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Development of Building Information Modelling Model for Residential Housing in Enhancing the Maintenance Work

Nur'Ain Idris[1,*], Muhammad Arif Muhammad Hafiz Saw[1], Nurkhairinna Adilah Mohamad Hairi[1], Ain Syazana Setia[1], Hamidun Mohd Noh[2], Khairi Supar[1], Noorul Hudai Abdullah[1], Siti Masturah Rahman[3], Rahmita Sari Rafdinal[4]

[1] Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Muar, Johor, Malaysia
[2] Department of Construction Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400 Batu Pahat, Johor, Malaysia
[3] Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400 Batu Pahat, Johor, Malaysia
[4] PS Construction Co. Ltd., Tokyo Shiodome Building, 1-9-1, Higashi Shimbashi, Minato-ku, 105-7365 Tokyo, Japan

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ABSTRACT

Building Information Modelling (BIM) is a digital model of a building that can be visualized in 3D physical form and contains various geometric information, functions, features, or parameters generated by various related software. The main goal of this study is to develop a BIM architecture and structure drawing of semi-detached house for maintenance purposes. Clients, developers, and contractors can use BIM as a resource when executing maintenance projects. There is few software can use to develop BIM system. Contractors around the world use a variety of BIM software, including AutoCAD, Navisworks, Data CAD, and others to develop BIM in software. In order to develop BIM system in this study, Revit software has been chosen to create a semi-detached house. Between the conventional method and the BIM method, there is difference. BIM is allowing different design teams to collaborate more easily by using a "live" version of the building model compared to conventional method which is working in storage facilities and taking snapshots. Getting a house plan from a developer is the first step in build BIM. The drawing needs to be converted from a PDF file to AutoCAD format. Next, create architectural and structural drawings using the Revit. The outcome of this study, BIM is developed from architecture and structure drawing using Revit software. Therefore, it may be inferred that using Revit software to create BIM saves more time for maintenance purpose.

1. Introduction

Building Information Modelling (BIM) is a digital model of a building can be visualized in 3D physical form and contains various geometric information, function, features or parameters generated by various related software. The concept of BIM envisions a virtual construction before the physical construction is built, to reduce uncertainty, increase safety, solve problems and simulate

* *Corresponding author*
E-mail address: ainidris@uthm.edu.my

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and analyses potential impacts. BIM system used for creating and managing data during design, construction, and operations process [1]. BIM was introduced in Malaysia about 16 years ago by the Director of Jabatan Kerja Raya (JKR). Cancer institute, Sepang is a government project that made the first use of BIM technology in 2010. As a result, Construction Industry Development Board (CIDB) facilitated the implementation of BIM in this country by establishing the Malaysian BIM Steering Committee. The Malaysian BIM Roadmap was started by CIDB with the intention of promoting the use of BIM in the construction sector by 2020 [2].

The reality is that BIM implementation is hampered and does not proceed as planned due to factors such as project team member compatibility, reliability, reluctance to change, and a lack of preparation. Cultural barriers to adopting new technologies have resulted in project team members adopting a silo mentality. The benefits of BIM can be divided into five stages of a construction project's life cycle, beginning with the conceptual stage. This stage can provide a better visualization, detect clashes, perform accurate assessments, and serve as a reliable foundation for decision-making. The detail design stage can reduce design errors, improve coordination, reduce waste and reduce legal disputes. The documentation stage can improve coordination, reduce waste and reduce legal disputes. The construction stage is completed with construction quality control expected to improve, and the construction management stage provides building maintenance services via preliminary cost estimates. To gain the advantages of BIM, multiple parties must work together, including authorities, project team, and construction sector implementers involved. Expert thinkers are also needed to contribute thoughtful and quality aspirations to the development of BIM's success in the construction industry.

This house was built using the conventional method, which does not use BIM in construction. When a construction project does not use BIM, it will be difficult and delay the work of engineers for maintenance or check the current state of the project after it is completed. In conventional 2D CAD design, the various parties must wait till the other's designs are finished; the data deliverables must first be stacked up in silos before they can be shared amongst the design teams. Contrarily, with BIM-based design, sharing and integrating the teams' building information models at any moment enables early and prompt interchange of incomplete information across participants. This enables the modification and development of designs in real time. As a result, the data is always current, and the design intent representation makes it easier for parties to communicate and enables for continuous information flow rather than batch flow that is interrupted providing this BIM to engineers as well to facilitate their work in making facility management. Facilities management can be defined as the tools and services that support the functionality, safety, and sustainability of buildings, grounds, infrastructure and real estate.

The research of this project is to show that BIM is more efficient construction than the conventional or traditional drawing in building construction. As the BIM replaces the conventional method, which can provide a model and building information to stimulate and help perform real activities involved in the project [3]. The objective of this project is to make a BIM for architecture drawing of selected semi-D house in Revit software, to develop a BIM for structural drawing of semi-D in Revit software and to provide BIM of the semi-D house for maintenance and renovation purposes. Based on PDF architecture and structural drawing obtained from developer; the findings of this study are expected to draw a BIM architecture and structural drawing with Revit software and Revit software was used to create a BIM semi-D house model based on a combination of the BIM architecture and structural drawing.

2. Methodology

The methods used to carry out this study compare developing a chosen semi-D house using a conventional way and using a BIM software-based approach, according to the conventional design process, each specialist works on individual industry drawings prepared on tracing paper that only contain the elements for which they are accountable. In order to ensure project compatibility, specialists impose trace papers on one another during the coordination meeting [4]. While for the BIM, it will make all work easier for all stakeholders involved. The differences process of development semi-D house project between conventional and BIM system as shown in Figure 1.

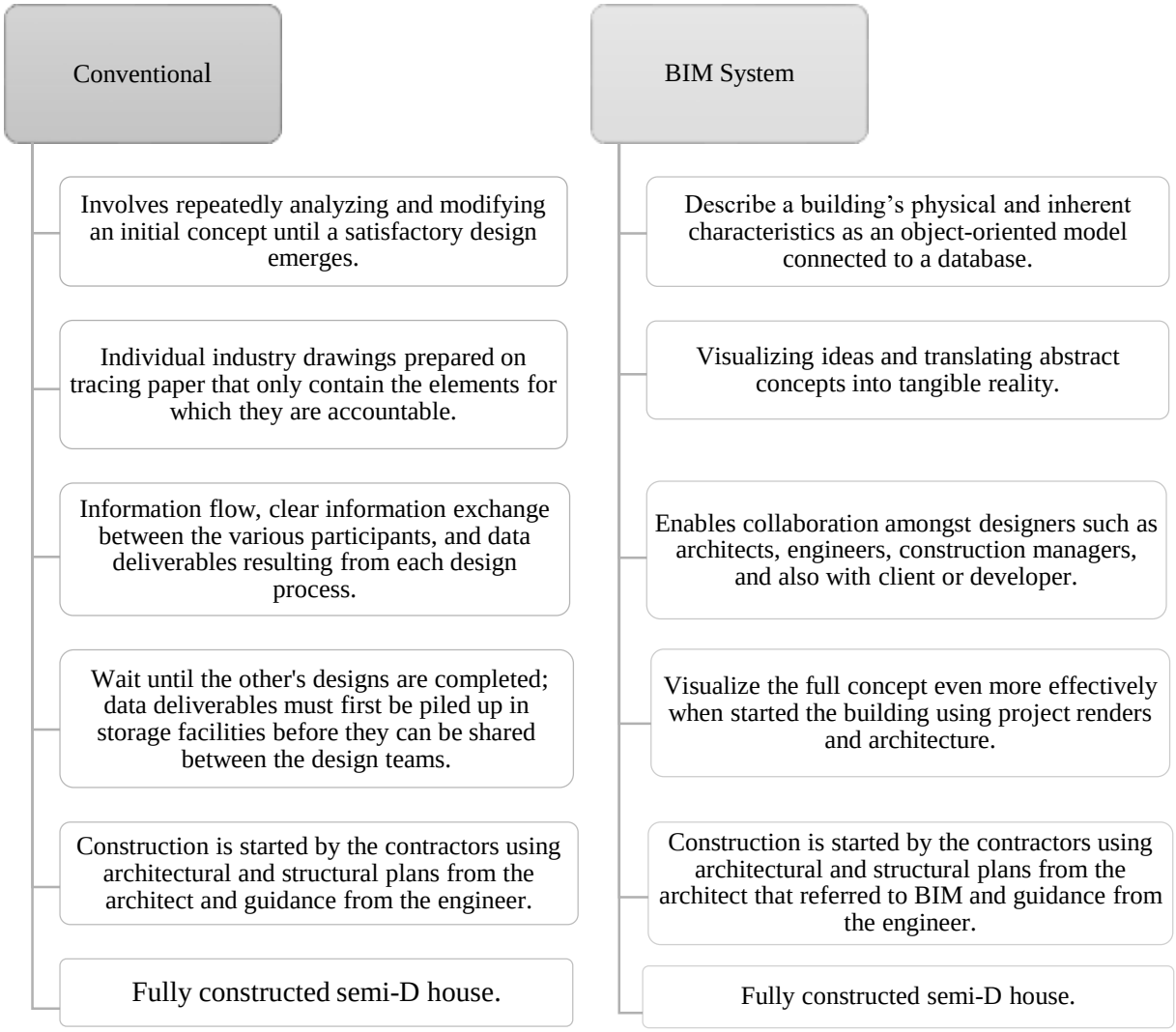


Fig. 1. Comparison of conventional and BIM system developing a semi-D house

2.1 Materials

The main objectives of this current study are to fulfil the focus of the study 'development of BIM system for renovation purpose'. Revit software is used to create architectural and structural drawings. To provide a BIM of a house, architecture, and structure must be combined to create a house model. Figure 2 below shows the flow chart of the work process throughout this study.

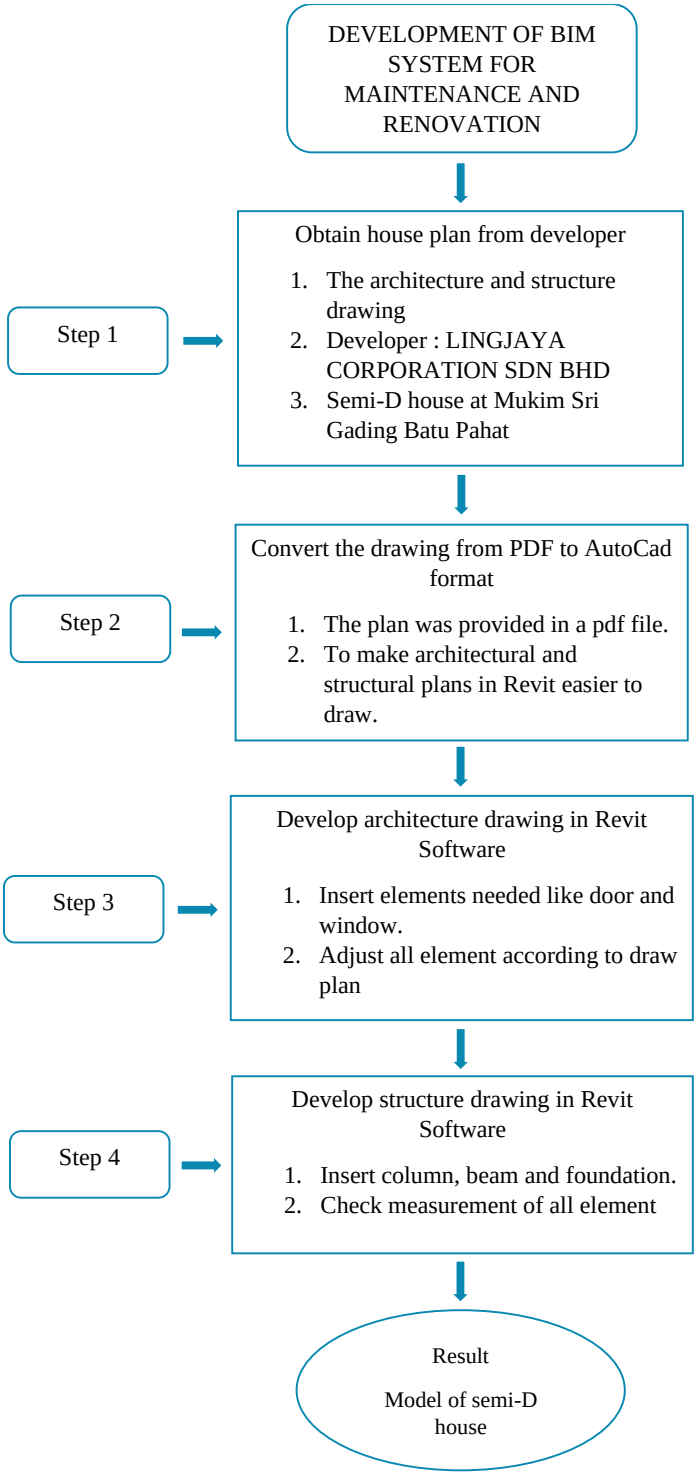


Fig. 2. The flow chart of the research methodology

2.2 Development of Semi-D House in BIM System

The architecture and structure drawings that were obtained from the developer were used to create the modal of BIM for a semi-detached house.

2.2.1 Obtain house plan from developer

The architecture drawing and structure drawing for Lot 22034 Mukim Sri Gading Batu Pahat are obtained from developer LINGJAYA CORPORATION SDN BHD. The plan obtained from the developer must be analysed because all building measurements, such as the dimension of the roof, wall height, and room area, must be known.

2.2.2 Convert the drawing from PDF to AutoCAD format

Figure 3 shows the process of converting a PDF to an ACAD file. Following that, both plans must be compared to ensure that there is no missing information or data from the plan after it is converted to an AutoCAD file.

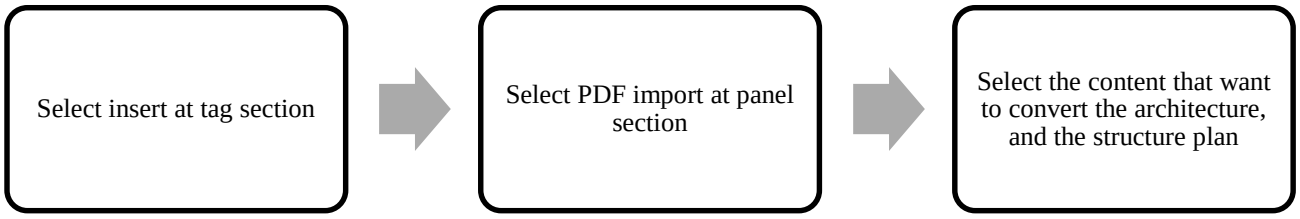


Fig. 3. Process of converting PDF to an ACAD file

2.2.3 Develop architecture drawing in Revit software

Developing an architectural drawing in Revit software requires several processes. The advice and program attended helped to complete the drawing. Figure 4 shows the process of developing an architecture drawing in Revit software.

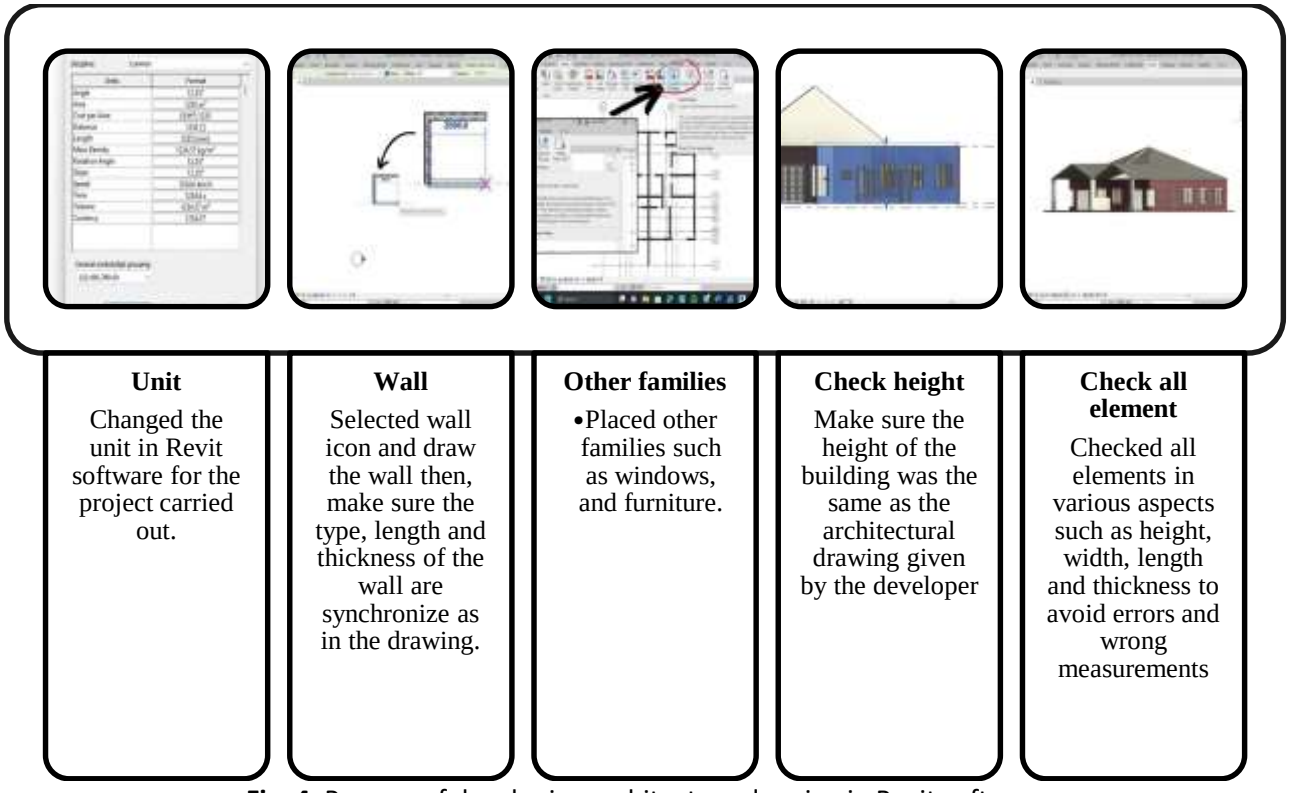


Fig. 4. Process of developing architecture drawing in Revit software

2.2.4 Develop structure drawing in Revit software

Developing an architectural drawing in Revit software requires several processes. The advice and program attended helped to complete the drawing. Figure 5 shows the process of developing an architecture drawing in Revit software.

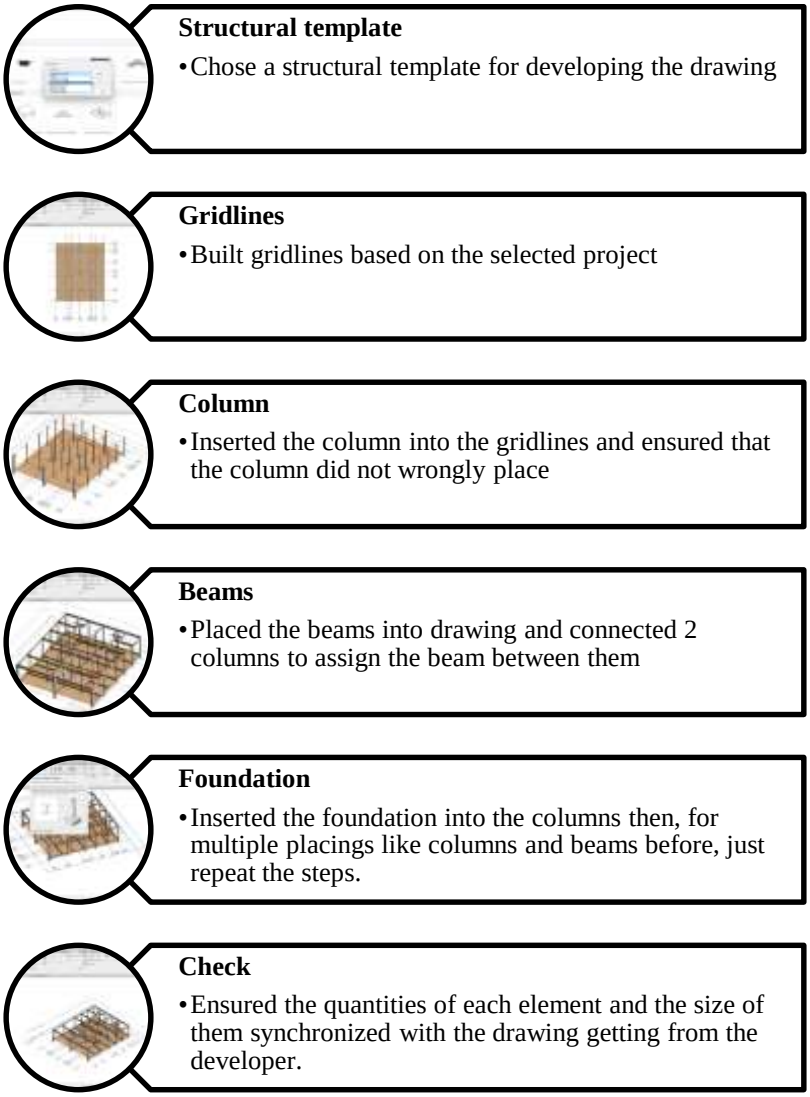


Fig. 5. Process of developing structural drawing in Revit software

3. Results and Discussion

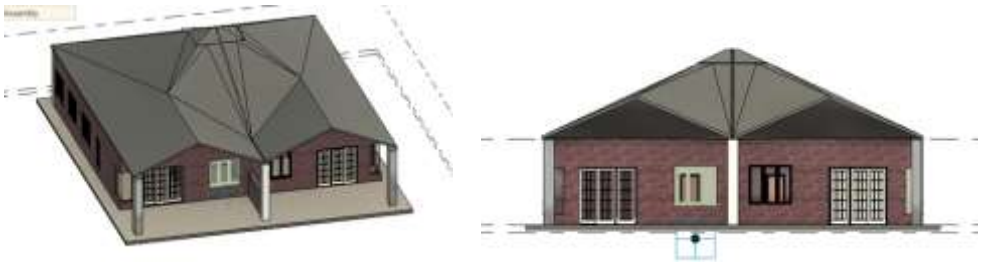
Autodesk Revit is a building information modelling software tool for architects, landscape architects, structural engineers, Mechanical, Electrical and Plumbing (MEP) engineers, designers, and contractors. The original software was developed by Charles River Software, founded in 1997, renamed Revit Technology Corporation in 2000, and acquired by Autodesk in 2002 [5]. The American Committee of the National Information Model Standard Project Committee defines BIM as a digital representation of a facility's physical and functional attributes as well as a shared knowledge resource for data about a facility that serves as a reliable foundation for decisions throughout its life-cycle, which is defined as existing from conception to demolition [6]. BIM system used for creating and managing data during the design, construction and operations process [7]. An architect's plan is a

basic structure drawing that describes how the project will be built and produced and contains detailed views such as floors, size sections, scale measurements and other related matters. Architectural drawings drawn in Revit software can describe more clearly and precisely how buildings are built and produced and contain more detailed views such as the length and width of the building, the height of the house and the roof structure. With Revit software, the drawing will make all sides works easier. All sides can stay in constant contact with the finished product and any changes made during the design process by working on a BIM 3D collaborative model. As a result, the project's design phase is finished more quickly and to a higher standard [8]. 3D drawings drawn in rivets can see every type of drawing and element at the same time. In contrast, in BIM-based design, early and timely exchange of incomplete information between participants is enabled by sharing and integrating the building information models of the teams at any point in time [9].

The 3D representation can contain a variety of information and data that can be used outside of the authoring tool [10]. Next, structural drawings play an important part in the project from the moment construction is begun. Engineers can more accurately understand the size, arrangement and strength of every component of the building with the use of drawings and calculations. The lack of fluency causes tedious duplication of models, design conflicts and inefficiency and frustration on both the architectural and engineering side of the coin [11]. By describing the size, shape and location of every component of the structure, structural drawings advance the architect's conceptual design and make it possible for that structure to be built on-site. Furthermore, BIM may give designers accurate data to affect a structure's location, direction and even construction materials [12]. The creation of reinforcement drawings also uses structural drawings. So, the best BIM system can describe a building's physical and inherent characteristics as an object-oriented model connected to a database [13].

3.1 Develop a BIM for Architecture Drawing

The 3D design that can be seen in Figures 6(a) and 6(b) was successfully created after the architectural drawing that was obtained from the developer was completed in the Revit software. In the architect's plan, there are several drawings, such as location plan drawings, site plan drawings, roof plan drawings and detail drawings [14]. It is important to make research and take advice because the responses often come from subjective experience, brain function, neural networks, and worldview, all of which are influenced by factors such as gender, geo-cultural background, socioeconomic situation, stage of development and many more [15]. Architectural drawings made with the Revit program contain more specific perspectives, such as the building's length and width, height, and roof structure, and may make the construction and production of buildings more precise and clearer. Every form of design and element can be seen simultaneously in 3D rivet drawings. The structural and mechanical 2D CAD plans were then reviewed while being layered over the architectural plans [16].



(a) (b)

Fig. 6. The 3D model of a semi-D house (a) from top view (b) front view

When drawing a building model, a gridline is a datum element that is used as a reference or a guideline. The two main grades of stainless steel that are offered in Malaysia are SUS 304 and SUS 316 [17]. A gridline serves as a drawing guide in architectural rendering. In structural drawings, this gridline function is used to specify the locations of columns, ground beams, stumps and footings as shown in Figure 7. Developing the model will be easier if users start by building a framework of grid lines early on in the project [18]. After that, the vertical height and features of a building are determined using levels in Revit. Each element or other significant building reference, such as the first floor, the top of the beam, or the bottom of the foundation, are designated by levels. Each level has a significant function when a building is being drawn.

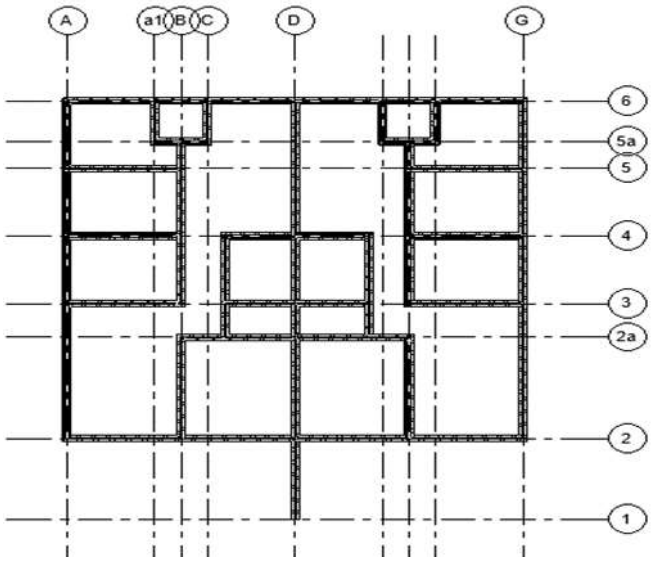


Fig. 7. The gridlines

Due to their numerous uses, walls are a crucial part of a building. The wall supports the load placed on it. A variety of factors, such as stability, weather resistance, strength and fire resistance, must be considered when constructing a wall [19]. The weight against the wall is supported by it as well. By looking at the given BIM, it is possible to determine the wall thickness and height for the semi-d home model. In the event of damage, this can make maintenance easier. A 3D wall drawing of a semi-D house can be seen in Figure 8.

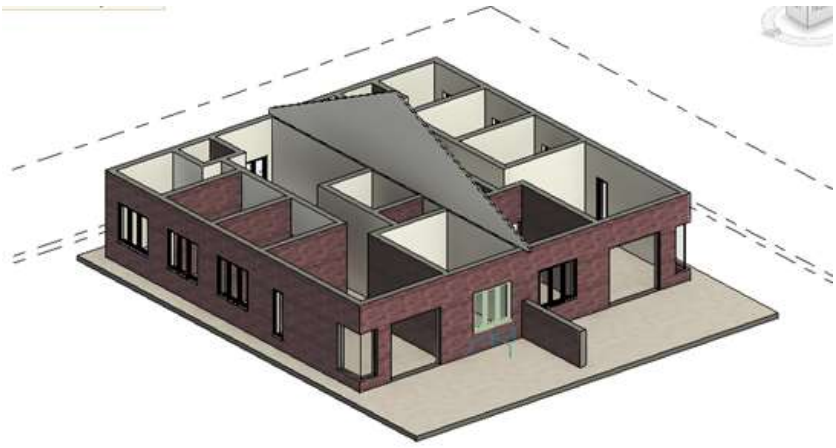


Fig. 8. 3D all of semi-D house

BIM can display the size and style of the doors and windows that are being used. The doors and windows used for each room vary in semi-detached homes, as depicted in Figure 9. The builder can accurately verify the size and kind of door and window and make the necessary alterations if there is damage to one in a particular room of the house.

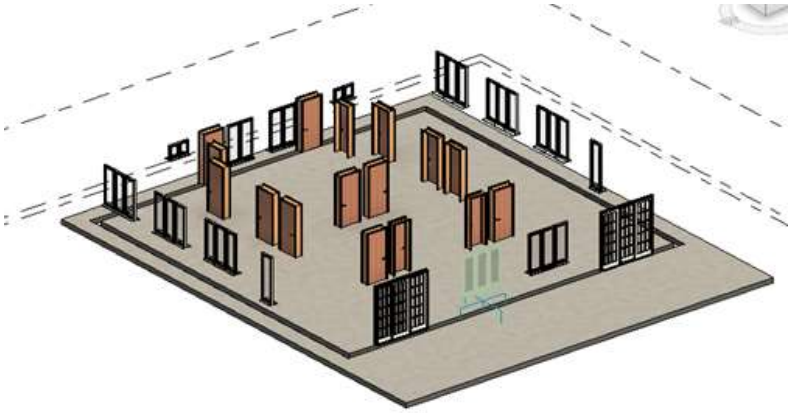
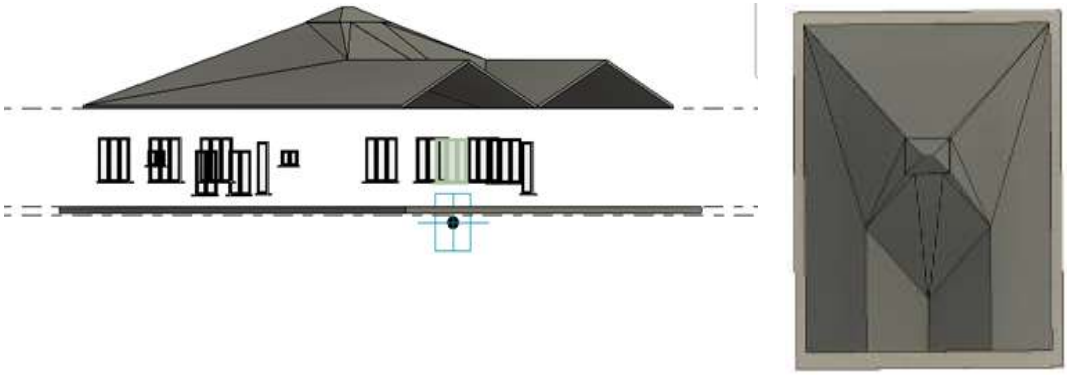


Fig. 9. Doors and windows vary in the semi-D house

The roof serves as a structure's top layer of protection from the elements, including rain, wind, chilly temperatures and direct sunshine. The connection will be designed to prevent composite action between the roof slab and roof beam because composite action increases bending capacity while not increasing the beam shear capacity, neglecting this effect could be very conservative [20]. BIM allows for the roof structure from several perspectives and provides an accurate representation of the roof shape of the semi-D home, as seen in Figures 10(a) and 10(b). It can also learn about the roof's measurements, including its width, height and inclination angle. Various types of roofs have been produced in Revit, and they can be selected based on how well the home being built fits them.



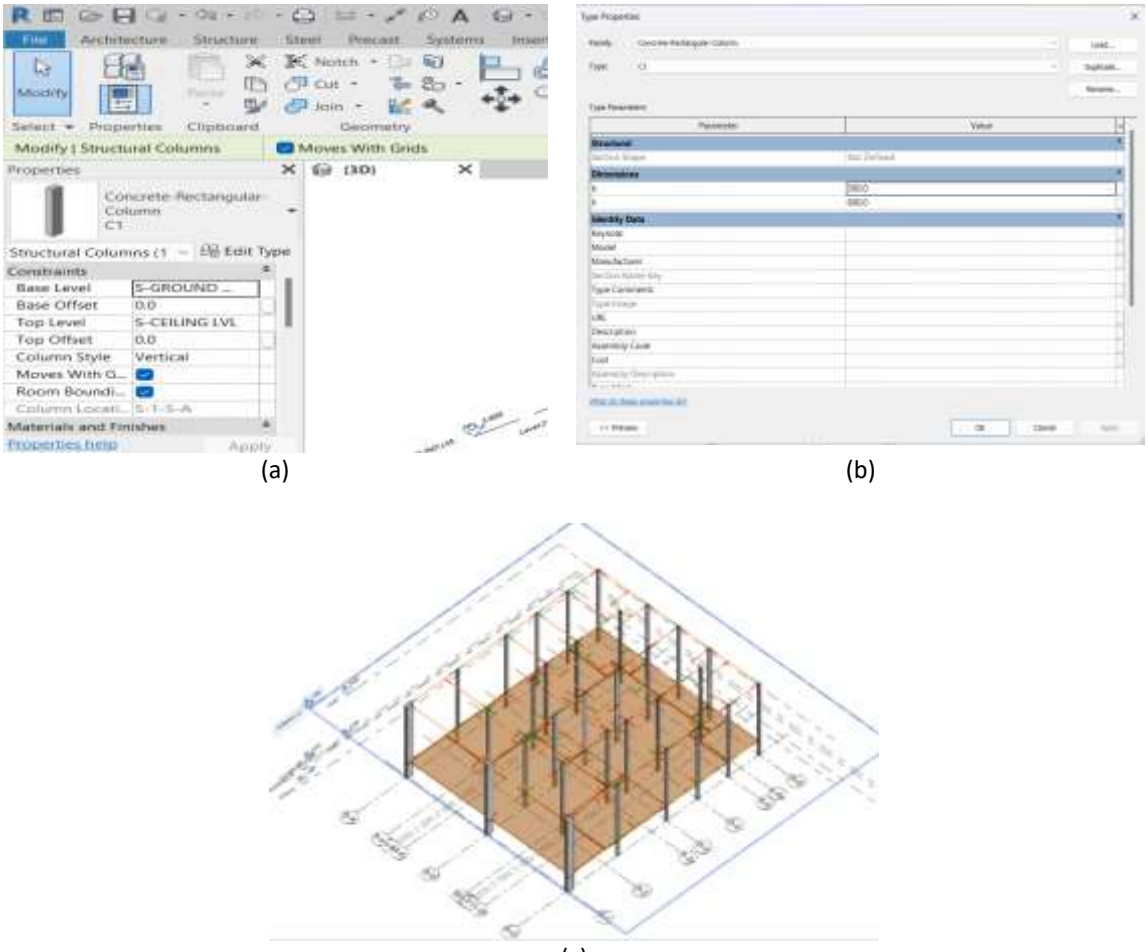
(a) (b)

Fig. 10. 3D roof of semi-D house (a) side view (b) top view

3.2 Develop a BIM for Structure Drawing

Revit is used in structural engineering. It provides resources for creating accurate models of architectural elements like walls, beams and columns. Engineers can assess a building's structural performance and determine whether it matches safety regulations using these models. A licensed professional engineer must produce, stamp and sign structural plans for them to be considered valid [21]. BIM, especially focusing on the structural analysis and design stage of a building [22]. Columns are compression members that can be vertical or inclined and are used to carry superstructure load

to the foundation. Due to the sudden removal of columns brought on by unanticipated extreme loading, the surrounding column-slab connections may experience significantly increased bending moments and shear forces. This may result in punching shear failure at these connections and the progressive collapse of entire reinforced concrete (RC) flat slab structures [23]. Structural columns also have extra characteristics defined by their design and industry requirements [24]. In terms of the project, this semi-D home in Mukim Sri Gading features a variety of column types and sizes. For the overall total of the two houses, there are 31 columns. There are 19 columns for each semi-D house, and the centre 7 columns are shared by both for the boundary. Make sure all columns to synchronized with types, dimensions and materials of structural drawing occur from the company. Figure 11(a), 11(b) and 11(c) displays the column constructed following the project's structural drawing. The types of the column need to be set first which is rectangular column with the specific dimensions and assign the correct position of the column in the drawing.



(a) (b)

(c)

Fig. 11. Construct column following the drawing (a) types of columns (b) dimensions of columns (c) 3D views of all columns

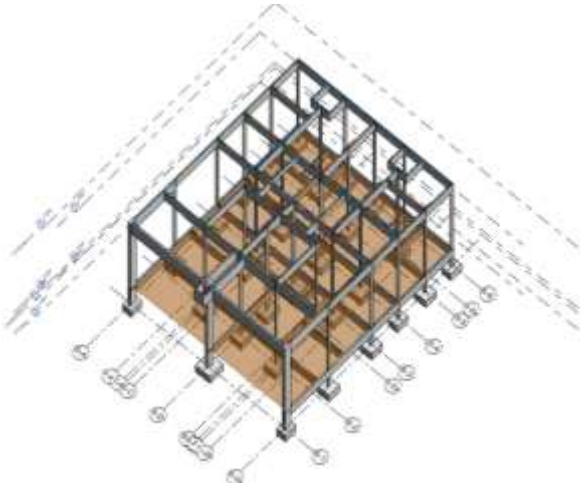
A beam is a horizontal part used in building construction that covers an opening and supports a load, such as a brick or stone wall above the opening, in which case the beam is frequently referred to as a lintel [25]. Ground beams are beams designed to bridge between pad foundations, piles and other structures rather than using conventional foundations. For low-rise buildings, ground beams are normally composed of concrete and constructed on-site; however, because this method may be a little time-consuming, the usage of precast concrete ground beams has increased. Including "intelligent" concrete elements, it also can now improve Dynamic Structural steel [26]. The

advantages of using ground beams over standard footings include easier installation and the elimination of ground condition uncertainties. Additionally, they generate a bearing level that is incredibly accurate, reducing the amount of levelling required before starting to construct the superstructure. This semi-D home in Mukim Sri Gading uses a range of ground beam types and diameters throughout the building. There are 9 different types of concrete rectangular beams sizes between the two houses as a whole. To avoid placing the wrong level of the beam, the level must be changed to 'S-Ground Level' before it can be set up. The beam selection and modification on the ground level are shown in Figure 12(a) and 12(b) below.

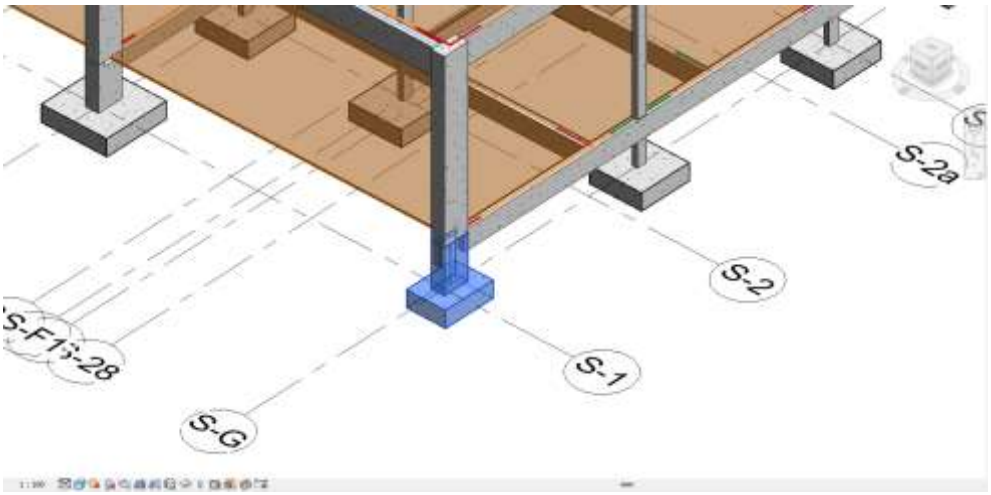
(a) (b)

Fig. 12. Set up of beam in Revit software (a) Beam selection and level selection (b) 3D view of ground beam level

The simplest and most well-known sort of footing for supporting buildings vertically and transferring construction weights to the foundation is the stump. Stumps are currently the most cost-effective way to support structures with timber frames. Each column in this project has synchronized stumps. There are 31 columns-like stumps. The stump's size is determined by the columns. It's crucial to adjust the stump's level under the drawing. Next, the foundation secures the distribution of loads from the structure to the ground at the lowest point of a building or other civil construction that is in direct contact with the earth. Foundations can be divided into two categories: shallow foundations and deep foundations. The project's foundation is determined by the position of the columns. For the semi-D home, there are 31 foundations with various dimensions. Figure 13(a) and 13(b) displays a 3D view of the foundation analysis.



(a)



(b)

Fig. 13. The foundation analysis (a) 3D view of the foundation (b) Zooms of the foundation

To avoid separation during rebound, the roof beam is joined to the roof slab. The connection is going to be made to stop the composite action between the roof slab and the roof beam. It supports the roof or floor above and fortifies the walls by holding them firmly in place to prevent them from spreading out or bending in. Roof beams serve to support the rest of the roof as well as any joists, trusses, battens, or roofing materials. Figure 14 shows the roof beam that has been finished following the project for the semi-D home. Producing flat, functional surfaces like floors, roofs and ceilings requires the usage of slabs, which are essential structural elements. It is a horizontal structural element with top and bottom surfaces that are parallel or nearly parallel. Usually, beams, columns made of concrete or steel, walls or slabs support the soil. The depth of a concrete slab floor is relatively small concerning its breadth. The slab may be supported by columns, walls, reinforced concrete beams that are typically cast in a single piece with the slab, or even by the earth. The drawing for this project specifies that, unless otherwise specified, all slabs must be at least 100mm thick.

Fig. 14. The roof beam has been placed synchronized with the project drawing

The outcome has been obtained after all the necessary pieces have been inserted into the Revit software to produce structural drawings. Specific checks must be made on each element, particularly on their position and measurements. If a small defect or dimension error is not fixed, it will cause a significant issue. Because of the unequal distribution of the weight from permanent and variable loads, the structure will be at risk of cracking or collapsing. Figure 15 displays the finished structural drawing created with Revit software.

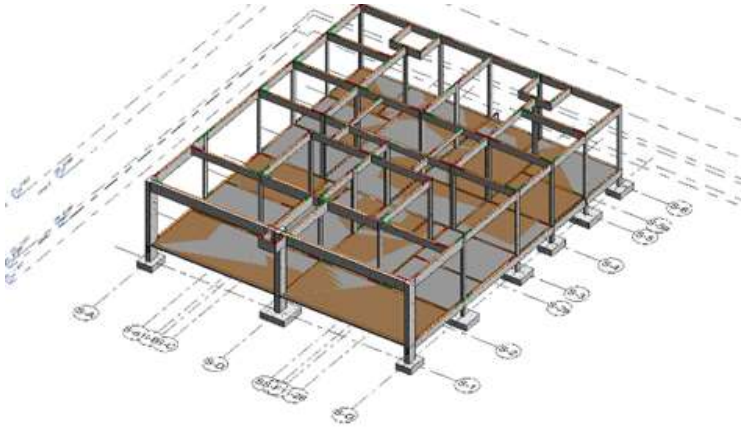


Fig. 15. Complete structural drawing in Revit software

3.3 Building BIM for Maintenance

The use of BIM can be extremely advantageous to all parties involved in the construction process, including those involved in the planning, design, construction, operations and maintenance phases. The implementation of the BIM in the management phase has become vital in today's world for a few key reasons. Due to the fact that BIM is already ingrained in the design and construction phases, its adoption in the management and maintenance phase that follows is both natural and unavoidable. In addition, will increase the effectiveness, affordability and transparency of the way assets are handled. Regardless of the scale of the assets that need to be managed, the BIM will gradually replace existing facility management practices. Planning improvements, reorganizations and conservation adaption interventions can be made easier with the help of BIM, which offers

fundamental information. The use of BIM for facility management is also very advantageous because it is much less expensive to create and maintain a database based on 2D drawings than it is to create and manage a BIM model specifically for that purpose [27]. In the current project, BIM is utilized to plan for future maintenance on a semi-detached home in Sri Gading, Batu Pahat based on combination of architecture and structure drawings as shown on Figures 16, 17 and 18.

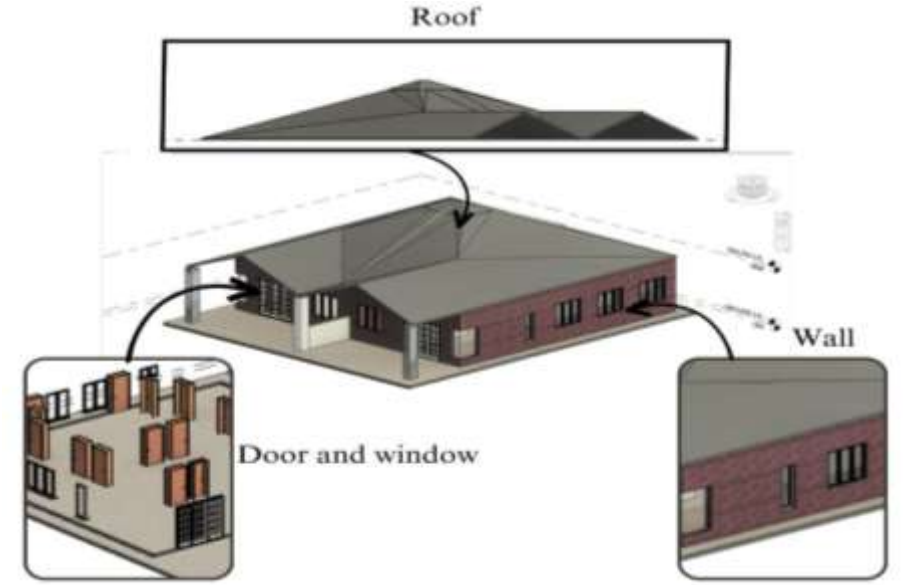


Fig. 16. BIM of architecture

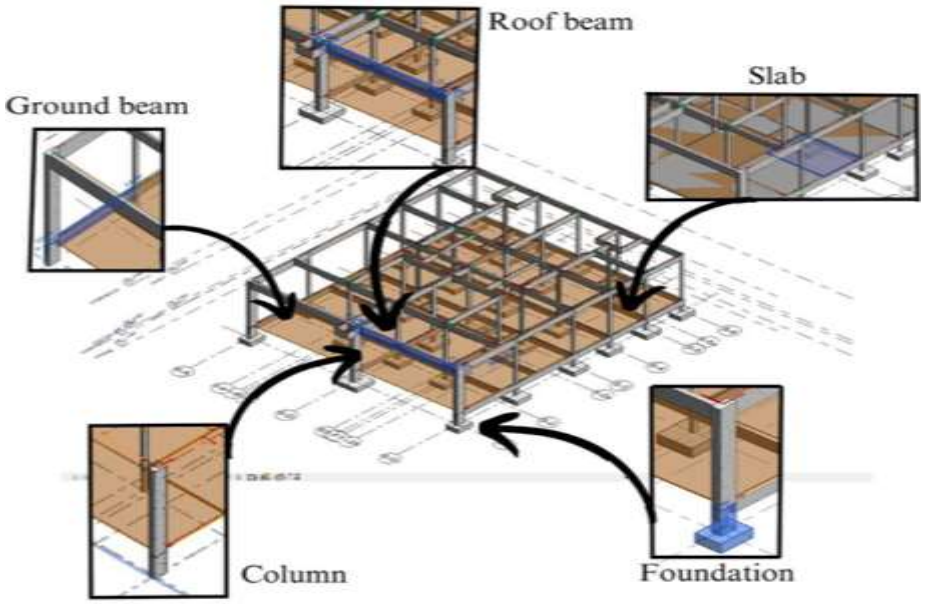


Fig. 17. BIM of structure

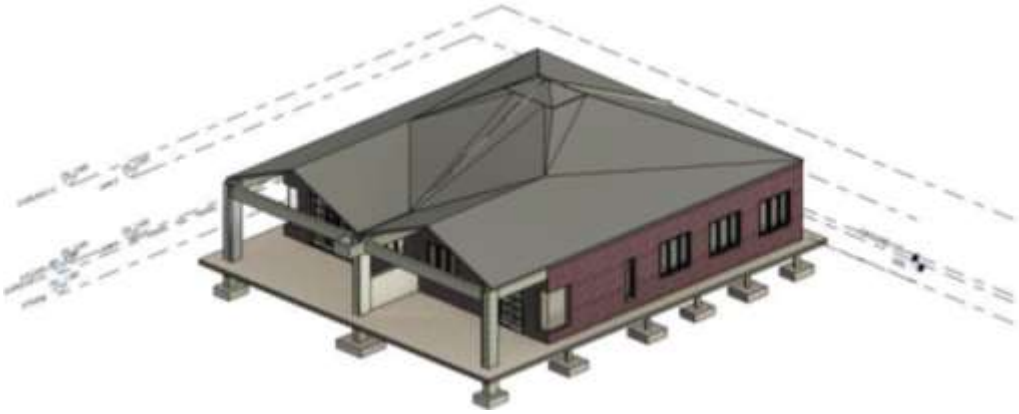


Fig. 18. Combination of architecture and structure drawings

BIM is typically used to identify clashes, but this project shows that it can also be utilized for future house maintenance, as well as for use before, during and after house construction. BIM is also useful for remodelling, which has additional benefits beyond maintenance. For instance, if a client decides to renovate an uncertain part of their home, the developer can utilize BIM to create a preliminary representation of the area that will be rebuilt. If the client rejects, the idea developer may present a different suggestion without first making any changes.

4. Conclusions

In conclusion, the project developed the BIM of the semi-D house at Sri Gading, Batu Pahat and showed that Revit software could be considered an efficient software for developing architectural and structural drawings for the project. Project results show that when Revit software is employed, it may nearly completely automate the viewing of project drawings for architects and engineers. Nowadays, many Architectural, Engineering and Construction (AEC) companies demand that employees refresh their Revit skills through an Autodesk-certified Revit architectural, Mechanical, Electrical, and Plumbing (MEP), or structural certification course that teaches users about the BIM procedure. So, it clearly can help for the better future. The objectives of this study are achieved: Drawing of architectural and structural drawings had been developed. Therefore, it can be concluded that more time can be saved when using Revit software to develop BIM, especially for architecture and structural drawing. The model developed in BIM can be referred by many parties such as contractor and also the owner of the building for the maintenance or renovation works.

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