process can prove to be useful. A 3D model would also prove effective when the different trades collaborate through the design process. However, having only one person develop the 3D drawings is a different approach which requires the person who is developing the model to have the experience in all the specialty trades including MEP, structural, and architectural to be able to produce a reasonable design. Figures 1.1 and 1.2 demonstrate the different views of the proposed medical center.

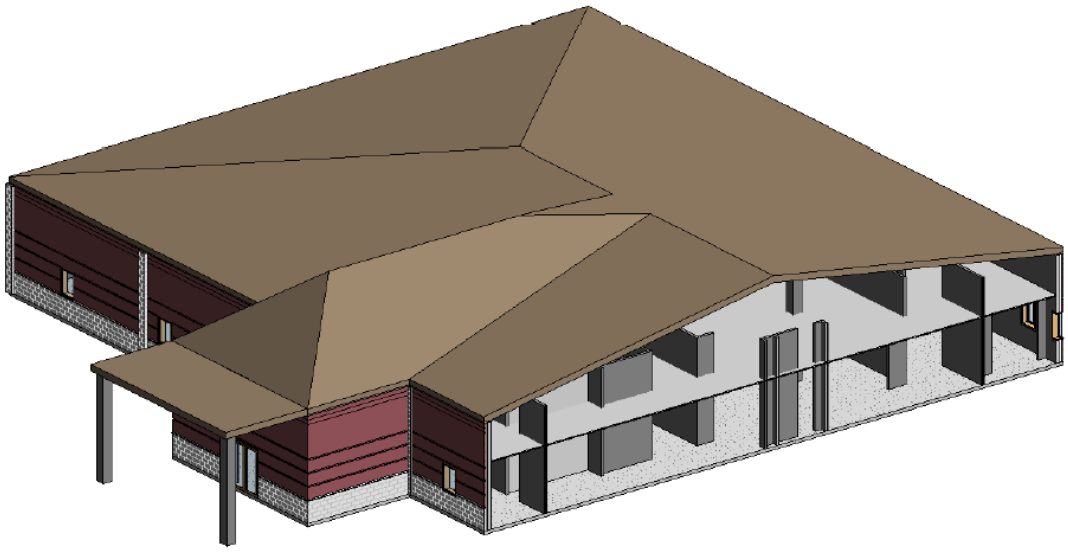

Figure 1.1: Revit Architectural (West Side)

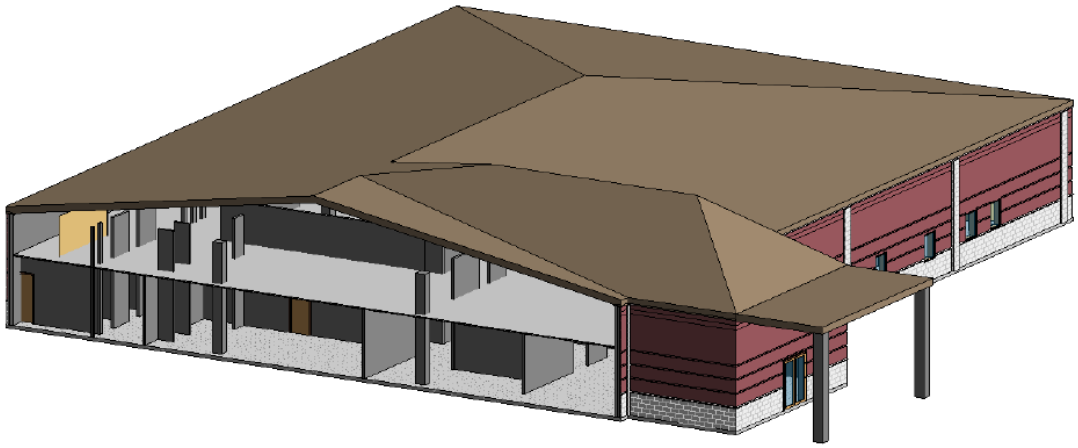

Figure 1.2: Revit Architectural (East Side)

The process is difficult for a designer when they lack the overall construction experience as they spend more time understanding the components or elements of each individual specialty trades. This observation was discovered during the design of the 3D model in Revit. The desired medical building required focusing and paying close attention to the interpretation of the mechanical and plumbing components in order to produce the model. The figure below shows the HVAC work that was incorporated into the design.

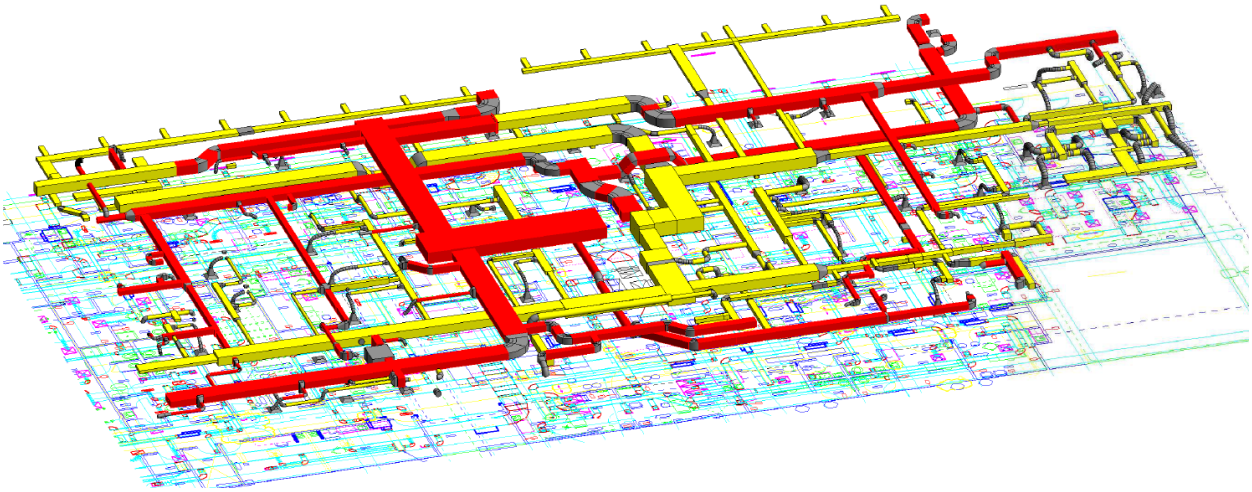

Figure 1.5: Plan view (MEP)

This translated into excessive time spent to develop the BIM model due to the nature and complexity of the drawings. We believe that BIM would be ineffective if only the designer develops the BIM model.. In addition, with all the detailing and component interpretations involved in a desired model, the designer might bear most of the responsibilities of any deficiencies or mistakes that might occur from the design. Therefore, the designer carries a great burden and overwhelming responsibility to assure the accuracy of the design. This means that liability of design would be shifted solely to the designer himself which creates a disadvantage to the designers who wish to develop the model on their own.

Conclusion and Recommendations

This study was intended to demonstrate the capabilities of the building information modeling software (BIM) to improve schedule sequencing as well as to identify potential clashes in the construction of the building. The absence of the proper experience and no design team collaboration affected the time to develop the model within the timeframe desired. A designer can accomplish the design of a model with a shared knowledge resource throughout all phases of the design. There is little empirical data regarding BIM application and it use because BIM is so new in the US Architecture, Engineering, Construction, and Operations industry (Patrick and Raja 2007). Only 25% of companies currently use BIM as their primary design communication

tool (Eastman 2008, p. 292). As a result, there must be a shared vision and team management to implement the applications of BIM which then positively impacts the design process in which the design becomes sustainable. It is a recommended approach that the design be created with all trades involved in the project with collaboration and consultation. Companies should begin using the software on a simple or low-risk project (Ernstrom et al. 2006, p. 11). Architects and contractors should collaborate with greater efficiency and interpret the project more accurately (Brady Schimpf. 2010) Also, during the design of a model, the design responsibilities and liabilities must be shared equally to relieve the idea of a single liable source.

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