Integrity of Revit with structural analysis softwares

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Abstract. This paper investigates how the utilize of Building Information Modeling (BIM) can be a useful platform for engineers. The interlinking of Revit with structural analysis software like Robot Structural Analysis and Etabs is evaluated. A case study was taken considering a multi-story reinforced concrete building. It was modelled in Revit and analyzed and design in Robot Structural Analysis and Etabs software. The difference in results of design between traditional methods and using BIM methods is discussed. Also, extract documentations from the same model. This study highlighted powerful of BIM technology for structural engineers in terms of analysis, design and documentation process.

Keywords - BIM, Revit, Robot Structural Analysis (RSA), Etabs

1. Introduction

Building information modeling (BIM) is one of the most promising last growth within the architecture, engineering, and construction (AEC) industry. Building information model, can be utilized for planning, design, construction, and operation of the facility. Also, it can recognize any potential design, construction, or operational cases because of its ability to visualize what will be built in a simulated environment, so it’s very helpful for architects, engineers, and constructions [1]. Structural BIM being a subset of BIM which can have the fundamental information for structural engineers. Such as geometry, material properties, sectional properties, loads, load combinations, boundary conditions, and so on. For that structural BIM can be utilized for structural analysis add to that generation of drawings and reports [2]. Structural BIM provides for any engineering project a flexible environment of interoperability and collaboration for relevant areas [3].

Many companies invested in BIM technology. In this field Autodesk is consider as the market leader. Autodesk Revit gives direct link with numerous of the common structural analysis software such, ETABS, SAP2000, SAFE, Staad Por and Autodesk RSA which is fully compatible with Autodesk Revit, and seamless interaction is permitted between the model of BIM and structural model [4]. BIM gives benefits in different methods to the structural engineer, where any changes in the general specifications or design at the BIM model can be updated immediately, with conservation all the information as accurate as possible. It has significant effect on structural activities, such as conceptual design and layout of structural analysis. Also, using BIM technology reduce the errors during design and drafting and hence reduce the cost of designing and drafting as a result of improved productivity. It permits for better analysis situations through simulation. The reality that the utilize of BIM lets one visualize the whole picture, thus he can recognize any potential design issues, and solve problems with new creative ways [4].

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One of the BIM benefits that are very significant for structural engineers: productivity, coordination and consistency of data, and enhancing visualization and simulation of situations and problems. BIM enables structural engineers to build projects with high efficiency, accuracy, and competitively as a result of its ability to design, visualize, simulate, analyze, and document the projects. [5]. The most significant contribution from BIM from the point of view of engineering is increasing productivity, particularly when generating construction documents. In most firms of structural engineering, particularly large scale ones, it is common to work with teams that have various geographical locations, and according to the needs of the firm at that moment, it is expected from the worker’s team to provide help with different projects. In structural engineering, the most labor-intensive part is the production of construction documents in 2D, this process is done completely automated when using a building information model. Important sections such as reinforcement detailing, diameter, number, and rebar schedules are automatically generated, and this process saves a lot of time and effort. Good coordination in a project is major to get the generality out of BIM. Using one building information model for both the analysis and documentation phases, participate in preferable coordination between the results of structural analysis and the general design, and increasing consistency throughout the whole project [5]. Structural engineers can spend more time easily coordinating a project instead of executing the structural analysis. The utilization of BIM reduces the time spent in coordination and rather than having to continually check for coordinating changes or errors made, BIM technology permits structural engineers to focus all their efforts in solving problems, also using creative methods and new to execute that. Any element or area of special interest from the structure, the engineers can have isolated and filtered it easily, in addition to being able to visualize it in 3D and enhancing its understanding and facilitating the process of solving problems and upgrade with ideas. Exploring the design of alternatives and their easy impact on cost at the conceptual design stage can improve results. BIM process can assist in creating the alternatives that address them once known the future design parameters to identify the most economical and time-effective approach to a construction [6].

This paper focuses on the building information modeling situation and its significance for structural engineers in terms of productivity, coordination and consistency of data, and visualization and simulation are also investigated, all this with the aim of getting a clear idea of BIM effect in structural engineering. Multi-story reinforced concrete building was taken as a case study which consists of 8 stories. Its structural elements with different material properties and section properties were modeled in Revit. Using the interoperability of BIM with Robot Structural Analysis (RSA) and Etabs, the building model was exported from Revit to RSA and Etabs. The results of the analysis and design by both software were compared.

2. Case Study
To understand the integration process between Revit and structural analysis software and how to obtain the best benefits from this process in terms of time and effort, a case study was adopted to provide the best application on integration process steps. It is significant before modeling to understand the concept of physical and analytical representations of structure [7]. The physical model (Figure 1) is the true model that contains all information, and this is what was modeled inside Revit by users and its used for coordination as well as documentation, while analytical model (Figure 2) is transferred just the information that structural engineers need, and its modeled automatically in the background of physical model inside Revit. The analytical model is what the structural analysis software deals with it. It used for structural analysis and design where structural loads, load combinations, and boundary conditions can be easily added.
After completing the structural modeling at Revit, integration process with RSA and Etabs started. Exporting the model to RSA was performed using Revit Extension (Figure 3). Then, the model directly opened at RSA (Figure 4).

Exporting the model to Etabs was performed using CSIXRevit tool which is a plugin for Autodesk Revit that empowers bi-directional information exchange to CSI software product as EXR file [8] (Figure 5). Then the Revit structure EXR file was imported inside Etabs to open the Revit model in Etabs (Figure 6).
Structural model imported at both RSA (Figure 7) and Etabs (Figure 8) was assigned the following loads: live load has different values for different levels = 2 kN/m² for floor 8, 4 kN/m² at the middle of floors 3 to 6 and 5 kN/m² for floors 0 to 2, 7 and in the edge floors 3 to 6, dead load values= 2.5 kN/m² to floors from 1 to 6, 3 kN/m² for floor 8, 3.5 kN/m² for floors 0 and, and façade load = 5kN/m. Load combinations and boundary conditions at RSA (Figure 9) and Etabs (Figure 10) were set. Then, the models were analyzed (Figures 11 and 12).

Figure 7. Applying Loads at RSA.

Figure 8. Applying Loads at Etabs.

Figure 9. Applying Boundary Conditions at RSA.

Figure 10. Applying Boundary Conditions at Etabs.

Figure 11. Analysis the Model at RSA.

Figure 12. Analysis the Model at Etabs.
3. Results and discussions

After completing the analysis, the design process is started for all structural elements (columns, walls and slabs) by select structural element then then click on design command to provide steel area required with detailing of reinforcement (bar diameter, number and spacing between bars) with perfect structural drawing at RSA. In the other side, in Etabs the design was achieved using the design command. It provides the area of reinforcement required for all frames in structure with less details compared with RSA. Figures 13 to 18 present the design output for different structural elements.

Figure 13. Design the Column at RSA.

Figure 14. Design the Column at Etabs.

Figure 15. Design the Wall at RSA.

Figure 16. Design the Wall at Etabs.

Figure 17. Design the Slab at RSA.

Figure 18. Design the Slab at Etabs.

Presenting of reinforcement according to the results of the design of RSA and Etabs inside Revit requires Naviate Rebar Extension tool (Naviate REX) to draw reinforcement of columns and walls (Figures 19 and 20).
respectively, and use Rebar tool that present inside Revit to draw reinforcement of slab (Figure 21). Finally extract schedules of Rebar quantity that calculated automatically at Revit (Figure 22).

The quantity of reinforcement calculated using Revit for columns, walls, and floors according to what was designed at RSA and Etabs were compared with real reinforcements of the building. A comparison was made by taken quantity of reinforcement for 6 columns, 6 walls and 3 floors. As Table 1 shows the percentage of reinforcement for the different structural elements calculated by RSA and Etabs compared with the real reinforcement. It is clear that there is difference in the percentages of reinforcement for each structural element. For columns the reinforcement quantity that designed by RSA is decreased by about 7% from the predesigned values, while and in Etabs it was higher by 5%. For walls there was high. Walls designed using RSA are needed lower reinforcements by 43% from the predesigned values. Etabs also provided higher amount of reinforcement by about 34%. For floors designed at RSA, the reinforcement was higher by about 9% from the predesigned values and in Etabs it was lower by about 6%.

| Structural Element | RSA  | Etabs |
|--------------------|------|-------|
| Column             | -7 % | +6 %  |
| Wall               | -43 %| -34 % |
| Floor              | +9 % | -6 %  |
4. Conclusions
Using Building Information Modelling (BIM) technology at structural engineering is very beneficial and saved time and effort for structural engineers. BIM enable structural engineers to check different structural scenarios and optimize the best scenario and obtain on the most economic design with low possibility of errors. Also, BIM model save all information of analysis, design and documentation in one place. hence use one model for purposes of analysis, design and documentation led to improves the consistency between the overall design the results of structural analysis, in addition to increase consistency throughout the entire project.

The case study developed here illustrated how does the connection work between the BIM software and structural analysis software. The smooth operation of creating structural model in Revit Structure then integrating model with RSA and Etabs for process of structural analysis and design, and through of that wide range of changes can be conducting and checked to optimum the best decision. At this study noticed that results of design obtained by using BIM technology is different from that at traditional method at some places higher percent and at other places lower percent, and this maybe return to the difference of structural analysis method followed, where in structural analysis software finite element method depended which is accurate method and appear real results for design, while traditional methods are done manually and is less accurate than finite element method.

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