

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

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**Abstract:** Building Information Modelling (BIM) is a modern alternatives technique that combines traditional approach with construction schemes. BIM is also a collaboration method, focused on different software solutions used by the architecture, engineering and construction (AEC) industry. The scattered data and information make the project complicated, confusing and hard to interpret. The main research objectives are to analyze and design of an existing building of Kuarters Pangsapuri Jelatek by using Tekla Structural Designer software in accordance to Eurocode Standard and this study contain four (4) phases which are obtain and study the existing building, transfer the details of the structure from As-Built to Tekla Structural Designer to get the result, perform a sketching of the building using Autodesk Revit and compare the analysis result by referring the Eurocode and British Standard. Tekla Structural Designer software and Autodesk Revit is used in this research to achieve the objective of this research. The adaptation of BIM in this mode designing requires Level of Development (LOD) to reach LOD 300: Design and Development. In summary, this study has been proven that BIM tends to provide efficiency and accuracy along the project lifecycle in the construction firm according to the conceptual design, visualization and analysis of structure.

**Keywords:** Building Information Modelling, Engineering Reference, Existing Building, Autocad Revit

### **1. Introduction**

Building Information Modelling (BIM) was a modern technology used in the construction industry. BIM was a new alternative approach of construction scheme replacing the conventional method. BIM modelling introduced in the 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

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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. 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.<sup>4</sup> [1]

Nowadays, BIM technologies are often developed in new projects in civil and industrial construction. Most of the existing buildings and structures not used BIM. Although developing BIM technology for existing buildings is complex, time-consuming and expensive, it is necessary for future works, historic preservation or future project references on a specific structure. [2] As a result, a BIM adaptation study on the Kuarters Pangsapuri Jelatek As-Built Plan is carried out for future engineering references. This study has transferred the information of the building to a 3D model for BIM implementation in accordance to Eurocode Standard. Tekla Structural Designer software was used to modelling, analysis and design the Kuarters Pangsapuri Jelatek. After that, the 3D modelling has been generated using AutoCAD Revit which is a software tool that provide efficiency and accuracy along the project lifecycle in construction.

Level of Development (LOD) of BIM is acts as a measure of the essential service level which explains how the 3D geometry of a building model can accomplish different levels of modifications. LOD is an important degree to applied in the adaptation of BIM projects. LOD specification allows a professional in engineering to clarify how an element's geometry and related information have evolved throughout the process, which allow all the team members to rely on the information associated with an element. With the help of LOD, the designers and engineers can communicate easily when using the model in the future to discuss more about the limitations of the model. LOD specifications were created to standardize the use of the LOD framework and to serve as an effective and collaborative communication tool. The emphasis of this study has reached the level LOD 300.

## **2. Materials and Methods**

### **2.1 Building Selection**

To establish the data design requirement, the category of the building is essential. This study focused on the existing building of Kuarters Pangsapuri Jelatek. The existing building consists of 4 level of 16 units houses. Figure 1 show the As-Built drawing and Figure 2 show the First Floor Plan for Kuarters Pangsapuri Jelatek.



Figure 1: As-Built drawing for Kuarters Pangsapuri Jelatek

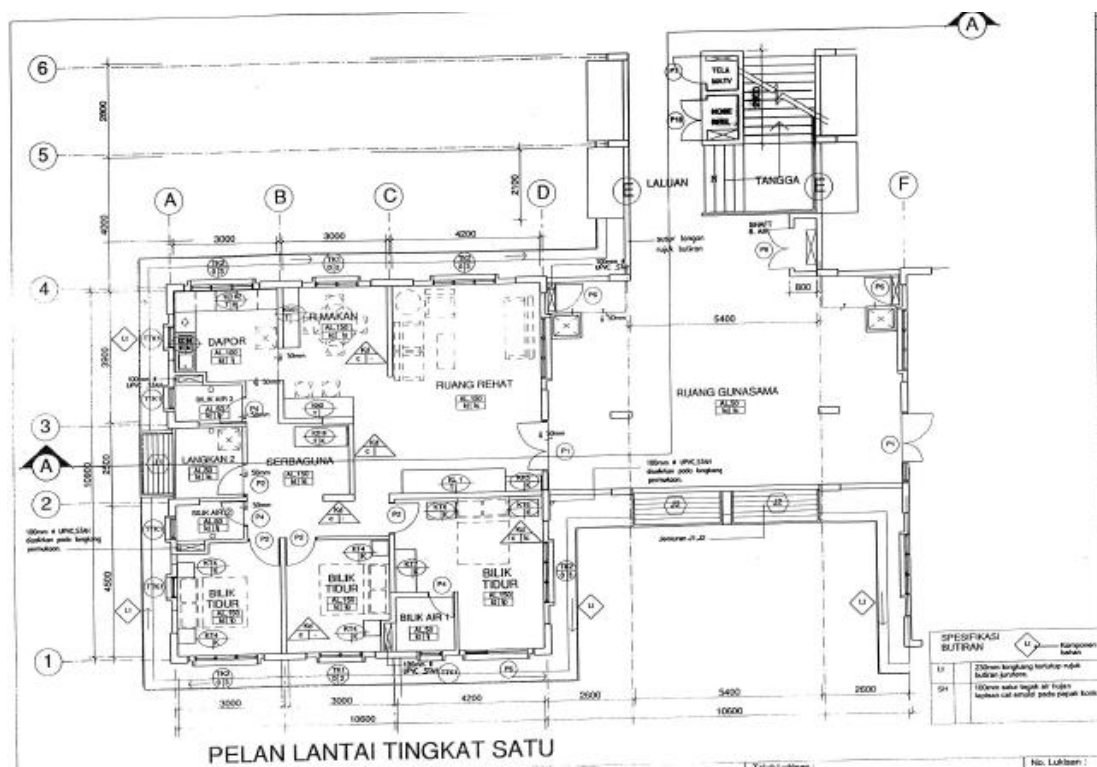


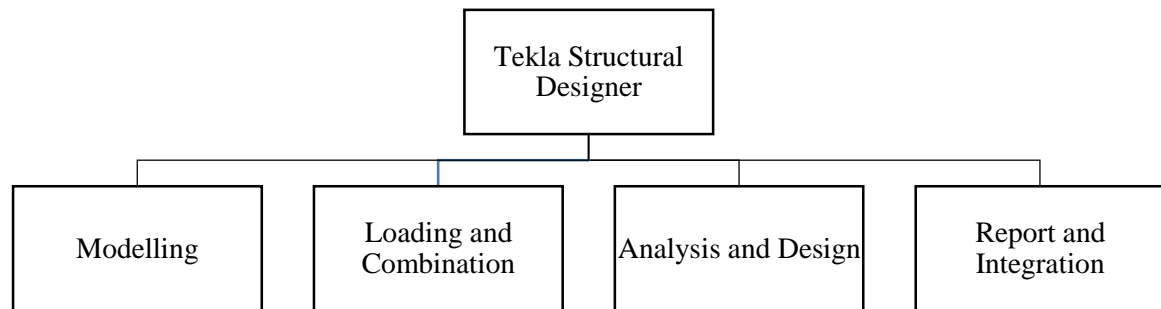
Figure 2: First Floor Plan As-Built drawing for Kuarters Pangsapuri Jelatek

## 2.2 Material Properties

For the concrete characteristic strength,  $f_{ck}$  is 28 days cylinder strength. The grade of concrete was selected based on the factors of adequate strength for the limit state requirement, durability, concrete grade and concrete unit weight. The concrete grade used in this study was C30/37 and the unit weight was  $25 \text{ kN/m}^3$ . For high yield steel, the strength was  $500 \text{ N/mm}^2$ .

## 2.3 Tekla Structural Designer (TSD)

Figure 3 show the flow of the Tekla Structural Designer software used to perform the analysis and design of Kuarters Pangsapuri Jelatek.



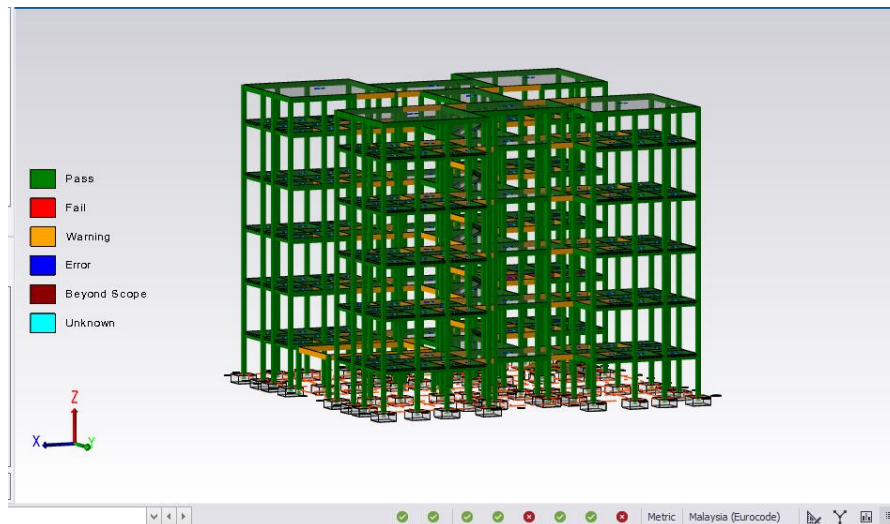
**Figure 3: Flow for performed analysis and design on TSD software**

For the modelling step, construction level of the existing building was created by referring the architectural drawing. Then, the gridline of the building had been created for denoting structural column. After that, the structural elements such as columns, beams and slabs were input in the TSD software. The loading was input into the building is shown in Table 1.

**Table 1: Imposed load on each area of the building**

Categories of loaded areas	qK (kN/m <sup>2</sup> )
Imposed 1 (Corridor)	1.5 kN/m <sup>2</sup>
Imposed 2 (Toilet)	2.0 kN/m <sup>2</sup>
Imposed 3 (Kitchen, Dining area, Bedroom, Stairs)	3.0 kN/m <sup>2</sup>
Roof	0.75 kN/m <sup>2</sup>

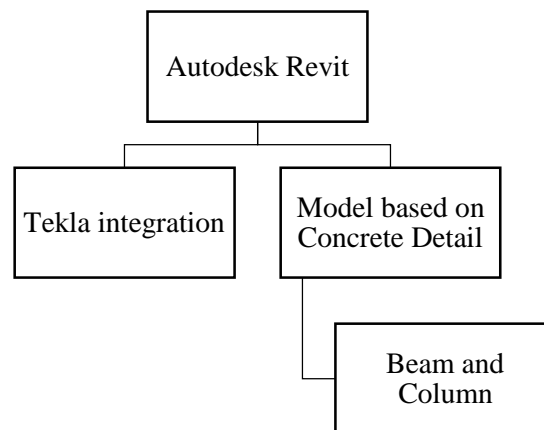
After input all the loading, the analysis and design have been run to determine the building's ability to withstand loads and to design reinforcement on structural elements. Figure 4 show the analysis and design result of Kuarters Pangsapuri Jelatek. Lastly, the report of the analysis and design have been generated for the building and modelling was exported into the AutoCAD Revit by using Tekla Integration.



**Figure 4: Analysis and Design Result of Kuarters Pangsapuri Jelatek**

## 2.4 AutoCAD Revit

JKR template was used in this project so that the format is standardized as Malaysia format. The flow of the AutoCAD Revit used to model of an existing building of Kuarters Pangsapuri Jelatek is shown in Figure 5.



**Figure 5: Flow for model an existing building using AutoCAD Revit**

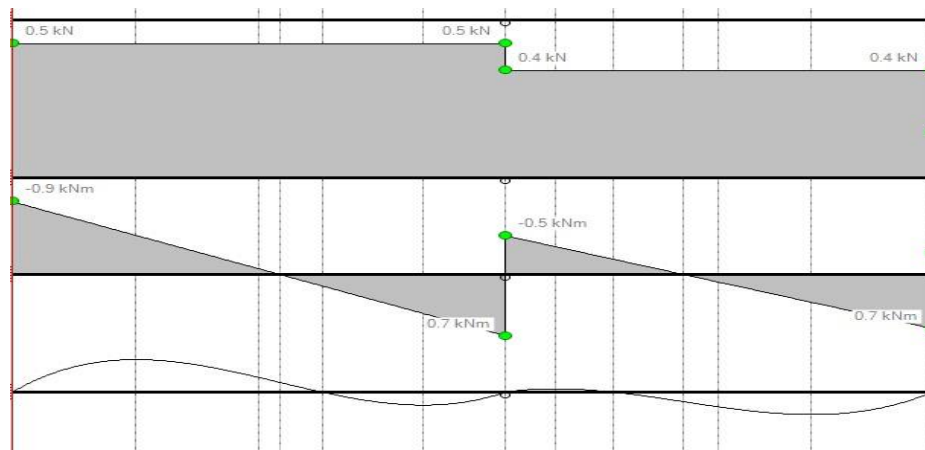
First, the Tekla Structural Designer was used to model and enter the type of structural column and frame as well as the material utilized. 'JKR Template' was used to choose the material. After that, the modelling was then displayed in 3D view. The elevation plan, Structural Plan and Floor plan was automatically updated in this software. Then, using the design result from Tekla Structural Designer software, input the reinforcement arrangement for beam and column. As a result, the reinforcement bar for the column and beam was designed in 3 dimensions.

## 3. Results and Discussion

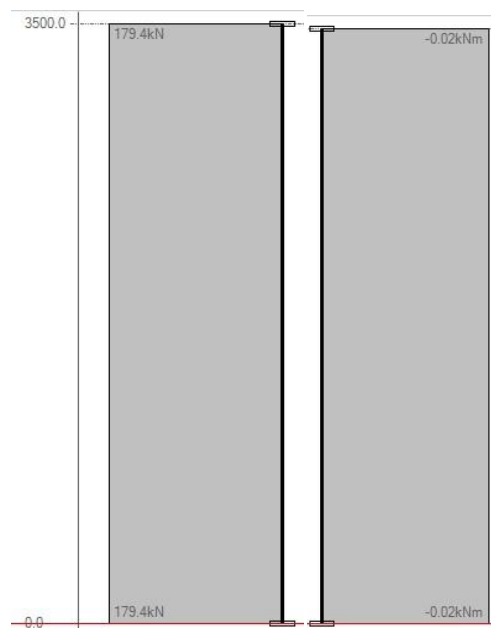
The analysis result of the existing building of Kuarters Pangsapuri Jelatek was obtained by performed in the Tekla Structural Designer software. From the analysis result, the maximum value of shear force (SFD) and bending moment diagram (BMD) of beam and column have been obtained. The value of the wind analysis was revealed. The design result of Tekla Structural Designer software was used to determine the reinforcement arrangement. AutoCAD Revit was used to perform the modelling of the building in 3D view, the elevation plan, floor plan, structural plan and arrangement of the reinforcement in 3D view as well as other model-based element such as staircase and roof.

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

The maximum SFD and BMD on beam B141 that located at the Ground Floor was shown in Figure 6. From the diagram of shear force diagram from point zero, it decreased till reached 0.5 kN and it linearly. Then it decreased to 0.4 kN and it linearly until reach zero. For bending moment, as shown in Figure 4, at BMD diagram, the slope of bending moment was equal to the zero at any point. From point zero to the middle point the value is zero and reach at another point which is 0.7 kN/m and it decrease to -0.5 kN/m and parabolic till reach point zero. The maximum value for shear force on beam was 0.5 kN and maximum value for bending moment is 0.7 kN/m. This happen because the loading applied on the beam that is from slab self-weight, and imposed load. Figure 7 shows the maximum SFD and BMD diagram on column C15. The column was located at the Ground Floor of the building. From the figure above, the shear force is 179.4 kN and the value remain same until it reached the other point. The maximum shear column was 179.4 kN. For the bending moment diagram, the shear force remains zero until the -0.02 kNm. Then the point decrease till it reached point that remains the same value. The maximum bending moment was -0.02 kNm. This happened because of the load from beam, slab, roof panel was transmitted to column.



**Figure 6: Maximum SFD and BMD on beam**



**Figure 7: Maximum SFD and BMD on column**

### 3.3 Wind Analysis

Simple wind load has been applied to the building in four direction which are front, back and both sides of the building. Wind load that applied was listed on Table 2.

**Table 2: Wind Load applied**

X1 Dir, kN/m <sup>2</sup>	X2 Dir, kN/m <sup>2</sup>	Y1 Dir, kN/m <sup>2</sup>	Y2 Dir, kN/m <sup>2</sup>
0.92	-0.92	0.92	-0.009
0.89	-0.89	0.89	-0.086
0.84	-0.84	0.84	-0.073
0.76	-0.76	0.76	-0.073

### 3.4 Design Result on Beam, Column and Slab

The maximum size of reinforcement on beam was shown in Table 3 that is 3H20 occurred on beam size 250x500mm while the maximum size of the reinforcement on column is shown in Table 4 that is H20 occurred on column size 400x400mm. Furthermore, the maximum size of reinforcement of slab was shown in Table 5 that is H8 for bottom and top occurred on slab size 150mm.

**Table 3: Maximum size of the beam size**

Beam size (mm)	Reinforcement size
250x500	H20

**Table 4: Maximum size of the column size**

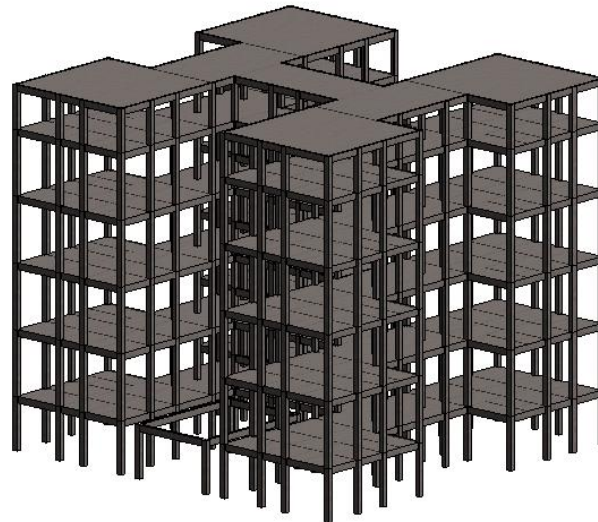
Column size (mm)	Reinforcement size
400x400	H20

**Table 5: Maximum size of the slab size**

Slab size (mm)	Reinforcement size
150	H8 (Bottom) H8 (Top)

### 3.5 Modelling an Existing Building

The modelling of an existing building Kuarters Pangsapuri Jelatek by using AutoCAD Revit was shown in Figure 8. This modelling was imported from the Tekla Structural Designer. Then, after the reinforcement bar was created on all beams and columns, the other element like staircase and roof was generated and all the information and the data for the element structure and reinforcement bar was viewed on 3D concept. Figure 9 show the reinforcement on Beam in AutoCAD Revit and Figure 10 show the reinforcement on Column in AutoCAD Revit.

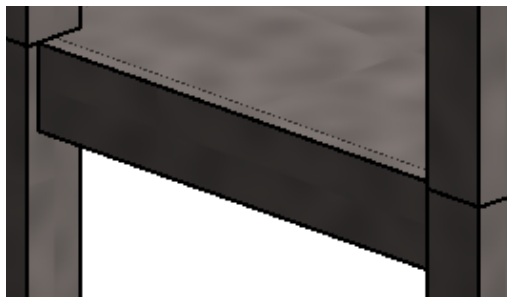


**Figure 8: Modelling of Kuarters Pangsapuri Jelatek**

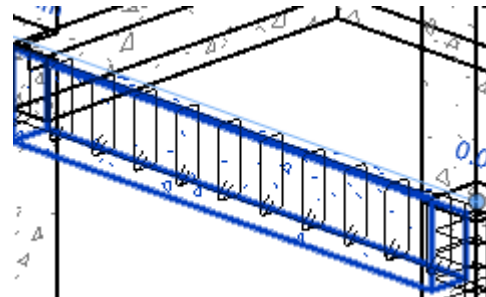
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Beam

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Structural Element without Rebar



Structural Element with Rebar

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**Figure 9: Reinforcement on Beam in AutoCAD Revit**

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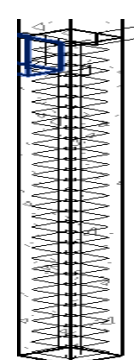
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Column

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Structural Element without Rebar



Structural Element with Rebar

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**Figure 10: Reinforcement on Column in AutoCAD Revit**

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#### 4. Conclusion.

Based on the result of this study, the main objective had been achieved for structurally analyzed and designed of the existing Kwarters Pangsapuri Jelatek. The elements of the building were successfully being analyzed and designed using Tekla Structural Designer (TSD) software. In Chapter 4, the outcome section, all of the analysis and design results were properly stated. The maximum shear force and bending moment diagram of the beam 1B1 75 are 0.5 kN and -0.9 kNm. For the column C15 the maximum shear force and bending moment diagram are 179.4 kN and -0.02 kNm.

This study has restriction from provided information from the As-Built drawing plan. The existing As-Built Plan does not provide the detailed data about the building such as the size of the structural beam elements, column elements and other that related to the structural. The detailing of the reinforcement also not provided on the As-Built drawing in order to compare the result of design that obtained from Tekla Structural Designer software with the existing As-Built drawing.

Autodesk Revit used to perform the modelling of the building. The design result obtained from Tekla Structural Designer is important in order to performed families in Autodesk Revit. The Families was created to form a 3D version of the reinforce concrete. Besides, each floor plan, elevations, sections and the 3D view were updated automatically. By performed this study, the main objective as reference to engineering in the future was succeed. The engineer can refer all the information and the data about the structure element such as size of element and size of reinforcement bar used easily. This because the building was in 3D model including the reinforcement bars, so the engineer can refer easily in the future.

In the nutshell, the existing building of Kwarters Pangsapuri Jelatek had successfully been implemented in BIM technology. The software used in this project which are Tekla Structural Designer (TSD) and AutoCAD Revit are both useful in generating Building Information Modelling (BIM). Architects and engineers are enabled to get instant information from the model produced in the software. Thus, this study can be contributed to the future engineer references and will also bring advantages to the future development in Kwarters Pangsapuri Jelatek.

#### 5. Recommendations

The recommendation for this study to was proposed to improve the quality of this study in the future for future reference and research:

- i. The structural drawing is required in the next research so the element of the building can be performed correctly using the software with the existing building.
- ii. The AutoCAD Revit need to be introduced widely to model an existing building to help the engineer to refer the information and the data of the building.
- iii. The structure modelling from Autodesk Revit can be combined with others element such as mechanical, electrical, and piping system.

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