

## The Adaptation of Building Information Modelling (BIM) on Existing Ibu Pejabat Daerah (IPD) Pasir Mas As-built Plan for Future Engineering Reference

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**Abstract:** Building Information Modeling (BIM) is a modern construction method that has largely replaced conventional methods. BIM is a collaborative tool utilized by the architectural, engineering, and construction (AEC) industries that is based on multiple software solutions. For the time being, the majority of BIM processes are geared toward new construction. As a result, most existing structures will be difficult to refer to in the future. The purpose of this study is to develop a more efficient method for engineers to obtain all of the information they require for future building maintenance and operations. As a result, the existing 'Blok F - Surau, IPD Pasir Mas' was analyzed and designed in order to collect information on the materials employed in the construction.

**Keywords:** BIM, Software, Building, Existing, Future, Maintenance

### 1. Introduction

BIM was implemented in the construction project to assist architects and engineers in the design of buildings. BIM began in general in 2002, when Autodesk published a paper titled 'Building Information Modelling' [1]. Despite the fact that BIM is not widely applied in Malaysia, the country does not miss out on the opportunity. However, a positive path has been taken as a result of increased awareness of BIM capabilities and benefits in lowering construction costs and avoiding design errors during the planning phase. Nowadays, most BIM processes are designed for new structures rather than existing structures [2]. As a result, the engineer will struggle to refer to most existing buildings in the future.

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As an outcome, the objective of this study is to apply BIM to existing buildings of Ibu Pejabat Daerah Pasir Mas As-Built Plans for future engineering reference. The study was conducted at one of the buildings in Ibu Pejabat Daerah Pasir Mas. The existing building in IPD Pasir Mas As-Built Plan will be obtained in order to utilize Tekla Structural Designer software for integrated modelling, design, analysis, and detailing of reinforced concrete structures. Furthermore, Autodesk REVIT Structure is one of the BIM tools recommended by the government for application in construction projects, allowing users to perform structural design and analysis via building modelling.

## 2. Literature Review

### 2.1 BIM Concept

BIM refers to the process of creating and managing information for a built object. BIM integrates structured, multi-disciplinary data into a digital representation of an asset throughout its life cycle, from planning and design to construction and operations, using an intelligent model and a cloud platform. BIM allows for the creation of intelligent data that can be applied throughout the life of a building or infrastructure project [3]. A building information model defines the geometry, geographical linkages, geographic information, quantities and attributes of building elements, cost projections, material inventories, and project timeline. This model can be employed to depict the entire life cycle of a building [4]. As a result, the model could be employed for operations and maintenance once it is completed. This is crucial to realize that BIM is both a method and a piece of software.

### 2.2 BIM for Structural Engineering

BIM is a building design method that employs a database of coordinated, graphically rich, internally consistent, computable information in three-dimensional models for design, engineering, construction, and facility management. BIM has the potential to irreversibly alter the structural engineering profession, including its universities, businesses, clients, markets, design codes, digital tools, contracts, insurance policies, global recruiting of people, work process, and many other aspects, in less than ten years [5]. Structural engineering encompasses a broad range of skills and abilities that can be applied to any project. This includes small-scale slope stabilization operations as well as large-scale tall-building structures [5]. Structural engineers must utilize tools that allow them to check the parameters of the system under development and evaluate the trustworthiness of the information supplied to preserve the quality of the final result [6]. BIM is one of the solutions that could deliver all of these features.

### 2.3 BIM Risks

The first legal risk to consider is that the BIM data is owned and protected by copyright and other laws. For example, if the owner pays for the design, the owner may believe he or she is entitled to ownership of the design; however, if team members provide proprietary information on the project, the information on their property must also be protected [7]. Another question is who would inspect and bear responsibility for any errors in data entry into the model. The responsibility for updating and ensuring the accuracy of BIM data entails significant risks. It also takes time to characterize and examine BIM data, which adds to the design and project management costs. While these new costs can be more than offset by efficiency and planned gains, they are still a cost to be borne by someone in the project team. Thus, not only must the risks of its application be identified and allocated before BIM technology is fully utilized but the costs of implementing it also have to be paid for [8].

### 3. Methodology

#### 3.1 Building Selection

The data for building design requirement was essential. The As-Built Plan drawing of 'Blok F - Surau, IPD Pasir Mas' is utilized in conducting this study. The existing 'Blok F - Surau, IPD Pasir Mas' is a single-storey building.

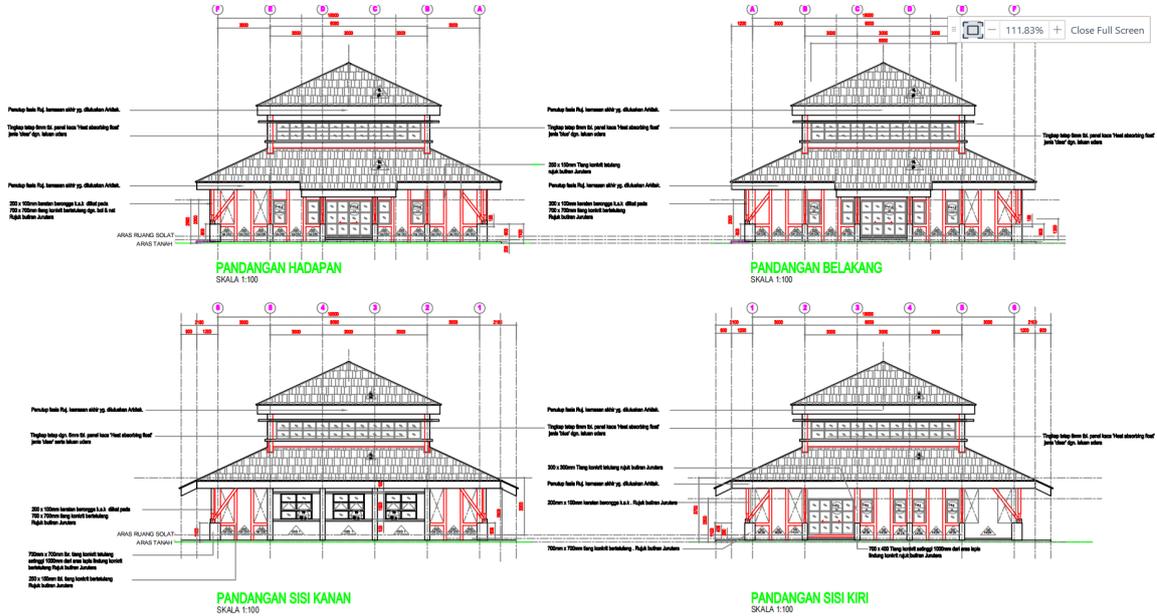


Figure 1: The views plan of 'Blok F - Surau, IPD Pasir Mas'

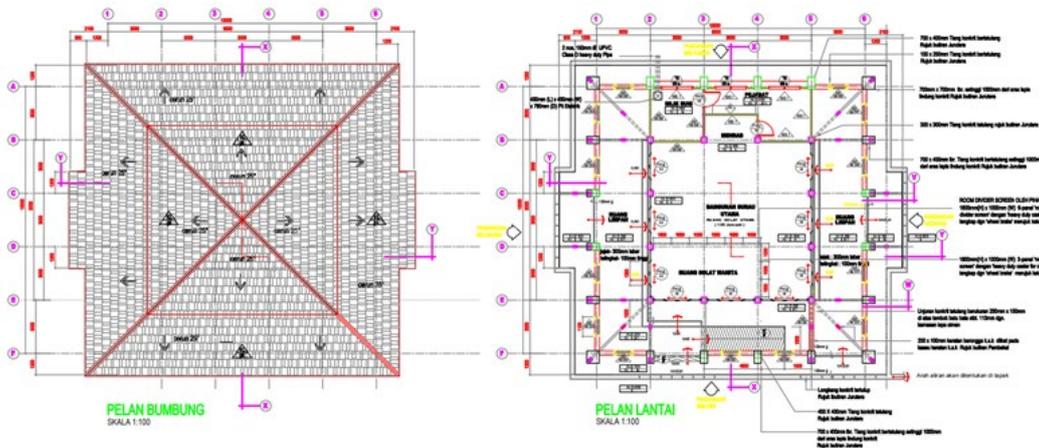


Figure 2: The floor and roof plan for 'Blok F - Surau, IPD Pasir Mas'

#### 3.2 Data Acquisition

According to relevant standard codes and guidance, the references shown in Table 1 and Table 2 were applied in this study.

Table 1: Action and Design Codes (TSD)

Action Code	Design Code
General Loading	MY EN 1991-1-1 + Malaysia NA:2002
Wind Loading	MY EN 1991-1-4 + UK NA:2005
Seismic Loading	MY EN 1998-1 + Malaysia NA:2004
Combination	MY NA 1990 + Malaysia NA:2002

**Table 2: Resistance and Design Code (TSD)**

Resistance Code	Design Code
Concrete Design	MY NA 1992-1-1 + Malaysia NA:2004

With these references, material properties and loading application for the As-Built plan of 'Blok F - Surau, IPD Pasir Mas' are needed to be specified according to Standard Eurocode 1 and Standard Eurocode 2. The characteristic strength of concrete,  $f_{ck}$  utilized was 28 days cylinder strength. The grade of concrete appropriate for the study was selected, by including the following factor:

- i. Adequate strength for the limit state requirement
- ii. Durability
- iii. The grade of concrete is C32/40
- iv. Unit weight of concrete is 25 kN/m<sup>3</sup>.

Design for deflection reduction and cracking control are based on the required characteristic strength or lower value if desired. For high yield steel, the strength,  $f_{yk}$  applied was 500 N/mm<sup>2</sup>. Table 3 and Table 4 show the permanent load,  $g_k$  and variable load,  $q_k$  implemented in this study. While Table 5 illustrates the category of the building function.

**Table 3: Permanent Load**

Element	Load ( $g_k$ )
Composite slab, normal concrete (130 mm thick, 2400 kg/m <sup>3</sup> )	2.4 to 3.0 kN/m <sup>2</sup>
Services	0.25 kN/m <sup>2</sup>

**Table 4: Variable Load**

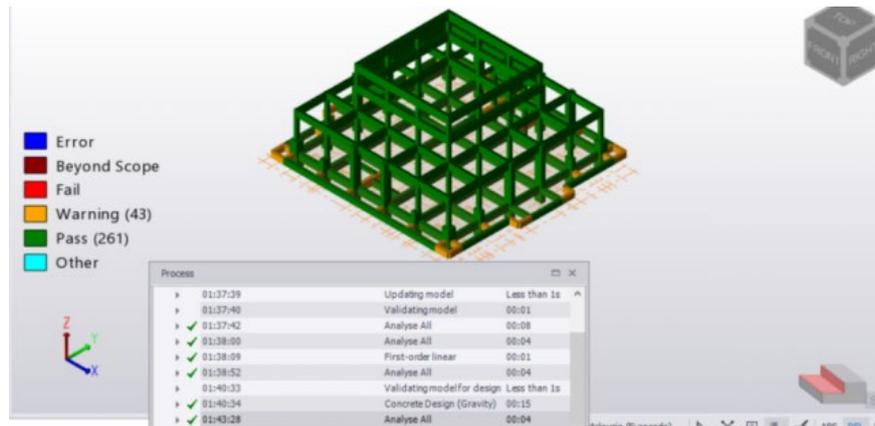
Category of Loaded Areas	Load ( $q_k$ )
Imposed 1 (Corridor)	1.5kN/m <sup>2</sup>
Imposed 2 (Meeting Room, Control Room, Store, Office)	3.0kN/m <sup>2</sup>
Roof	0.75kN/m <sup>2</sup>

**Table 5: Category of Function**

Category	Specific Function	Example
C	Area where people may congregate (with the exception of area defined under category A, B, and D)	C1: Areas with tables, etc. E.g. areas in schools, cafes, restaurants, dining halls, reading rooms, receptions.

### 3.3 Tekla Structural Designer Software (TSD)

The first step in TSD was to apply the model construction level. The grid line was then built in accordance with the plan. The concrete columns were then created, and the properties were reviewed by inserting the section size, cover, releases, top and bottom levels, and angle. The concrete beam was then created, and the properties of size, covers, releases, and how the beam is aligned were reviewed. Afterward, before inserting the slab on the beam, consider all of the details of the slab rotation angle, decomposition, and depth. Continue to include load cases and combinations to analyse and design the model that been created. Wind load was neglected for a single-story building. The analysis and design settings include critical options that must be entered based on the model specifications.

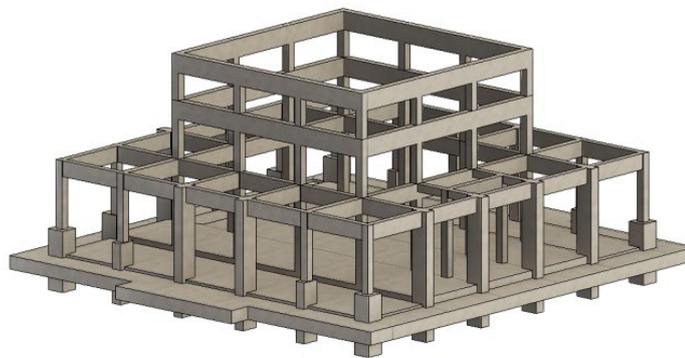


**Figure 3: Review Design and Analysis Status**

The green colour represents pass members, while the yellow colour represents members that are under warning. The members that were under warning were not assigned to fail. On the report ribbon, the show report button was clicked to generate the report. As a result, the report will be reviewed. Finally, the BIM integration was completed in order to export the model to Tekla Structure.

### 3.4 Autodesk REVIT Structure

Utilizing Tekla integration, a new project was created with a suitable template and imported the analyzed and designed model from TSD. The Mapping File not recognize structural columns, structural framing types, or structural materials. As a consequence, the Family structural components must be manually added. Following that, material grade mapping was applied in accordance with the model specifications. After completing all steps, the 3D button was pressed to view the 3D model. And after that, model-based concrete was built by creating reinforcement bars for beams and columns.



**Figure 4: 3D model imported to Autodesk REVIT Structure**

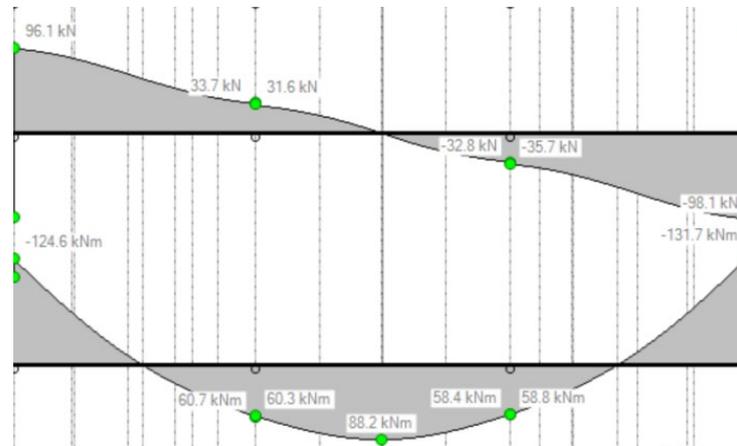
## 4. Results and Discussion

The size of the reinforcement on each of the building structural elements was derived utilising the analysis and design results. The model '*Blok F - Surau, IPD Pasir Mas*' was then created in 3D using Autodesk REVIT software. The 3D modelling of the existing structure distinguishes this study from the others. This study also depicted a building design in 3D, with information or details such as the size of reinforcement bar employed in structure elements included in the modelling.

### 4.1 Analysis Result

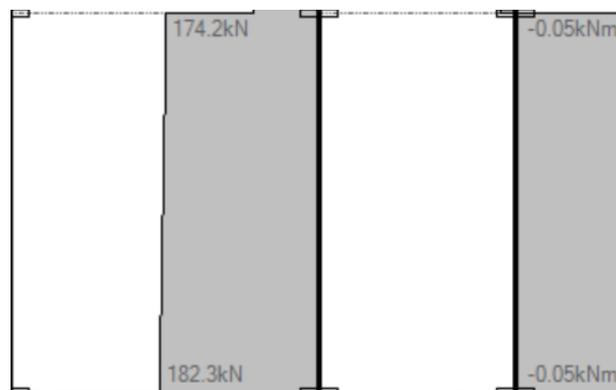
**Figure 5** represents a diagram of the maximum shear force (SFD) and bending moment (BMD) on beam ATB328. The beam was found on the first floor. It decreased from 0 kN on the shear force diagram until it reached 96.1 kN. Then it decreased insignificantly to 98.1 kN and increased to 0 kN.

As shown in the figure at BMD diagram, the slope of the bending moment diagram was always equal to 0 kN. The bending moment diagram is parabolic from point 0 kNm to the middle point at 88.2 kNm, and then it is ascending. As a result, the beam maximum shear force was 96.1 kN, with a maximum bending moment of 88.2 kNm. The critical shear force and bending moment occurred in this example of the beam due to the loading applied to the beam, which included the uniformly distributed load (UDL) and the point load, which consisted of loads from the slab self-weight, brick wall, and imposed load.



**Figure 5: Maximum SFD and BMD on Beam**

The maximum shear force diagram (SFD) and bending moment diagram (BMD) for column C30 are shown in **Figure 6**. The column was located on the building ground floor. **Figure 6** shows that the shear force remains constant at 0 kN until it reaches 174.2 kN. It was then increased from 174.2 kN to 182.3 kN. The maximum shear force in the column was 182.3 kN. Begin at 0 kNm and decrease linearly until -0.52 kNm is obtained for the bending moment diagram. The maximum bending moment on the column was -0.05 kNm. This occurred as a result of the load transferred to the column by the beam and roof panel.



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

**Figure 7** shows the slab deflection on the building that occurred on the middle part of the building. The critical deflection of the slab occurred on the ground floor level of the building.

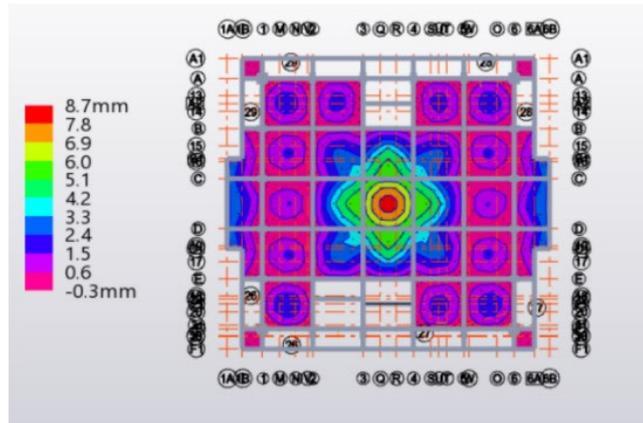


Figure 7: Deflection on Slab in 2D plan

4.2 Design Result

The total number of columns on plan was 44 while the total numbers of beam on plan was 52. The size of the columns and beams applied in the model were varies. While the thickness of the slab utilized in the building was 150mm. The design of the building was then run, and the result as in Figure 8 that shows the elements were result in warning and pass, hence the structure building were qualified to proceed the modelling processes.

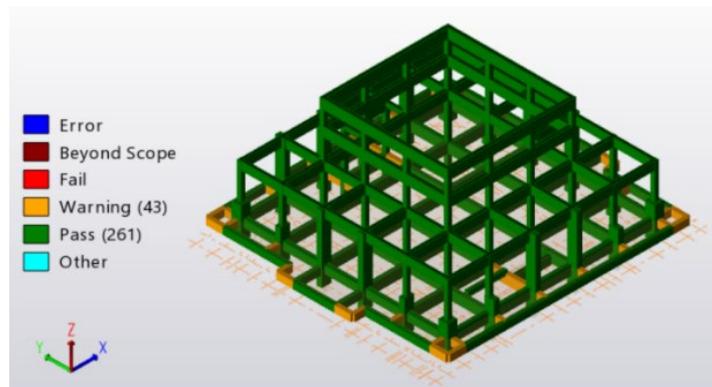


Figure 8: Design Status from TSD

The summary of the beams and columns reinforcement are shown in Table 6 and Table 7. The size of the reinforcement will vary depending on the size of the element. While the reinforcement summary for slab S41 shown in Table 8.

Table 6: Beam Reinforcement Summary

Beam	Length, mm	Bottom Reinforcement	Top Reinforcement	Bottom Reinforcement (Max), mm <sup>2</sup>		Top Reinforcement (Max), mm <sup>2</sup>	
				AS <sub>Req.</sub>	AS <sub>Prov.</sub>	AS <sub>Req.</sub>	AS <sub>Prov.</sub>
AT2B49 (250x600)	3000	2H16	2H16	256	402	256	402
ATAB16 (300x700)	2700	3H16	3H16	309	339	309	339
AT2B69 (250x300)	1000	2H12	2H12	164	226	164	226
ATB63 (300x500)	900	3H12	3H12	244	339	244	339
ATB272 (300x600)	3000	3H12	3H12	269	339	269	339

**Table 7: Column Reinforcement Summary**

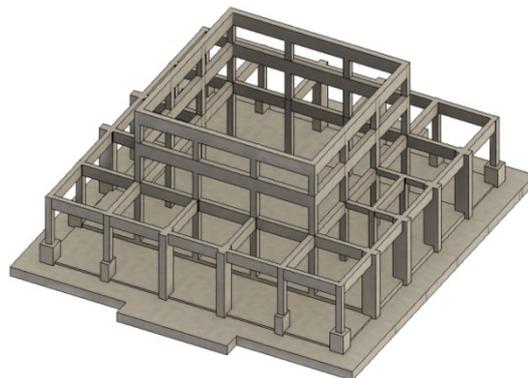
Column	Design Status	Stack	Axial Force, $N_{Ed}$ (kN)	Moment, $M_{Ed}$ (kNm)	Longitudinal Reinforcement Area, $mm^2$	Longitudinal bars
					$A_{SReq.}$	
C23 (300x300)	Pass	4	95	2.2	360	4H16
C3 (700x700)	Pass	2	31.3	1.3	1960	12H16
C5 (400x700)	Pass	2	46.8	7.4	1120	10H16
C13 (700x400)	Pass	2	46.9	1.1	1120	10H16

**Table 8: Slab S41 Reinforcement Summary**

Reinforcement Layer	Reinforcement Provided	Area Provided ( $mm^2/m$ )	Area Required ( $mm^2/m$ )	Design Status
Bottom-X	H8-200-B2	252	51	Pass
Bottom-Y	H8-200-B1	252	43	Pass
Top-X	H8-200-T2	252	103	Pass
Top-Y	H8-200-T1	252	88	Pass

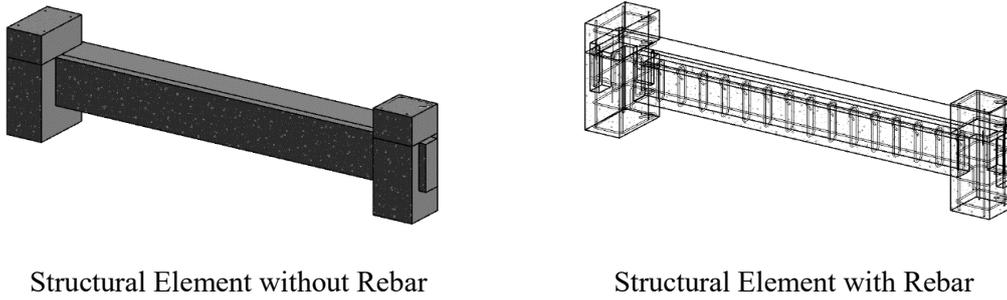
4.3 Modelling an existing ‘Blok F - Surau, IPD Pasir Mas’

Figure 9 shows the execution of Autodesk REVIT to model an existing ‘Blok F - Surau, IPD Pasir Mas’. Tekla Structural Designer was utilized to import this modelling. All information and data related to the element structure and reinforcing bar were viewed in 3D concept.



**Figure 9: Modelling of ‘Blok F - Surau, IPD Pasir Mas’ in Autodesk REVIT**

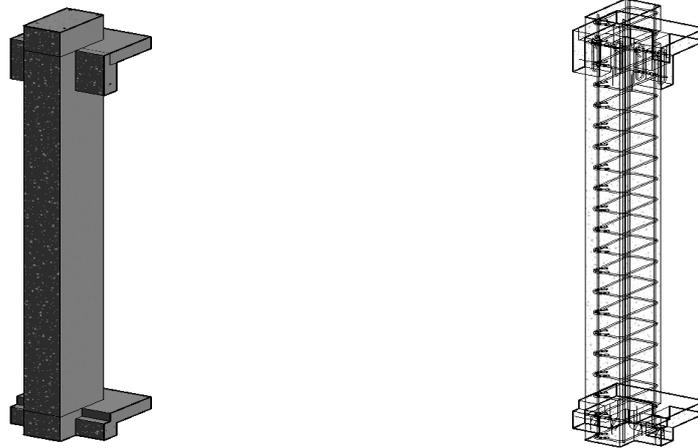
By applying Autodesk REVIT, allows the engineer to easily access all reinforcement data in 3D. Figure 10, Figure 11 and Figure 12 illustrate examples of 3D reinforcement on beam, column and foundation, respectively. By clicking the reinforcement, all relevant data such as number, size, and spacing will appear. But before that, the reinforcement must be sketched into an Autodesk REVIT based on a 2D drawing produced by Tekla Structural Designer.



Structural Element without Rebar

Structural Element with Rebar

**Figure 10: Reinforcement on Beam in Autodesk REVIT**



Structural Element without Rebar

Structural Element with Rebar

**Figure 11: Reinforcement on Column in Autodesk REVIT**

Foundation



Structural Element without Rebar

Structural Element with Rebar

**Figure 12: Reinforcement on Foundation in Autodesk REVIT**

## 5. Conclusion

This study primary goal was to structurally analyse and develop an existing 'Blok F - Surau, IPD Pasir Mas'. Tekla Structural Designer software was executed to successfully analyse and design the building elements structures. Autodesk REVIT was also practised to model the structure. In order to perform families in Autodesk REVIT, this modelling required the application of Tekla Structure

Designer design results. Families was created in order to create a three-dimensional representation of reinforced concrete. As a result, the primary aim of conducting this study was met, which was to provide future references to engineers. Engineers will have precise access to all element structure information and data, including element size and quantity, as well as the size of the reinforcement bars utilized. It also provides an easy storage option that eliminates the need for paper. Furthermore, because it enables engineers to access accurate information from any location, this software is critical for the adoption of BIM for existing buildings.

### 5.1 Recommendations

The recommendation for this study was proposed to future improved the quality of this study and for future references and investigation:

- Structural plans will be necessary to ensure that each component parameters of the building are relevant for the current structure.
- To aid engineers in referring to the building information and data, Autodesk REVIT should be widely applied in modelling existing buildings.
- This AutoCAD REVIT modelling technique have to be expanded in the future to include mechanical, electrical, and pipeline systems, among other things.

### Acknowledgement

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