The Adaptation of Building Information Modelling (BIM) on Existing UTHM As-Built Plan for Future Engineering Reference

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Abstract: Building Information Modeling (BIM) is a new alternative approach from construction schemes that replaces conventional methods. BIM is also a collaborative tool used by the architecture, engineering and construction (AEC) industry based on various software solutions. Currently, most of the BIM processes are being developed for new structures. Therefore, it is difficult for engineers to refer to most existing buildings in the future. The purpose of this study is to facilitate engineers in obtaining all data for maintenances and operation buildings in the future. Therefore, the analysis and design of the existing building in "Bangunan Gunasama Kegiatan Pelajar dan Kafeteria, Universiti Tun Hussein Onn" was conducted to obtain detailed data on the materials used in the building such as the type of building materials, size of reinforcement and others involved. In addition, this study was also conducted to compare the design results of the building using conventional design software with an existing As-built plan. Literature review is also useful to get information on the use of BIM in existing buildings and its benefits. This study was also conducted with the tools of BIM software that is Autodesk Revit as well as software to analyze the structure of the building that is Tekla Structural Designer Therefore, the software will help to documentation in detail the design of steel and concrete in 3 dimensional concepts. Thus, the model elements are directly presentation of information from the building database for engineering reference in future.

Keywords: Building Information Modelling, Engineering Reference, Existing Building And Autodesk Revit

1. Introduction

Building Information Modelling (BIM) was a modern technology used in the construction industry. So that BIM was a new alternative approach of construction scheme replacing the conventional method. BIM modelling introduced in the pilot project to support building design of architects and engineers. In general, BIM was started in 2002 after a paper entitled "Building Information Modelling" was released by Autodesk . The first country that implements BIM is United State America (USA) than followed by United Kingdom (UK), Hong Kong, Denmark, Norway, Australia, Finland and Singapore. Therefore,

Malaysia also does not miss the opportunity even though BIM in Malaysia is not very applicable. But the positive way has taken because of the government's awareness of the abilities and benefits of BIM to reduce construction costs and avoid design error in the planning phase. Furthermore, BIM is a collaborative tool used by architectural, engineering and construction (AEC) industries based on various software solutions [1]

Building and structure vary by their type of use (e.g. in residential, commercial and municipal use), as well as by age (e.g. new, existing, heritage). These differences will influence the use of BIM. Nowadays, instead of existing buildings, most of the BIM processes are developed for new structures Therefore, it is difficult for the engineer to refer to most existing buildings in future [2]. Thereby, this study is about the adaptation of BIM on existing UTHM As-Built Plan for future engineering references.

This research conducted to perform analysis by conventional software with the accordance of Eurocode. The study conducted at one of the buildings in Universiti Tun Hussein Onn Malaysia (UTHM). The As-Built Plan of the existing building in UTHM will be obtained for integrated modelling, design, analysis and detailing of reinforced concrete structure by using Tekla Structural Designer software. Tekla Structural Designer software is the software specifically designed for the structural engineer in designing the reinforced concrete building to provide an integrated solution. Hence, result from the Tekla Structural Designer software after designing will be compared with the manual calculation by referring to the Eurocode. After that, the modelling of the building performed by using the Autodesk Revit Structure. Besides, Autodesk Revit Structure is the BIM tools suggested by the government that applied to the construction project enables structural engineers to carry out structural design and analysis through building modeling.

1.1 Application BIM for existing buildings

Building Information Modeling commonly used for a new building. This is because capitalising on BIM for new buildings is easy just start with a clean, fresh file and set out all the necessary information precisely where it should be.The existing building, however, still needs to be extend, renovate or historically preserve. Most of what is important to a structural engineer is possibly concealed behind an existing facade or surface.. But the building industries are still not very aware of their advantages on existing buildings. Nowadays, many types of research are underway to solve the problems of building conditions in existing buildings and lack of documentation because of the valuable benefits of efficient management of resources.

The construction industry agrees that compelling photos can record delivers better for point cloud surveys. With a laser scanner, you could see every bit. These surveys are the basis for the creation of geometric building models. There is no question about the advantages of this kind of survey. It ensures precise in geometric information. As a result of these surveys, we can return to the point which could further discussed later. Moreover, it significantly reduces the need for site visits [3].

An existing model can be of great strategic benefit by getting information on the performance, requirement and life cycle as well as other feature of the windows, walls, door and other structures in the building. The scanner can't record it, unfortunately. But, the stakeholder needs the implementation of BIM and research in existing buildings because of the rapid developments in BIM research [3].

1.2 As-built drawing that scan to BIM conversion approach

A revised 2D drawing in AutoCAD produced and submitted by a contractor after completion of a construction project is an as-built drawing. They provide modifications made from the original sketches during the construction process which include an exact representation of the building and property when it appears to be completed. Also, minor details, such as the materials used, should be registered to allow future reference to changes in the construction process if the details are different from those specified in the original plan [4].

As-built drawings are normally regarded as a necessity if a structure demolished for reconstruction [5]. When reconstruction is necessary, survey companies will measure a building manually and develop 2D As-built drawings in AutoCAD. This usually led to a delay and a lack of data as these measures carried out externally. Therefore, Virtual Construction Modelling led to a complete technical revolution in the AEC and construction sector [5]. It also can be one of the easiest and effective references for an engineer to reconstruction or renovation an existing building in future.

It is also able to facilitate the work of contractors since they will only refer to BIM. This is because all the requirement of the existing building already recorded into the BIM system.

2. Materials and Methods

2.1 Building Selection

This study focused on the existing building of Bangunan Gunasama Kegiatan Pelajar dan Kafeteria in UTHM. The existing UTHM building consists of 3 level of Cafeteria Block and two levels of HEPA block. Figure 1 and Figure 2 showed the As-Built drawing for Cafeteria and HEP Block.
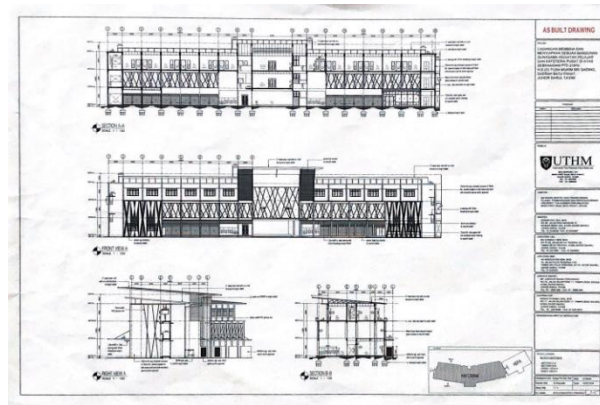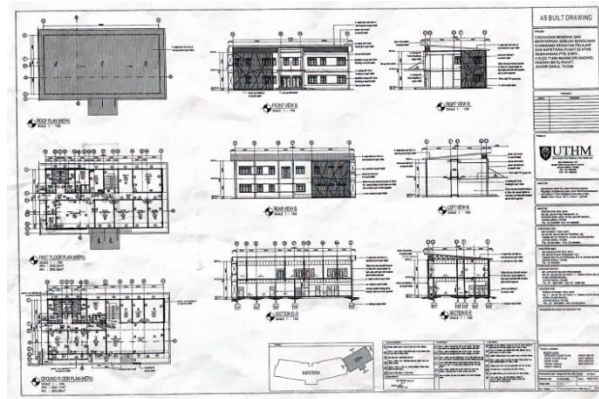

Figure 1: As-Built drawing for Cafeteria

Figure 2: As-Built drawing for HEP Block

2.1 Material Properties

For the concrete characteristic strength, fck is 28 days cylinder strength. The grade of concrete appropriate for used was selected by including the factor of adequate strength for the limit state requirement, durability, concrete grade and unit weigth of concrete. The concrete grade used in this study was C30/37 and the unit weigth of concrete used was 25 kN/m³. Meanwhile, the design of reinforcement used to minimize deflection and control cracking, based on the required characteristic strength or lower value if desired. For high yield steel, the strength was 500 N/mm².

2.2 Tekla Structural Designer (TSD)

Figure 3 showed the flow for performed analysis and design of Bangunan Gunasama Kegiatan Pelajar dan Kafeteria using Tekla Structural Designer software.
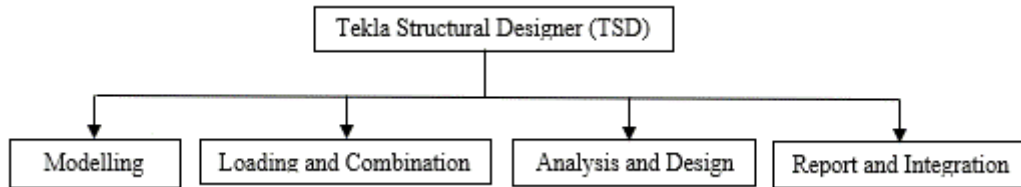
Figure 3: Flow for performed analysis and design on TSD software

For modelling step, Level of the existing building was created by referring the As-built drawing. Second, created the gridline of the building for denoting structural column and bearing wall. Then, input the structural elements such meshed walls, columns, beams and slabs. According to the Table 1, its showed the loading that input for the building.

Table 1: Imposed load on each area of the building

Categories of loaded areas	qK (KN/m²)
Imposed 1 (Corridor)	1.5 KN/m²
Imposed 2 (Toilet)	2.0 KN/m²
Imposed 3 (Kitchen, Dining area, Meeting Room, Club Room, Store, Fail Room, Printing Room, ICT Room, Office, Surau)	3.0 KN/m²
Imposed 4 (Cafeteria, Counter)	4.0 KN/m²
Stairs	3.0 KN/m²
Roof	0.75KN/m²

After input all the loading, run the analysis and design for determine the building's ability to withstand loads as well as to design reinforcement on structure elements.Lastly, generated the report of the analysis and design for the building and export the modelling into the Autodesk Revit by using Tekla Integration.

2.3 Autodek Revit

Figure 4 showed the flow for model an existing building of Bangunan Gunasama Kegiatan Pelajar dan Kafeteria by using Autodesk Revit.
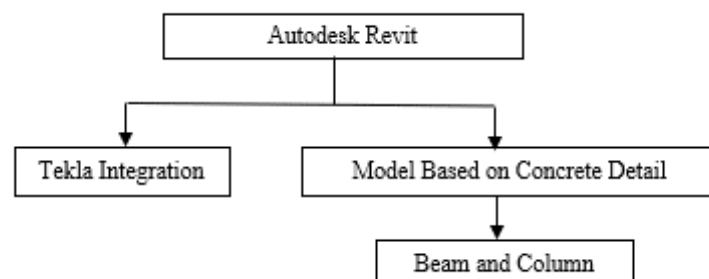
Figure 4: Flow for model an existing building using Autodesk Revit

First, integrated model with Tekla Structural Designer and input the type of structural colum and framing also the materials used.The material was selected by using 'JKR Templete'. After that, the modelling was showed on 3D view. The elevation plan, Sructural Plan and Floor plan was automatically

updated on this software.Next, input the reinforcement for beam and column by referring the design result that performed from Tekla Structural Designer software. Hence, the reinforcement bar for column and beam was formed on 3D view.

3. Results and Discussion

This shown the result of analysis of the existing building of Bangunan Gunasama Kegiatan Pelajar dan Kafeteria. This result obtained by performed the Tekla Structural Designer software.The analysis result was showed the maximum value of shear force diagram (SFD) and bending moment diagram (BMD), the maximim deflection that occurred on beam, column and slab also, the maximum value occurred on column due to the wind analysis.The design result was performed for knowing the arrangement of the reinforcement.

The result occurred while performed Autodesk Revit was showed the modelling of the building in 3D view, the elevation plan, floor plan, structural plan and arrangement of reinforcement in 3D view.

3.1 Maximum Shear Force Diagram (SFD) and Bending Moment Diagram (BMD)

Figure 5 showed the maximum SFD and BMD on beam B708 that located at Ground Floor Level. The value of the maximum shear force on the beam was 146.4kN while the maximum value for bending moment diagram was 464kNm. In this case, the critical shear force and bending moment happened because of the excessive load on load combination. Figure 6 showed the maximum SFD and BMD on column C14 that located on Second Floor Level. The maximum shear force of the column was -97.7kN and the maximum value of the bending moment on column was 369kNm. This happened because of the load from beam, slab, roof panel was transmitted to column.
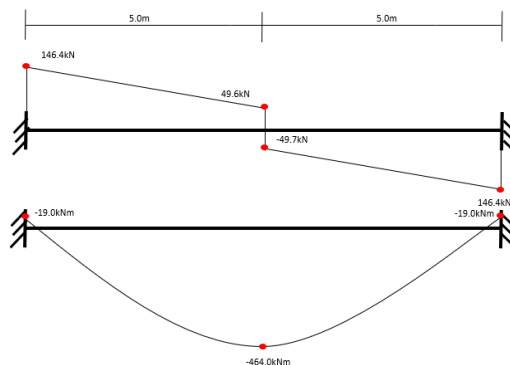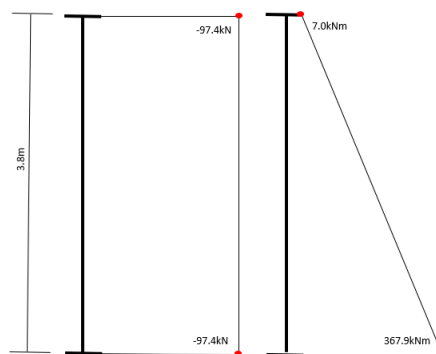

Figure 5: Maximum SFD and BMD on beam

Figure 6: Maximum SFD and BMD on column

3.2 Maximum Deflection on Beam,Column and Slab

The difference types of load also caused deflection. Figure 7 showed the deflection on beam B708. The value of deflection occurred on the beam was 43.1mm while Figure 8 showed the critical value of deflection on column was 10.8mm. Figure 9 showed the maximum deflection of slab occurred on slab S853 and S854. The maximum value of deflection was 31.6mm. The slab was located at First Floor Level.
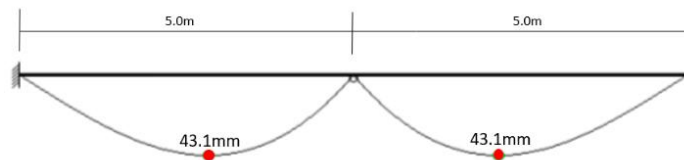
Figure 7: Maximum deflection on beam

Figure 8: Maximum deflection on column
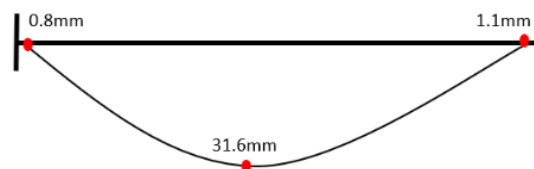
Figure 9: Maximum deflection on slab

3.3 Wind Analysis

Simple wind load has been applied to the building in four (4) directions namely the front, back and both sides of the building. The critical part of deflection and drift was analyzed. It shows the critical wind direction occurred in front of direction at the building.Column on C11 have rhe critical value of deflection due to wind analysis. The critical value of the deflection was 0.6mm on direction 1 and 0.7mm on direction 2.

3.4 Design result on beam, column, wall and slab

The maximum size of reinforcement on beam was showed on Table 2 that is 3H12 occurred on beam size 300x600mm. While the maximum size of reinforcement on column showed on Table 3 that is 8H32 occurred on column size 400x500mm. Based on Table 4, showed the maximum size of reinforcement on wall that is 60H8 on vertical bar and H12 on horizontal bar. For the slab, the maximum size of reinforcement occurred on slab that thicknees was 200mm. The reinforcement size was H8 on bottom-X and bottom-Y while, H10 on top-X and top-Y that showed on Table 5.

Table 2: Maximum size of reinforcement on beam

Beam size (mm)	Reinforcement size
300 x 600	H12

Table 3: Maximum size of reinforcement on column

| Column size (mm)	Reinforcement size
400 x 500	H32

Table 4: Maximum size of reinforcement on wall

Wall thickness (mm)	Reinforcement size	
250	H8 (Vertical bar)	H12 (Horizontal bar)

Table 5: Maximum size of reinforcement on slab

Slab thickness (mm)	Reinforcement size	
200	H8 (Bottom-X)	H8 (Bottom-Y)
	H10 (Top-X)	H10 (Top-Y)

3.5 Modelling an existing building

Figure 10 showed the modelling of an existing Bangunan Gunasama Kegiatan Pelajar dan Kafeteria by using Autodesk Revit. This modelling was imported from Tekla Structural Designer. All information and data for element structure and reinforcement bar was viewed on 3D concept.
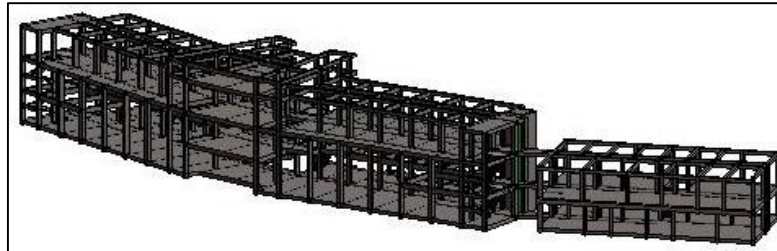
Figure 10: Modelling of Bangunan Gunasama Kegiatan Pelajar dan Kafeteria

3.6 Discussion

The analysis of shear force and bending moment is important for knows the affected of the structural elements on reinforcement. In this case, shear force and bending moment was surely affected on arrangements of reinforcement bars in beam. Shear force and bending moment diagram also was the represented of shear force and moments acting at the beam. So, reinforcement was provided to resist these acting forces and their arrangement is based on the magnitude and direction of the diagrams. Therefore, the portion of beam where shear force was higher, the shear reinforcement or stirrups was provided closely. While, the portion where the bending moment was higher, the longitudinal reinforcement was provided in maximum amount. Same to some longitudinal reinforcement was curtailed when the affected of bending moment reduced or bending stresses changed the direction or the stresses on the web reinforcement becomes higher.

4. Conclusion

Based on the result of this study, the first objective was achieved for structurally analyzed and designed of an existing "Bangunan Gunasama Pelajar dan Kafeteria" The element structures of the building were successfully being analyzed and design using software Tekla Structural Designer. All the analysis and design result was clearly explained in result part in Chapter 4. The maximum value of shear force and bending moment diagram of the beam B708 stated as 146.4kN and 464kNm. For the column C14 was -97.4kN and 367.9kNm. This happened because of the excessive load of load combination was applied on it. So, in order to avoid failures in a beam and column structure, a load factor is used in the case of combination of loads acting on a building. The value of maximum deflection on beam and column was 43.1mm and 10.8mm. This happened also due to the loading that applied on it. So, if the beam B708 and column C14 was in maximum bending moment, the deflection of beam B708 and column C14 also must be in maximum value compared to other structural members.

For the value of maximum deflection of slab S853 and S854 was 31.6mm. This happened because slab S853 and S854 was the large area in the building that was 32m². So, in order to reduce the deflection, increased the slab thickness or placed the secondary beam on it. For the wind load analysis, the critical part of deflection occurred on the structure in front direction of the building. Hence the value of the maximum deflection was in column C11 that placed in front direction of the building that was 0.6mm on Dir 1 and 0.7mm on Dir 2. So, in this case, strong wind speed and pressure occurred in the front direction of the building.

For the second objective, the modelling of the building that performed by using Autodesk Revit was achieved. By performed this modelling, design result from Tekla Structure Designer was important in order to performed 3D version of reinforcement in Autodesk Revit. In addition, the floor plan, elevations, sections and 3D view were updated automatically. For Level of Development (LOD) of this study was accomplished and shown in Table 6 below.

Table 6: Classification Level of Development [6]

LOD	Design Stage	Description	Building Design Elements
LOD 100	Conceptual Design	Basic information regarding the building site and the shape of the building.	Site Plan
LOD 200	Schematic Design	Details layout of the building and spaces with structural details and specifications.	Preliminary Building Plan, Sections and Elevations
LOD 300	Detailed Design	Coordination review and clash detection	Complete Building Plan, Sections Elevations, Superstructure; column, beam, slab

Hence, by performed this study, the main objective as references to engineering in future was successfully. The engineers will easy to refer all the information and data about the element structure such as size of elements structure, the size and the numbers of reinforcement bars used. This is because, the building was model in 3D concept including the reinforcement bars. So, it's easy for engineer to refer in future.

For overall conclusion, this software is very helpful in the implementation of BIM for existing buildings in UTHM to enable engineers to get instant information wherever they are. In addition, a convenient storage method without any paper is used.

Acknowledgement

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