DEVELOPING QUALITY AND PERFORMANCE OF CONSTRUCTION USING 3D MODEL IN BUILDING INFORMATION MODELLING

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ABSTRAK

Tujuan kajian ini adalah untuk meneroka potensi teknologi BIM (Building Information Modeling) yang digunakan untuk pengurusan dan penyelenggaraan prosedur pembinaan bangunan yang lebih khusus. Ia memberi tumpuan kepada konsep objek dan didedikasikan untuk penerangan 3D (tiga dimensi) persekitaran yang dibina. Ia membolehkan penerangan dan perwakilannya secara holistik, dengan menerangkan objek yang dibina melalui skala lebih atau kurang terperinci, dan kompleks, jika satu menggabungkan satu set data geometri dan bukan geometri dengan kemungkinan parametrization objek. Selain itu, kajian ini menyiasat proses penyelarasan perdagangan model BIM 3D untuk cabaran dan masalah melalui pendekatan kajian kes dan menawarkan wawasan untuk penambahbaikan berterusan.

ABSTRACT

The purpose of this study is to explore the potential of BIM (Building Information Modeling) technology used for the management and maintenance of more specialized building construction procedures. It focuses on the concept of objects and is dedicated to the 3D (three-dimensional) description of the built environment. It allows its description and representation holistically, by describing objects constructed over more or less detail scale, and complex, if one combines a set of geometric and non-geometric data with the possibility of parametrization of the object. Additionally, this study investigates the BIM 3D model trading alignment process for challenges and problems through a case study approach and offers insights for continuous improvement.

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LIST OF SYMBOLS

BIM	Building Information Modeling
AEC	Architectural, Engineering and Construction
CAD	Computer-Aided Design
2D	Two-Dimensional
3D	Three-Dimensional
FM	Facility Mnagement
PM	Project Management
KK4	Kolej Kediaman 4
UMP	Universiti Malaysia Pahang
UMPH	Universiti Malaysia Pahang Holdings Sdn. Bhd.
PDF	Portable Document Format

LIST OF ABBREVIATIONS

BIM	Building Information Modeling
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CHAPTER 1

INTRODUCTION

1.1 Introduction

Building Information Modeling (BIM) is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle, defined as existing from earliest conception to demolition. BIM is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructures (Autodesk, 2018). It is a process for creating and managing all the information on a project before, during and after construction.

Besides that, BIM is a platform to share knowledge and communicate with project participants. Architects, contractors and engineers use the software to visualize, design and coordinate the construction of a building end to end (G2 Crowd, 2018). BIM software is similar to CAD but the difference is that all the tools are for designing a building. Both 2D and 3D modelling tools are often included in BIM, which allows for creating construction documents and visualization. The output of this process is the Building Information Model, the high-quality 3D renderings and digital description of every aspect of the built asset.

This project intends to address the topic of developing quality and performance of construction using the 3D model in BIM within an organization which include visualization, 3D coordination and record model in detail. BIM tools were further analyzed by developing a prototype 3D model. The research concluded that although BIM tools do pose some shortcoming such as interoperability issues, the use of BIM is very beneficial to the construction managers.

Figure 1.1 The Process of Building Information Modelling

1.2 Background of Study

Participants in the building process are constantly challenged to deliver successful projects despite tight budgets, limited manpower, accelerated schedules, as well as problems that regarding the issue of waste, which is happening due to the fragmented nature of the AEC industry (RCS, 2014; Man and Machine, 2014). The AEC industry has long sought to adapt techniques to increase productivity and quality, decrease project cost, reduce delivery time and eliminate waste which one of these techniques is BIM. Traditionally, architectural design, structural analysis and construction management are three separate steps with distinct objectives in building engineering activities. With the prevalence of information technologies in the building industry, the combination of design and construction activities can be achieved through the integration of BIM and 3D technology (Zhenong *et al*., 2008).

BIM is an inevitable development from 3D CAD (Malleson, 2013). BIM represents the development and the use of the computer generated n-dimensional (n-D) model to stimulate the design, construction and operation of the facility. It is the process and practice of virtual design and construction throughout its lifecycle (AGC, 2005; Lorch, 2012). The key benefits of BIM are its accurate geometrical representation of the parts of a building in an integrated data environment (CRC Construction Innovation, 2007). The use of BIM can increase the value of a building, shorten the project duration, provide reliable cost estimates, produce market-ready facilities and optimize facility management and maintenance (Eastman *et al*., 2011).

On the other hand, the realization of the benefits of BIM is contingent upon a proper implementation of 3D BIM at an organisational level and its integration at the industry level (Khosrowshahi and Arayici, 2012). In general, the barriers to BIM adoption in the AEC industry may be knowledge barriers, technical barriers, process barriers, managerial barriers, legal barriers, cultural barriers, as well as barriers to education and training (Fischer and Kunz, 2004)

1.3 Problem Statement

Implementing BIM into a company construction will cause some changes. Employees need to be able to work with different software such as Revit, ArchiCAD or Navisworks. Training enables them to use these software programmes. This does not mean they are fully capable to use all the facilities BIM offers to its users. BIM is not just software; it is a process and software but they to implement a new way of thinking BIM entails (Hardin, 2009). This new way of thinking should lead to more collaboration, effectively deploying and utilizing data multidisciplinary and throughout the building lifecycle (Adamu, 2014). Most of the people involved in the construction project are lack of communication and less interaction among the project teams directly contributes the problem. The earlier the changes are identified, the lesser impact it will have on the project. Besides that, conflicts over project changes can be minimized when the problem is found at the earlier phase of the project.

The problem with the traditional/conventional method is that the documents produced are same as manual and did not save the building design and construction industry from being inefficient. CAD systems did nothing to reduce errors and wastages which basically arise due to coordination problems. With the introduction of 3D modelling techniques, advanced definition and complex surfacing tools were added. It is clear that 3D BIM model could improve quality and performance in the construction industry.

Usually, during the design stage, planners and architects work independently with little input and lack of communication with each other (Granroth, 2011). Due to this, revisions of plans and design always occur that affect government and the private are required to have a close collaboration and working together to bring positives changes in the industry. Most of the practical and exploratory CAD tools focus on a single discipline or a single task in the process. Therefore, the usefulness of models should be judged not against an imaginary perfection, but in comparison with the mental and descriptive models that could be used alternatively (Radford *et al.,* 1998).

1.4 Aim & Objectives of Study

The aim of the study is to develop the accuracy of as-built model through BIM approach. The objectives of the study are :

i. To identify how the 3D BIM-model can contribute to time, cost and quality during the maintenance process.

ii. Analysis of the benefits and obstacles of using BIM to support sustainable design.

iii. To analyze potential problem areas and fix them before the error is committed in the physical world.

1.5 Scope of Study

Project success is dependent on the performance of the design team. The designers are the key players in the construction industry whose services are need from the conception stage of the project to its completion. The performance of the designers is therefore important because of any decision made at the inception of the project will affect project success. Defective designs adversely affect project performance and the participants and are responsible for many construction failures (Minato, 2003). Therefore, this study focuses on construction planning as they are still using the traditional way which is the 2D CAD systems. Other than that, it focuses on the design stage, focusing on BIM modeller in three triangle practises; time, cost and quality. The critical information required to achieve the study objectives is to a degree present in the presentation drawings provided.

1.6 Limitations of Study

The first problem of applying BIM is how to get the effective model in project construction phase (Xue Li, 2017). Take the contractor as an example; contractor get information from the designer in the traditional way is through the 2D drawings (paper or electronic document). In recent years, with the application of design software based on BIM at home and abroad construction projects; some contractors have access to such building information model based on the 3D model. There are some problems based on the above two kinds of circumstances. Regarding the first kind of situation, we establish the BIM-based on the 2D design information by certain software tool and professionals.

At the same time there will be time and the cost consumption and in the process of information exchange, there may appear lost or wrong of information. For the second method, although we can directly obtain BIM formed in the design phase, the key point of the demand and applying is not the same in different stages, so the BIM cannot be equivalent to the stage of construction. Therefore, we need to add information not contained in the data model to the BIM, such as quality information, cost information, the contract schedule, construction method, standard, etc. Only in this way can we realize the integration of information management. This problem also exists in the first model to a certain extent.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will review 3D BIM model applicability and contribution in the building and construction sphere; as it will investigate how the 3D BIM model can contribute to time management during the maintenance process. Secondly, to review BIM as giving benefits and obstacles to support sustainable design. Thirdly, to review BIM as it will analyze the potential problem areas and fix them before the error is committed in the physical world. As seen in the previous chapter, BIM applicability in the construction industry relates to its backbone of software in the professions related which is Autodesk Revit..

2.2 Project Management (PM)

Construction is one of the important sectors which influence the economy of our country. This sector creates many work opportunities to the citizen and involves several parties such as contractors and architects. Project management is defined as the short-term objective relatively in planning, organizing, directing and controlling the company resources establishing to complete the specific goals and objectives (Kerzner, 2006). Generally, project management is not much different from construction project management.

According to (Walker, 2007), construction project management is defined as planning, coordinating and controlling of a project from the beginning to completion on behalf of a client demanding objectives. This includes utility, quality, function, time and cost, and the establishment of the relationship between the resources, integrating, monitoring and controlling the contributors to the project and their output, and evaluating and selecting alternatives in pursuit of the client's satisfaction with the project outcome.

Construction process can be divided into three important phases; project conception, project design and project construction. A project is a one-time task controlled by time, cost and quality, and its success depends on how to fit these constraints are balanced (Atkinson, 1999). All construction projects comprise two different phases: the preconstruction phase (the period between initial conceptions of the project to awarding of the contract) and the construction phase (the period from awarding the contract to when the actual construction is completed). Delays and cost overruns can occur in both phases.

2.2.1 Time, Cost and Quality

Management in the construction industry is considering as one of the most important factors affecting the performance of works. In the industrial world and construction industry, in particular, time, cost and quality form a triangular relationship (Figure 2.2.1). In the majority of decision-making parts, management has to compromise in one area in order to get the best result in the other two. Primarily, cost and quality are always fighting for time (Saputra, 2011).

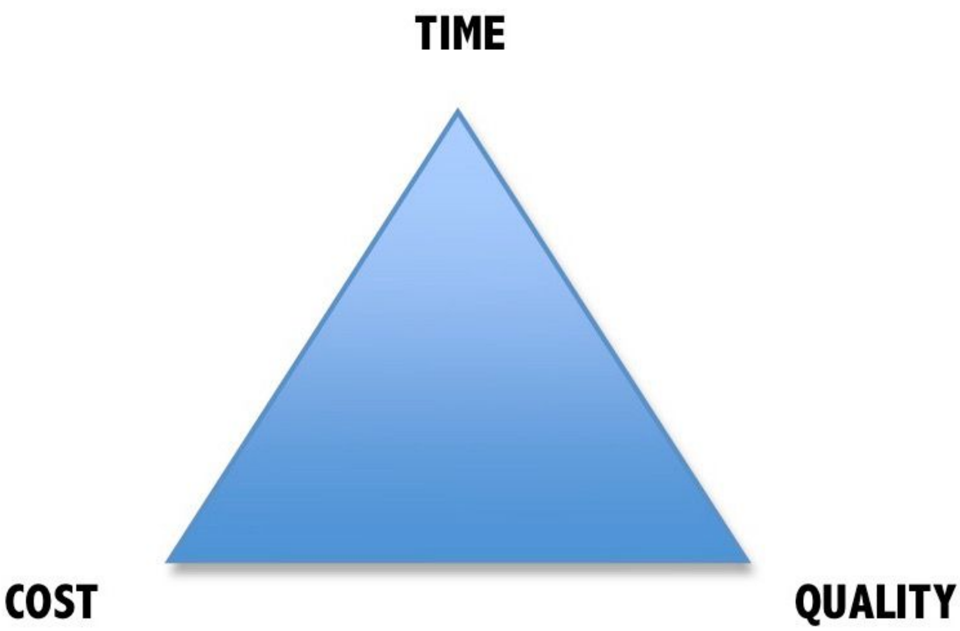

Figure 1.2 Triangular Relationship

2.2.1.1 Time

Timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors and consultants similar. Successful companies must deliver projects on time, within budget, and meet specifications while managing project risk (Raymond & Bergeron, 2008). In construction, a delay could be defined as the time overrun either beyond completion date specified in a contract or beyond the date that the parties agreed upon for the delivery of a project.

Realistic construction time has become increasingly important because it often serves a key benchmark for assessing the performance of a project and the efficiency of the contractor (Kumaraswamy & Chan, 2007). Samuelsson (2008) said that the use of technology that can handle 3D computer object has doubled by architects and increased by over 30% by technical consultants (Figure 2.2.1.1).

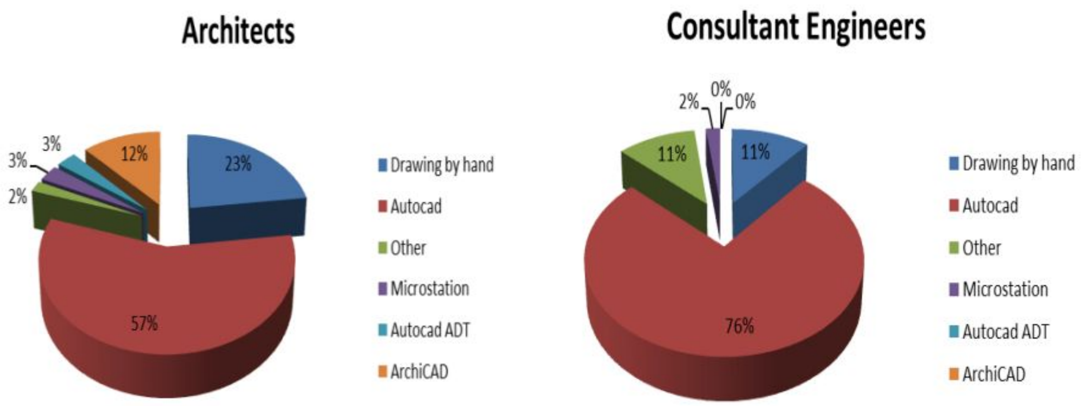

Figure 1.3 Usage of Technology to Produce Model in 2007 (Samuelsson, 2008)

In the current situation, all participants in the project use a common database to store drawings and exchange information with each other (Bergmark, 2014 & Noren, 2009). In conventional method 2D "plain old" hidden lines views but in Revit Architecture colour settings done and leaving the visualization studio to focus on the high-quality presentation material needed for reviews, approvals and marketing the project save time. The platform from Revit linked to the visualization of 3D StudiaMax that minimizes the time required to coordinate the architectural design and visualization (Autodesk, 2008).

2.2.1.2 Cost

Cost is among the major consideration throughout the project management lifecycle and can be regarded as one of the most important parameters of a project and the driving force of project success (Azhar *et al.,* 2008). Furthermore, cost performance is an effective technique in project management effort expanded and it is widely accepted in the literature and industry (Gido & Clements, 2003). According to Angelo *et al.* (2002), cost overrun is the main problem in a project development and is a regular feature in the construction industry but it is not as much of effective compared to time management (Ramli, 2003). Categories of project cost management include project resource planning, cost budgeting, cost control and cost estimating.

Two important components of cost control are cash flow management and project accounting. It should determine the projected final cost and consider the projections of future cost where it involving scope, time and quality. Normally, cost estimation made before the start of a project so that it can be controlled by cost budget. A project may require more than one person and occur more than once during the life of a project which depends on the complexity of the project. It may be very simple or extremely complex when managing the cost of a project. In project management, it should also consider the needs of project stakeholders in the project cost (Gido & Clements, 2003).

2.2.1.3 Quality

Quality of the finished project is one of the components that contribute to value for money to the client (Flanagan & Tate. 1997). According to Vincent & Joel (1995), the total quality management is defined as the integration of all functions and processes within an organisation in order to achieve continuous improvement of the quality of good and services. The goal is customer satisfaction. In Malaysia, the application of the cost of quality concept in the construction industry is a relatively new field of interest. Hence, the economic sense of improving quality not well understood within the players of the building construction industry, It is no surprise that some building contractors may avoid quality improvement processes believing that these processes add only time and cost to the process of construction. At the same time, less satisfactory performance in the construction industry has led to the belief that construction projects cannot be completed within budget and desired quality (Rahman, 1996).

2.3 Benefits and Obstacles of BIM.

BIM technology makes it possible to improve many aspects of the construction process. Even though Eastman et al. (2008) mention that BIM is still in the early days of the architecture, engineering and construction and facility management (AEC/FM) industry, already significant improvements have been realized. First and foremost, it increased the building performance and quality by creating a design model and alternatives using analysis or simulation tools to evaluate the overall quality of the building will increase. The 3D model from early on is generated to correspond with the BIM software, where at any stage of the process this model can visualize the design rather than it is generated from multiple 2D views.

Table 2.1 Difference between BIM and CAD

Building Information Modelling	**Computer Aided Design**
2D, 3D, 4D, 5D 6D and beyond	Primarily 2D
Intelligent objects	Dumb graphics
Walls, doors, floors, roofs	Lines, arcs, circles
Using Autodesk Revit	Using AutoCAD

Other than that, 3D BIM model can generate accurate and consistent 2D drawings at any stage of the design. At any time during the project, accurate and consistent drawings can be produced. If there are any changes made to the design, new and fully consistent drawings can be produced as soon as the modifications are set. This reduces time and errors that are related to creating all construction drawings for all specific disciplines. The 3D BIM model can improve energy efficiency and sustainability where it has the possibility to link the model to various types of tools that can analyse the project to improve the quality of it such as the energy use. This is already possible during the early stages of design, whereas using 2D drawings and their associated tools require a complete design. At the post-construction phase, the model contains information including graphics and specifications for every system used in the construction project.

2.4 Clash Detection

Clash detection is an important and integral part of the BIM modelling process. A clash occurs when elements of different models occupy the same space (The Bim Center, 2016). Clash detection arises out of the fact that, in BIM modelling, there is just not one model but several, which is in the end integrated into a composite master model. After each of the disciplines has finished their work, the next step in BIM modelling is clash detection which is the process of finding where the model "clash": elements of separate models occupying the same space, or with parameters that are incompatible.

The 3D BIM model can discover any design errors and omissions before construction which is called as clash detection. This eliminates every design error caused by 2D drawings that are inconsistent. Sytems and designs from different disciplines are brought together and checked systematically and visually. This method identifies conflicts in the design phase before they are detected in the field. If there are any problems in the suggested design alternatives, changes can be entered into the design model. This building model will update every change automatically based on established parametric rules. The consequences can be viewed and resolved immediately.

Nevertheless, there are also some obstacles to implement BIM in the construction industry. Adoption of technology in construction has been slow but the industry is increasingly becoming aware of BIM's potential in the field. BIM promises better decision making throughout the lifecycle of a project. As BIM addresses age-old problems in a more cost-effective manner with better problem solving, more effective communication and faster project building, for all its benefits, BIM brings new challenges around creating and collaborating on models.

Basically, it is quite burdensome to view the model especially when you are at the site. Plus, the model will have large file sizes which can be difficult to distribute files securely and efficiently. Typically, people on a project work with different authoring tools. The BIM Manager then compiles and distributes the federated model. This might happen on a weekly cycle, which can be too slow for a fast-moving project. Allowing each party to contribute its model as needed, while others access the information in real time, makes BIM more valuable to everyone.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The creation of a 3D model using the Autodesk Revit showed the powerful features of BIM. The creation of an element on a view such as floor plan translated correctly to a different view such as elevation view. This saved a lot of time in comparison to if the design were drawn in traditional 2D view. In the BIM methodology, the project uses a Autodesk Revit software and all production is automated. The 2D planes are directly extracted from the model, through the definition of plants, sections and elevations that will be required and directly linked to it, so that the changes that are entered in the model are automatically updated in all planes. In order to produce the perfect 3D model, one should follow the process accordingly based on flow chart below:

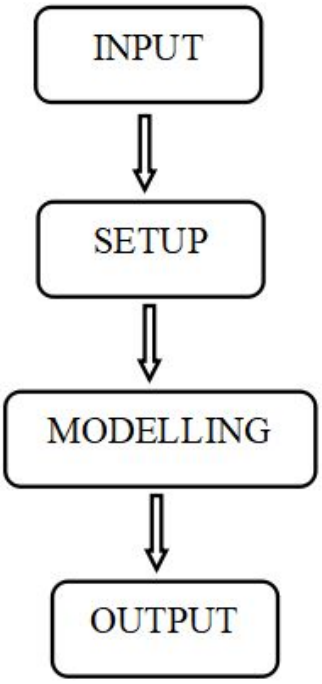

Figure 1.4 Process of 3D Model

3.2 Collection of Data

This project will be about Kolej Kediaman 4 (KK4) located in Universiti Malaysia Pahang (UMP). Before starting any project, the 2D plans must be required first from the authorities which is Universiti Malaysia Pahang Holdings Sdn. Bhd. The drawings can be a file in CAD format or a file in PDF format. The drawings must contain every information needed for the 3D model like elevations and cross sections. In this case, the drawings obtained are in PDF file format. Figure below show the data collected from UMPH :

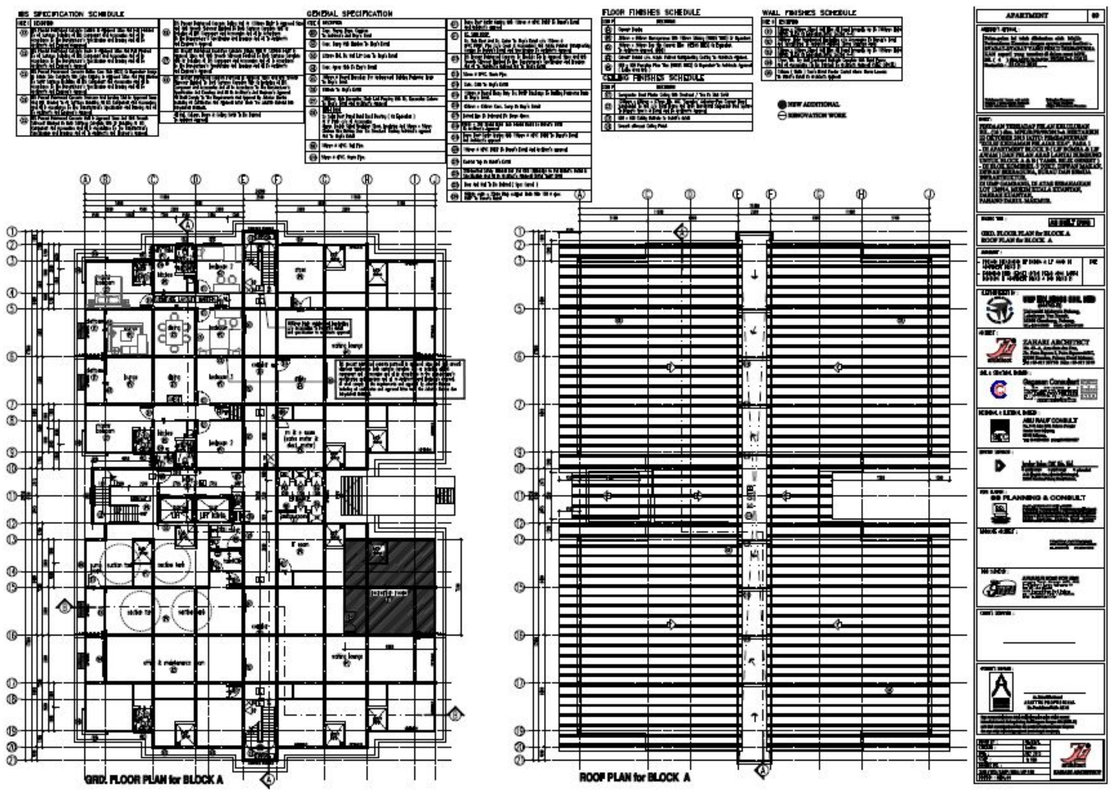

Figure 1.5 Ground Floor Plan of KK4

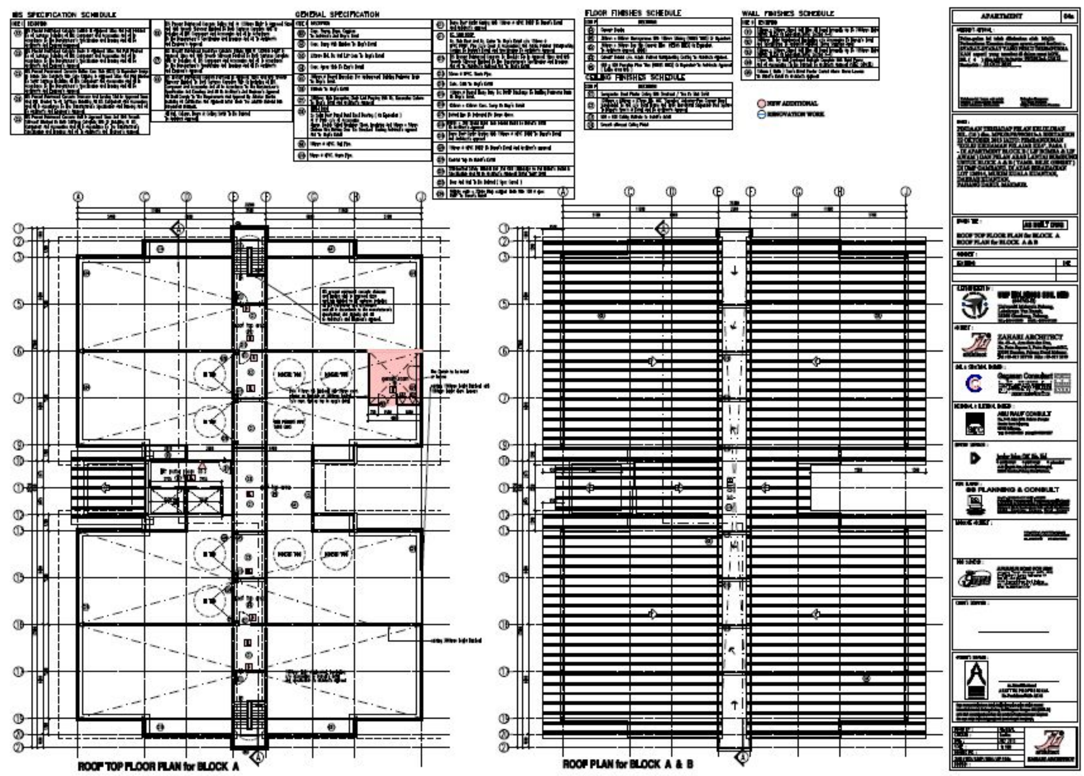

Figure 1.6 Roof Top Floor Plan of KK4

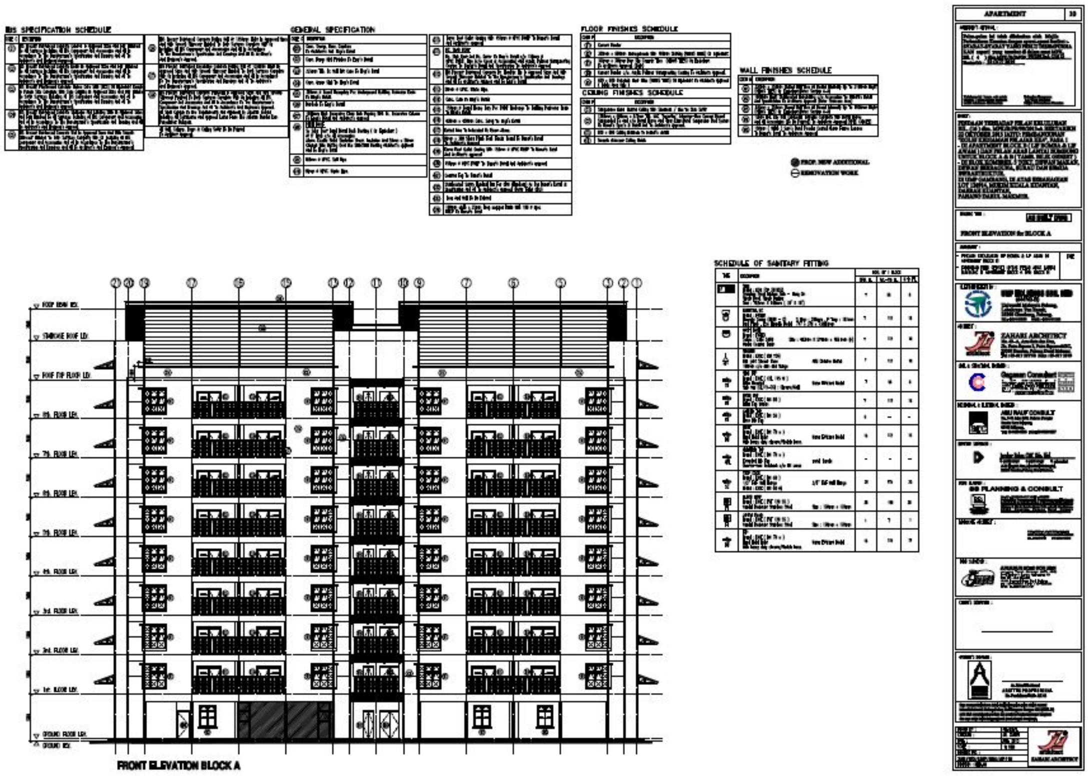

Figure 1.7 Front Elevation Plan of KK4

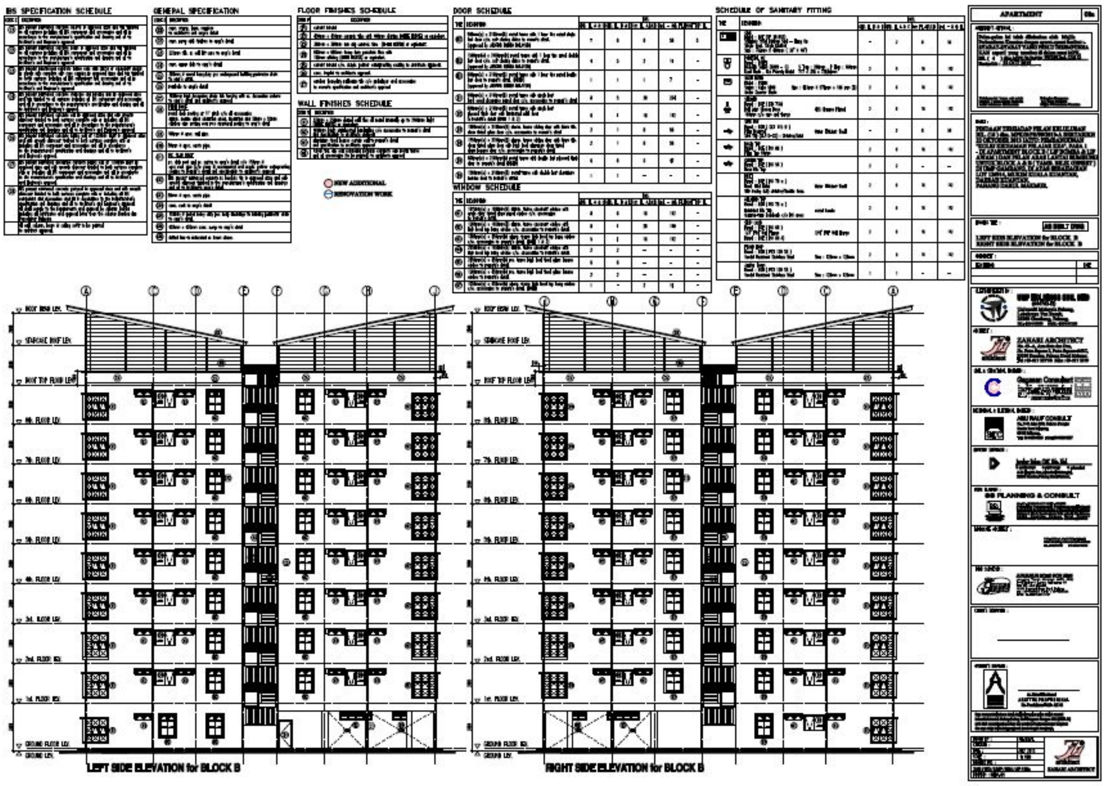

Figure 1.8 Left and Right Elevation Plan of KK4

3.3 Setup

After the data is collected, the 3D process can be started by setting up templates of the project. A project template provides a starting point for a new project, including view templates, loaded families, defined settings and geometry. Revit provide several templates for different disciplines and types of building projects. It can be either architectural template, structural template and family template.

3.3.1 Template

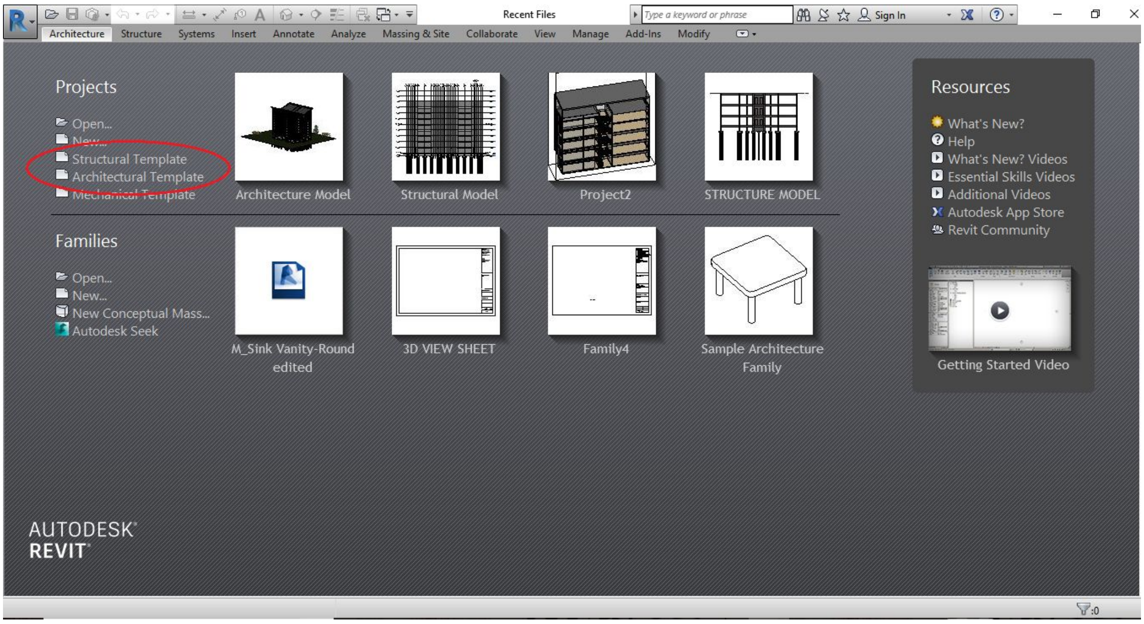

Figure 1.9 Architectural and Structural Template in Autodesk Revit

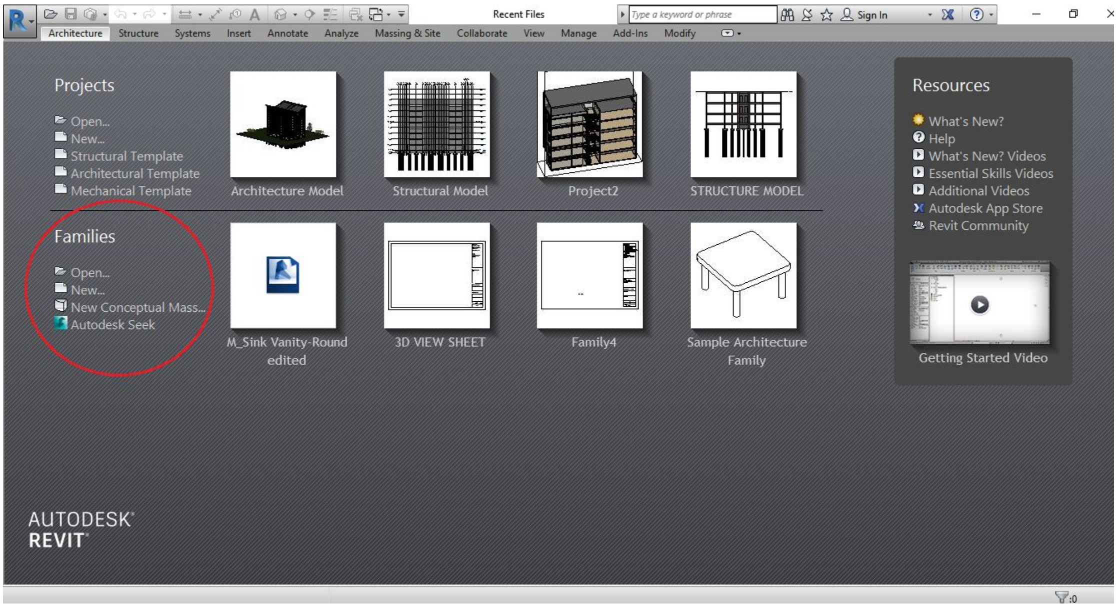

Figure 1.10 Family Template

3.4 Modelling

3.4.1 Architectural Model

3.4.1.1 Grid lines

To be started with, one must create elevations and grid lines to help organize the design. Grids are annotation elements so they are not part of the actual model like a wall, door or window would be. However, they do appear across different views. For example, you can draw a grid on your ground floor plan and it would then appear on the subsequent floors (ie Levels) of the model. A grid line consist of two main parts which are the grid line itself and the grid header.

The grid lines will be created at Site in Floor Plans in the Project Browser.

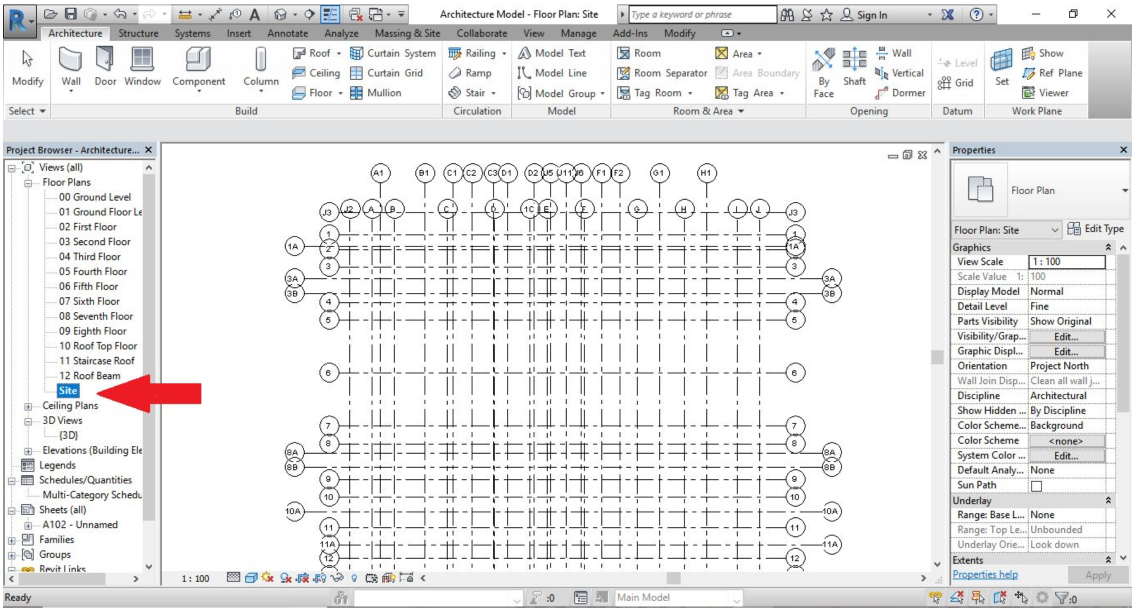

Figure 1.11 Grid line created in Revit

3.4.1.2 Elevations

The elevations is used to look at a project from different locations, either exterior or interior. It is created at East in the Elevation in the Project Browser and will automatically be same for other elevations like North, South, and West.

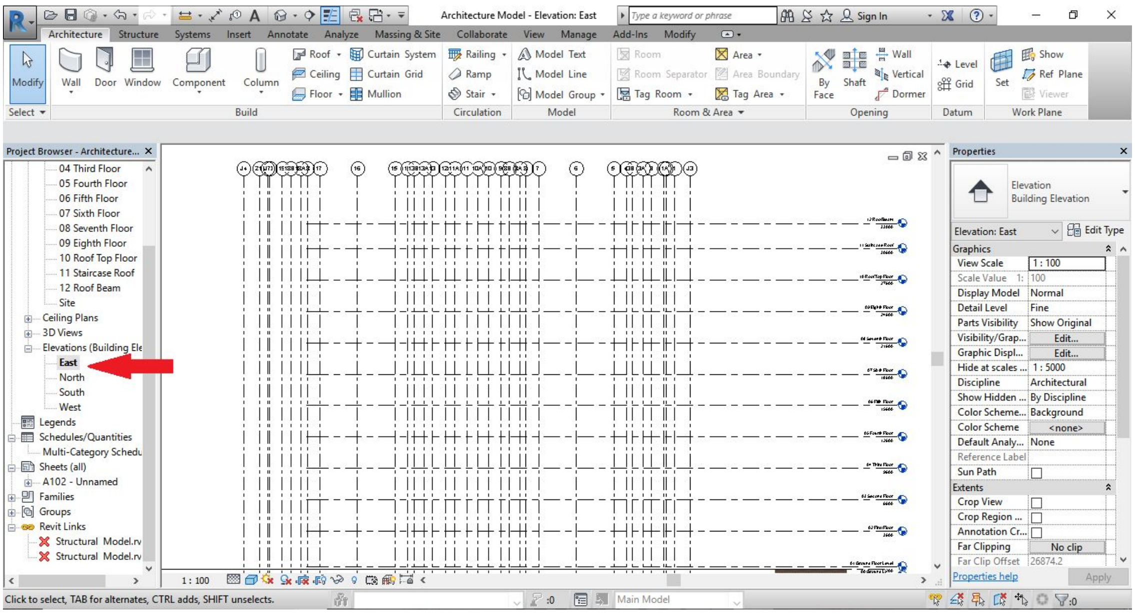

Figure 1.12 Elevations created in Revit

3.4.1.3 Placing of Component

In architectural model, components like wall, floor, stairs, doors and windows will be placed one by one by referring the characteristics given. The components for architectural can be found based on Figure 1.13.

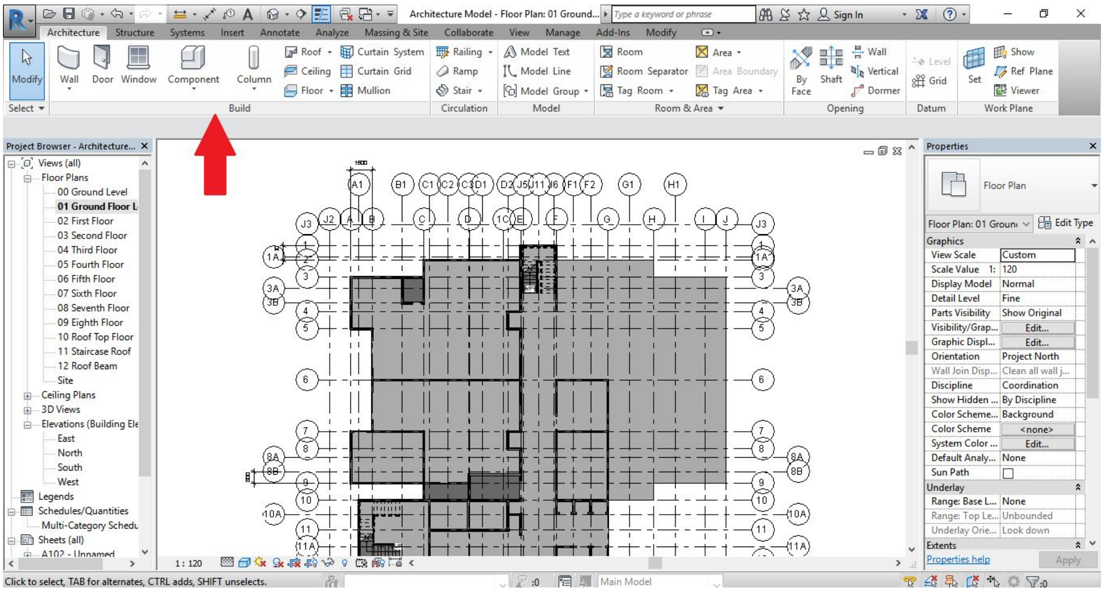

Figure 1.13 Architectural Components Tab

The characteristics of the component can be adjusted at the Properties then Edit Type.

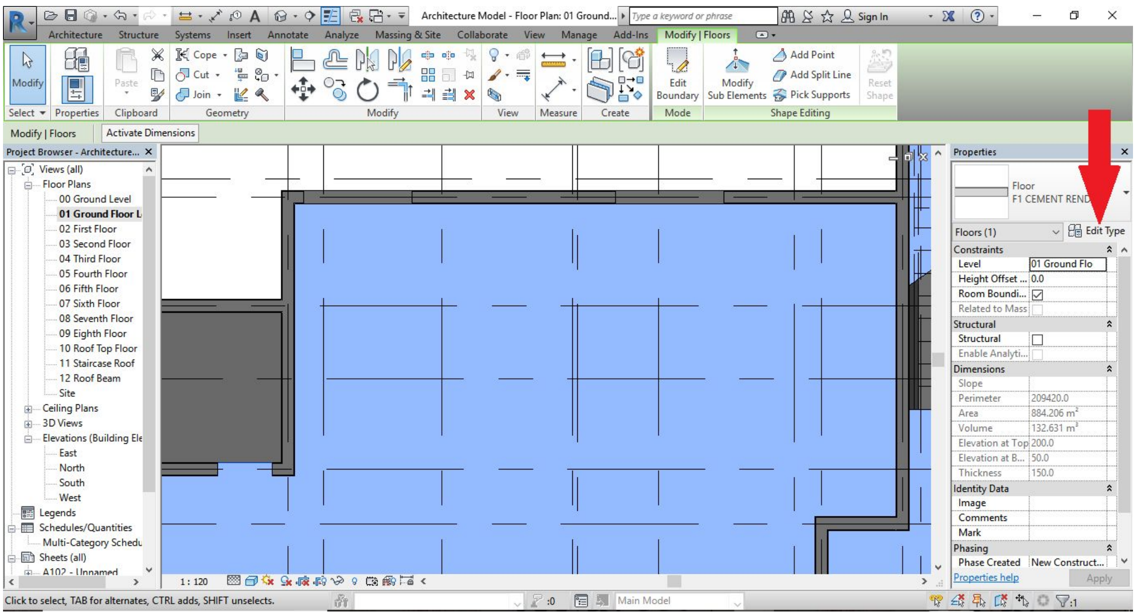

Figure 1.14 Properties of component

By referring Figure 1.15 and Figure 1.16, at Edit Type, you can adjust and set the material and thickness of the component based on client's requirements.

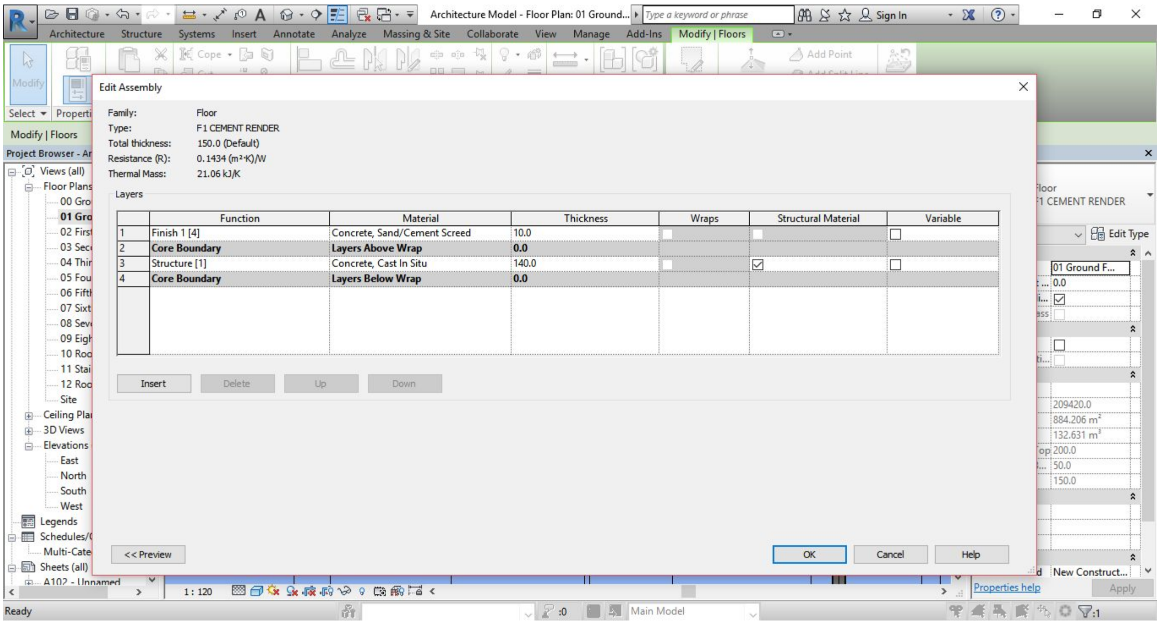

Figure 1.15 Edit Type of Component (a)

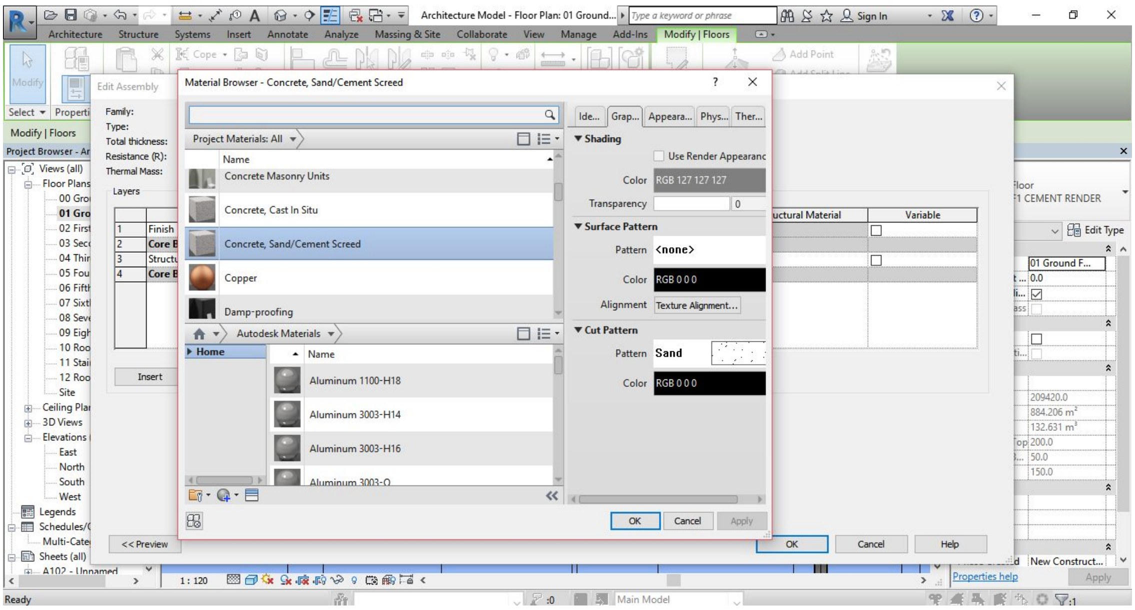

Figure 1.16 Edit Type of Component (b)

3.4.2 Structural Model

3.4.2.1 Grid lines

The step for Structural Model is most likely the same with Architectural model. To be started with, one must create elevations and grid lines to help organize the design. Grids are annotation elements so they are not part of the actual model like a wall, door or window would be. However, they do appear across different views. For example, you can draw a grid on your ground floor plan and it would then appear on the subsequent floors (ie Levels) of the model. A grid line consist of two main parts which are the grid line itself and the grid header.

The grid lines will be created at Site in Floor Plans in the Project Browser.

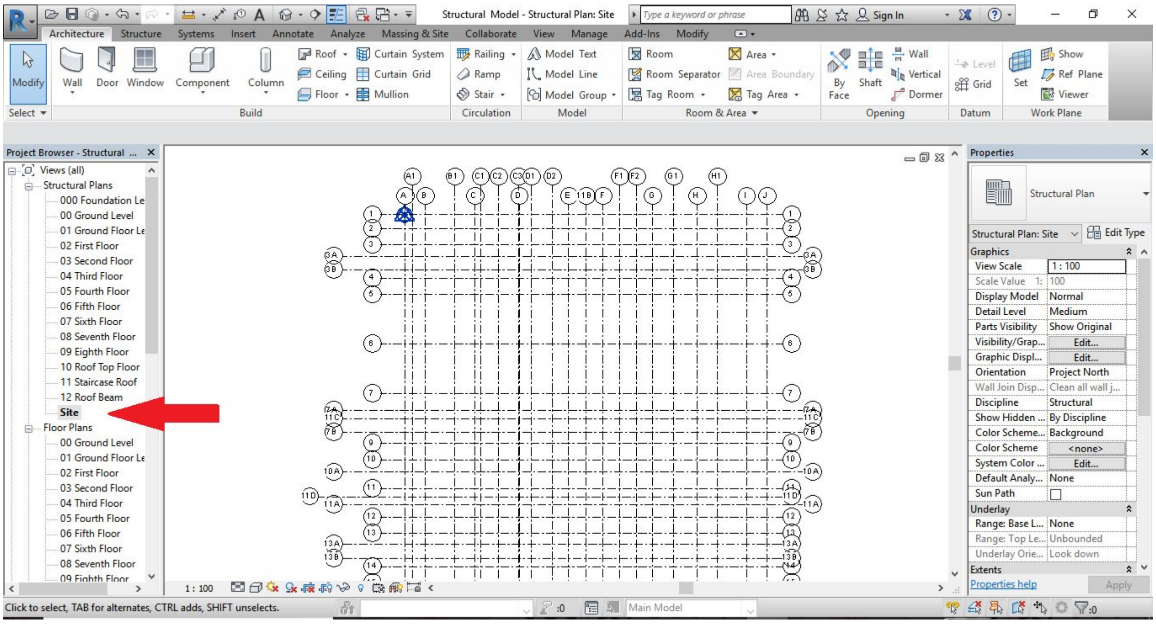

Figure 1.17 Grid line created in Revit

3.4.2.2 Elevations

The elevations is used to look at a project from different locations, either exterior or interior. It is created at East in the Elevation in the Project Browser and will automatically be same for other elevations like North, South, and West.

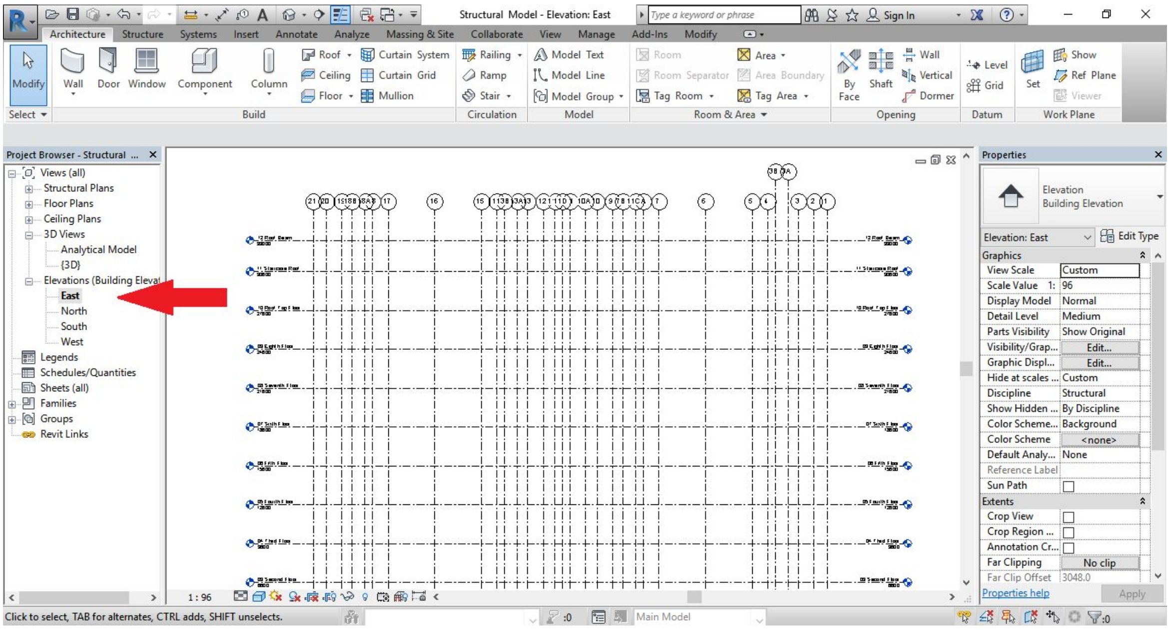

Figure 1.18 Elevations created in Revit

However, the elevations for Structural model is quite difference than Architectural model where foundation level is added at the elevations.

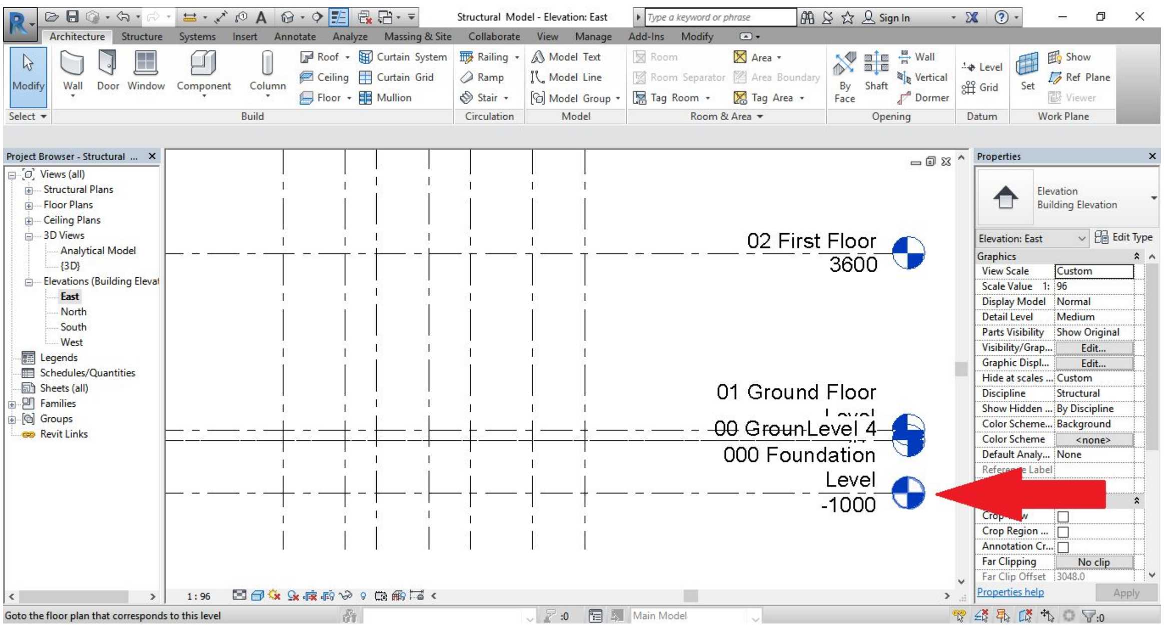

Figure 1.19 Foundation level in Elevation

3.4.2.3 Placing of Component

In Structural model, components like column, beam, slab, precast wall and foundation will be placed one by one by referring the characteristics given. The components for architectural can be found based on Figure 1.20.

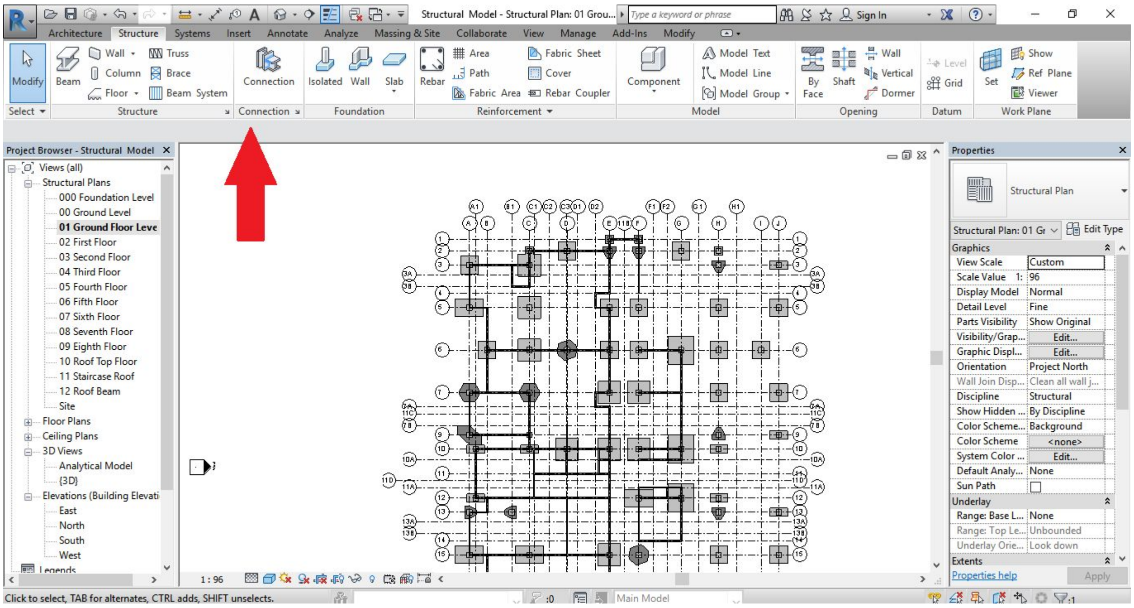

Figure 1.20 Structural Components Tab

The characteristics of the component can be adjusted at the Properties then Edit Type.

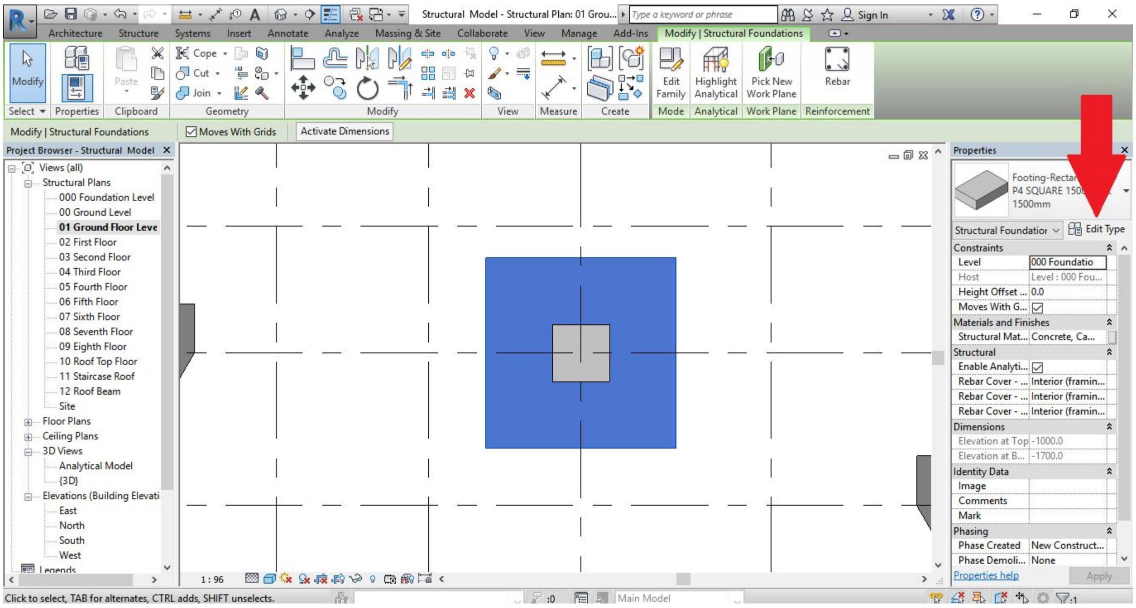

Figure 1.21 Properties of component

By referring Figure 1.22, at Edit Type, you can adjust and set the material and thickness of the component based on client's requirements.

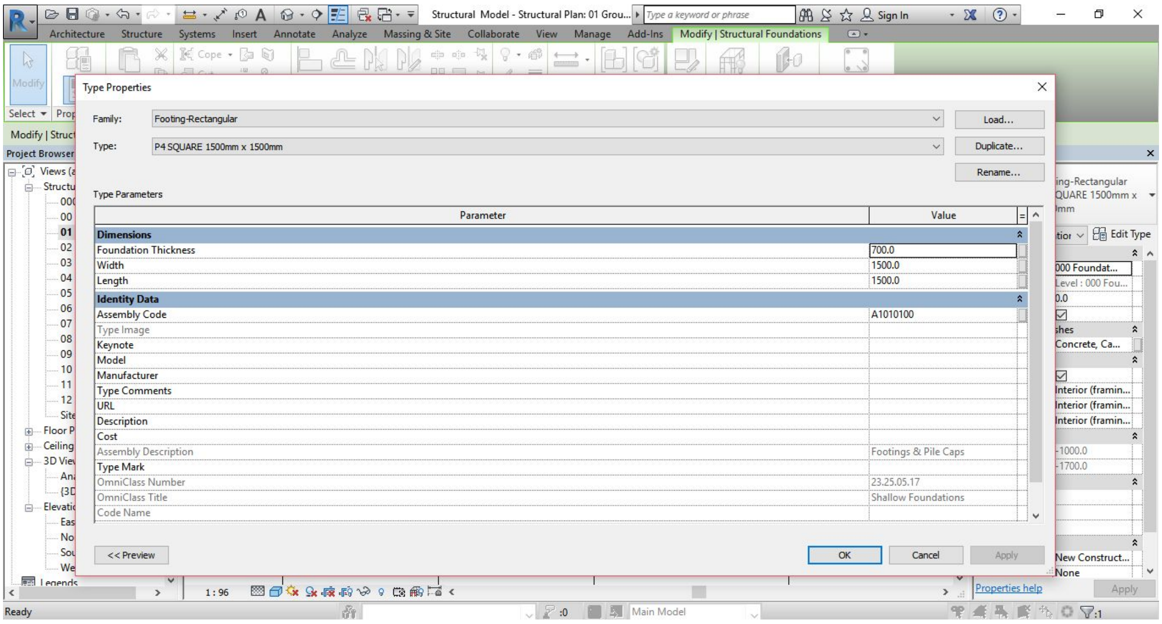

Figure 1.22 Edit Type of Component

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

After all the process has been done, the result of it are the scheduling, the sheet drawing and the 3D BIM model.

4.2 Scheduling

Utilization of 3D BIM Modeling links to a project schedule and provides a unique visualization of the project schedule sequencing of key events, milestones, tasks, build strategies and simultaneous activities before you strike the first arc. ome of the benefits of utilizing the 3D model link to the project schedule:

- Provides validation of the install sequence
- Maximizes resource loading and minimizes task congestion
- Provides efficient verification to follow on test and commissioning
- Allows for real-time task progress updates to clearly see the impact to the overall schedule

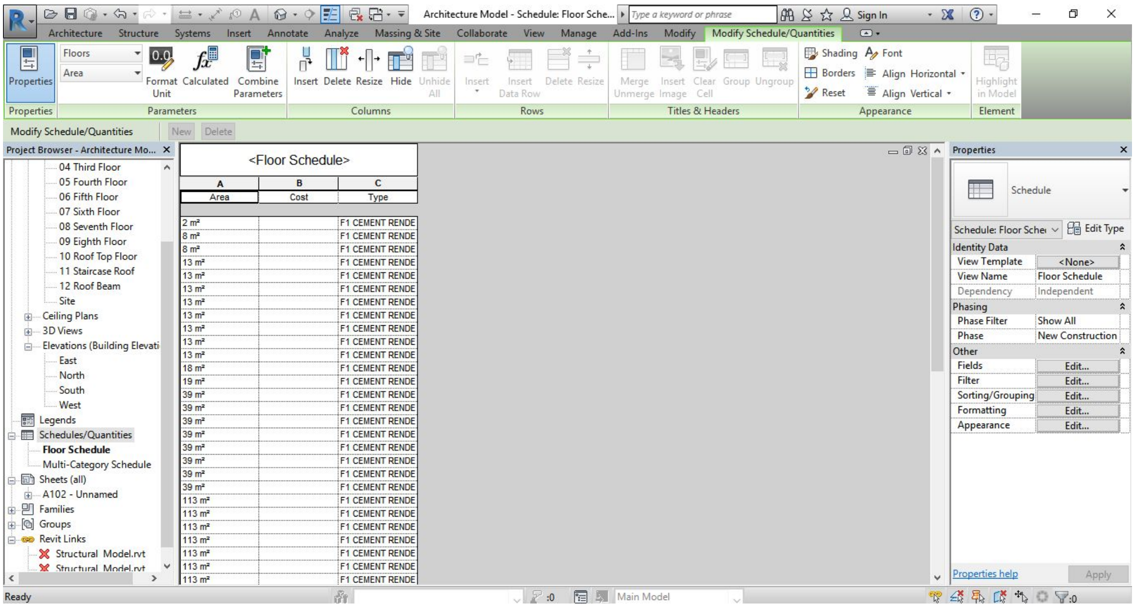

Figure 1.23 Floor Scheduling in Architectural model

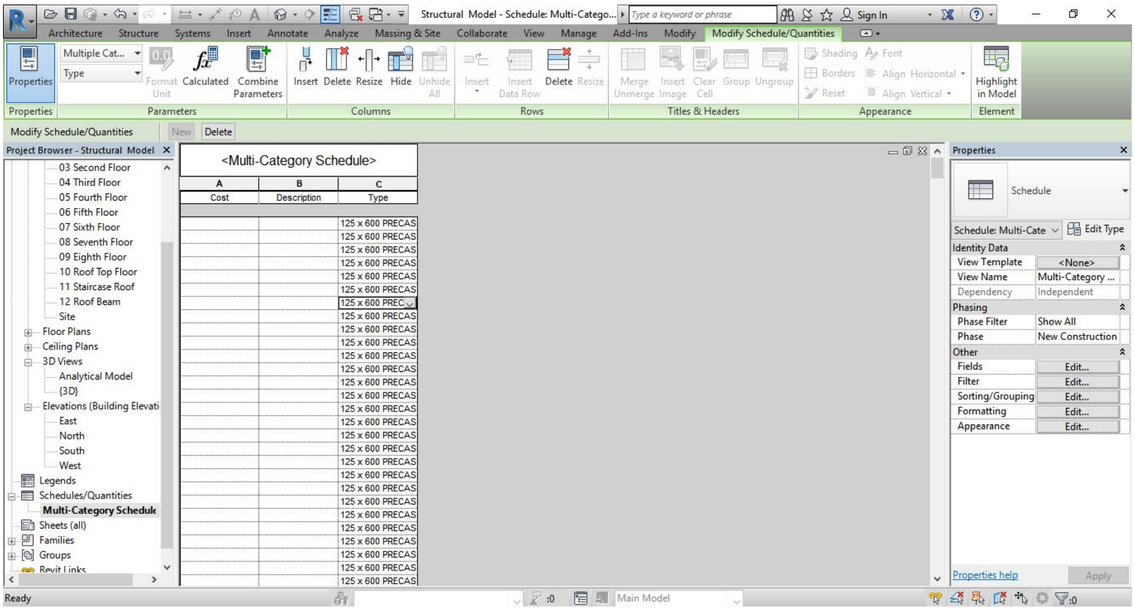

Figure 1.24 Multi-Category Scheduling in Structural model

4.2 Sheet Drawing

A construction document set (also called a drawing set or a sheet set) consists of several sheets.

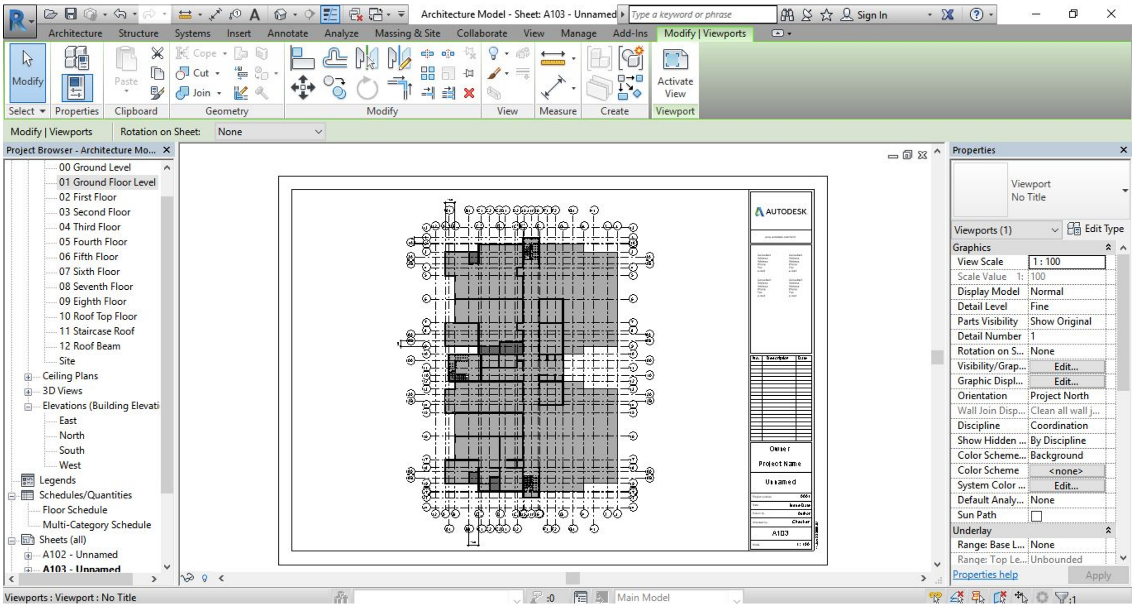

Figure 1.25 Sheet Drawing of Architectural Model

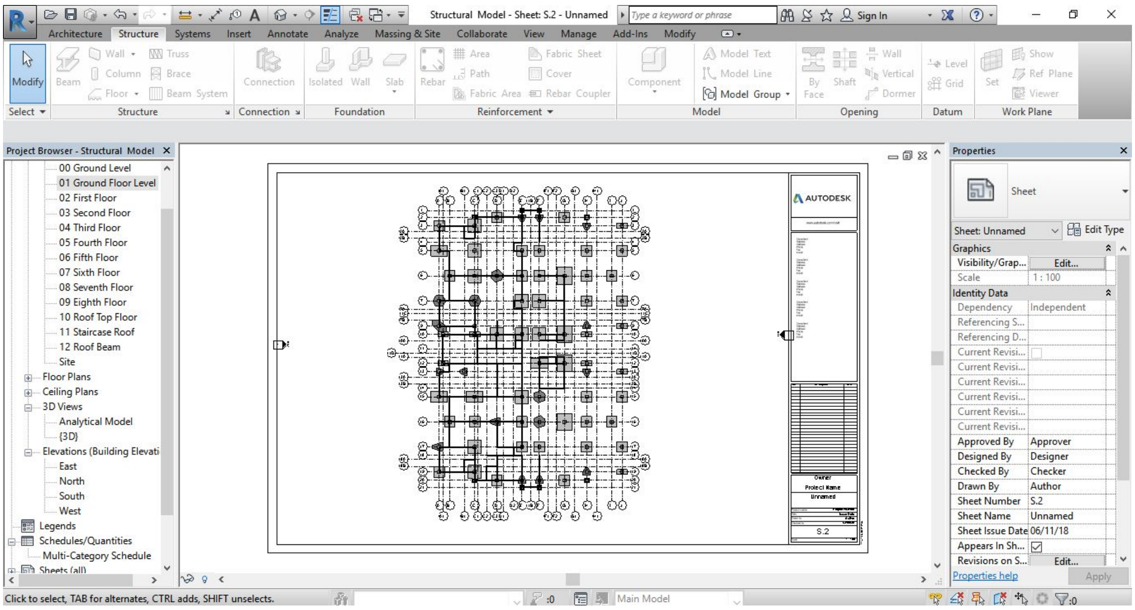

Figure 1.26 Sheet Drawing of Structural Model

4.3 3D BIM Model

It can be said that the 2D plans is now can be visualize by looking at the 3D BIM model. From the model, we can see how the structure look like and the material for every components suitability to the structure.

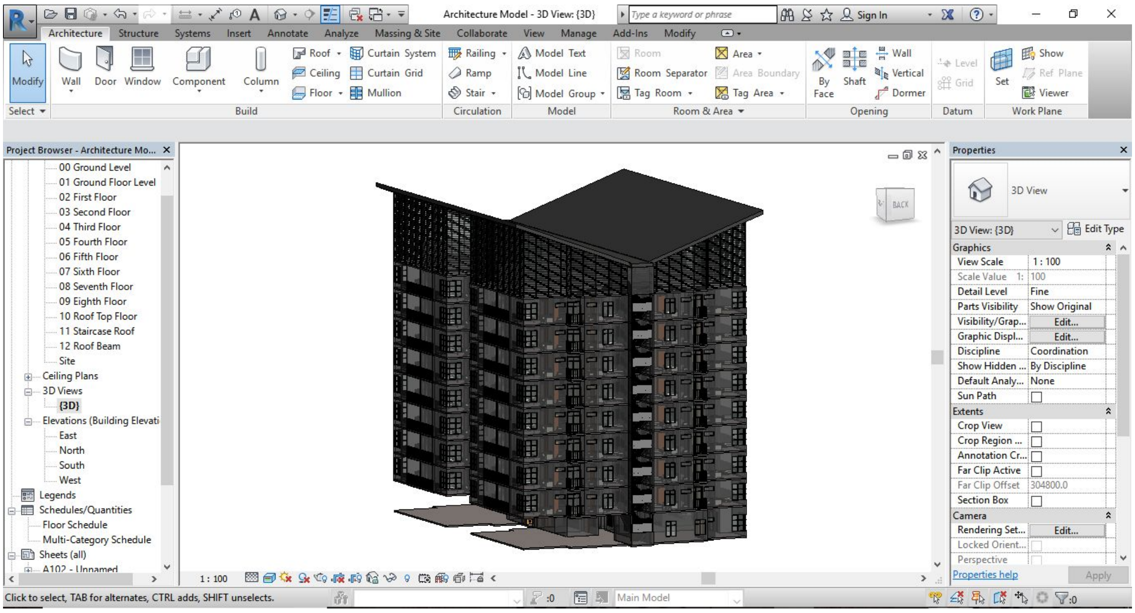

Figure 1.27 Architectural Model

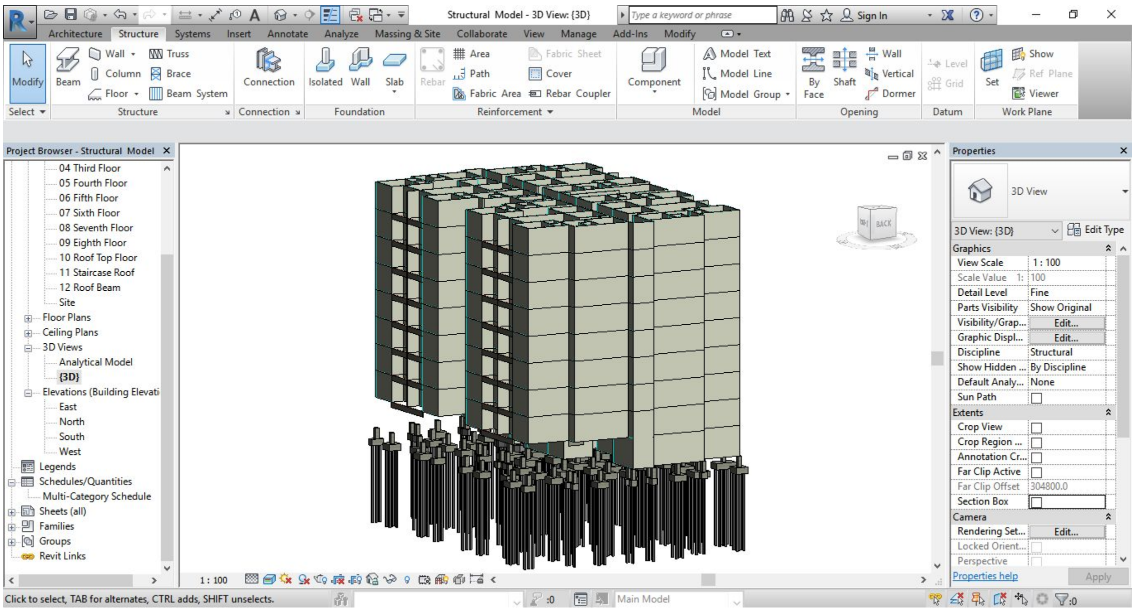

Figure 1.28 Structural Model

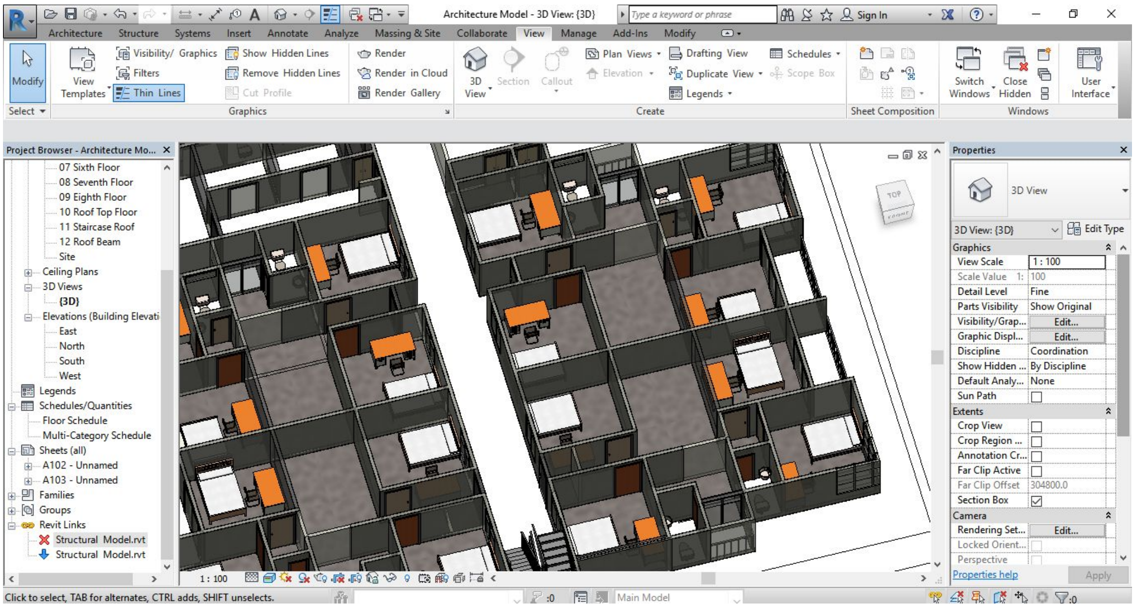

Figure 1.29 One of the Room View in KK4

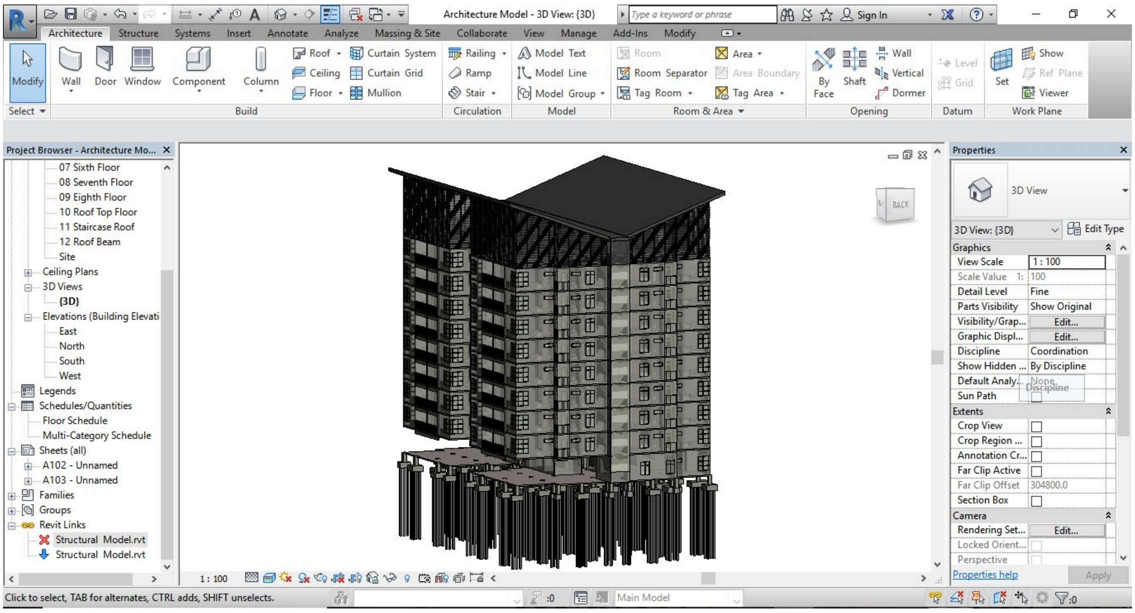

Figure 1.30 Combined Model of Architectural and Structural

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

IntroductionThis chapter concludes and recommends all the work for this project.

5.1 Conclusion

This document presents a research study in order to identify how the BIM model can contribute to time planning during the maintenance process. The results obtained in this research can be concluded that the results obtained from the BIM model are, in most cases, reliable and easily obtained, thus reducing the time spent. Using BIM, a modeller can visualize a completed building and all its components and systems before the first shovelful of dirt is moved on the construction site. This information allows better planning and design that takes best advantage of available space and resources.

Other than that, BIM allows you to see potential problem areas and fix them before the error is committed in the physical world. Last but not least, BIM allows you and your partners to more easily prefabricate components of the project offsite, which saves time and money.

5.2 Recommendations

BIM causes a change in the market. The workload will shift from the construction documents towards the schematic design and design developments, often from the contractor to the architect or engineer. The fact that this movement takes place is beneficial for the costs of design changes (that increase with time), however, the increase in workload for engineers must also mean an increase financially. The contractor saves time and effort if he receives a well structured and developed BIM.

This movement in time and effort should also mean a change in financial reward. The contractor is willing to pay for this extra effort in case this model is enriched with data. If the contractor does not recognize the benefits of this, the extra reward could be accomplished by the client by making a redistribution. The change in the design process also fits the performance specifications. Herewith the contractor can determine the necessary activities and quantities of building materials to achieve the desired result and is not restricted to what needs to be done, how it should be done and how often it should be done.

The involvement of engineers, contractors and/or suppliers should be stimulated. BIM enables early collaboration if the project requests it. Engineers, contractors and suppliers with specific knowledge support the progress of the project by advising or collaborating in the concept or preliminary phase instead of the detailed design or specification/fabrication phase. The client or the engineering firm can initiate this. By recognizing the importance of this the client can insist on early involvement or a Construction Team.

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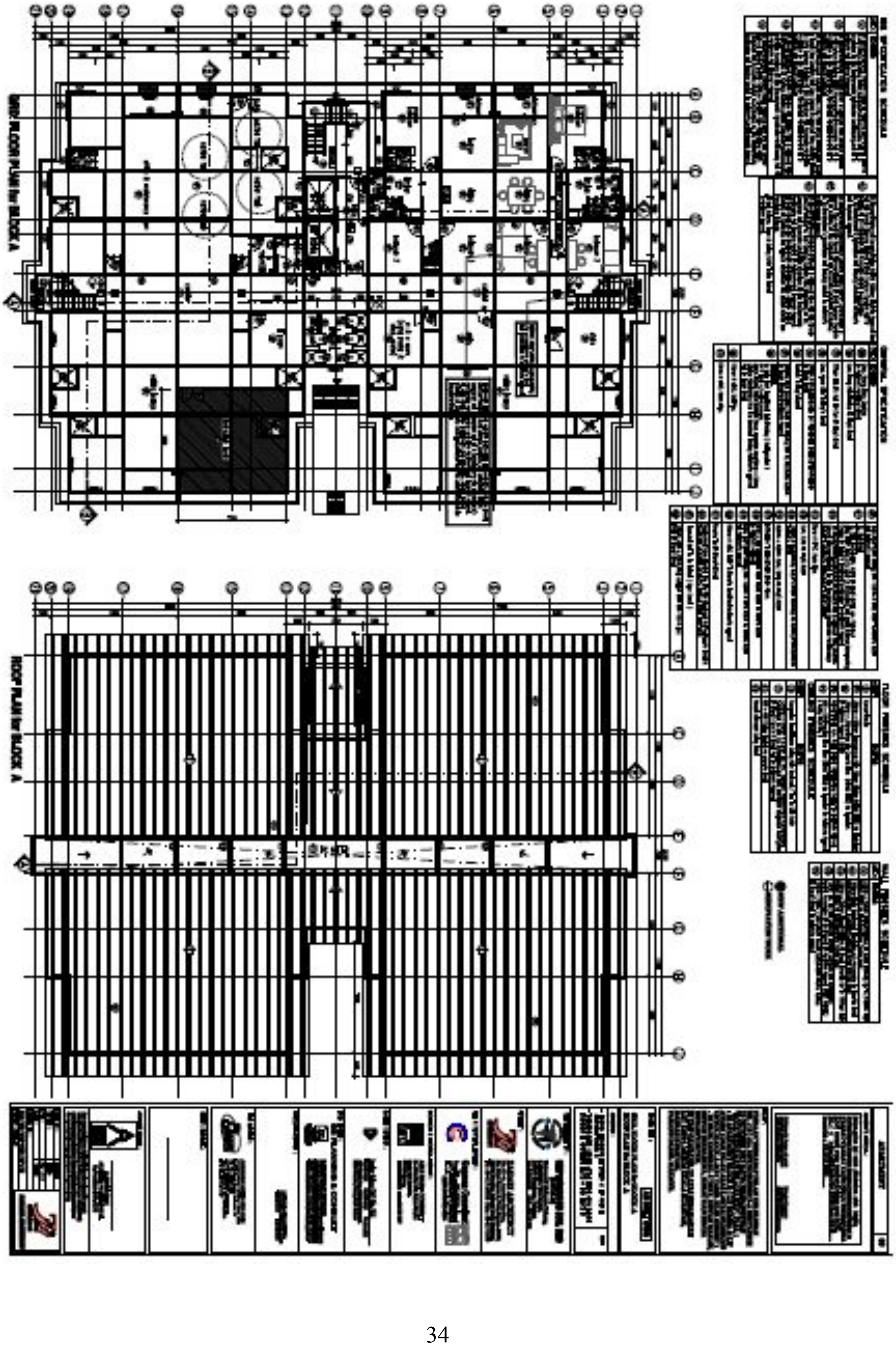
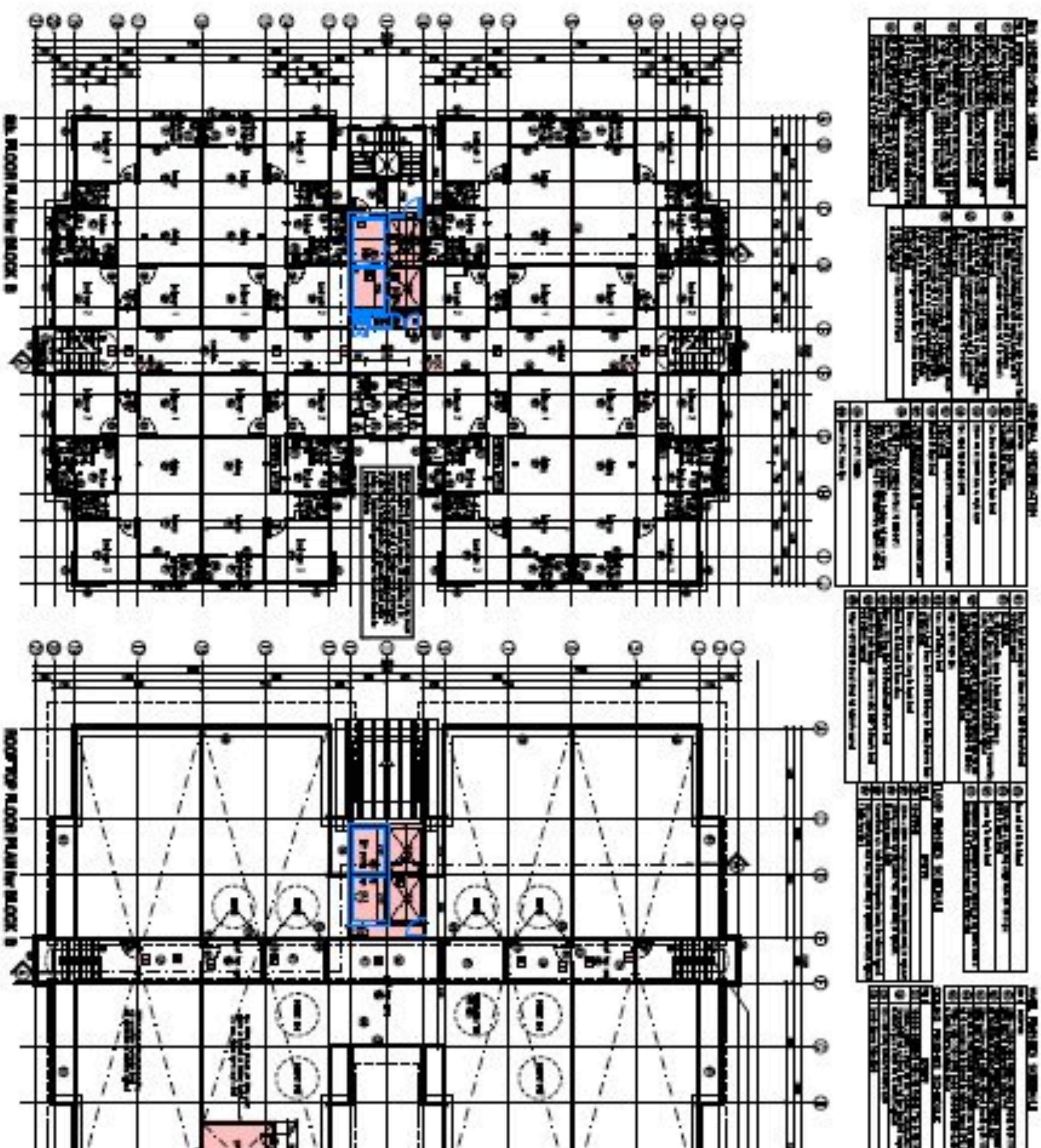
APPENDIX A
SAMPLE APPENDIX 1

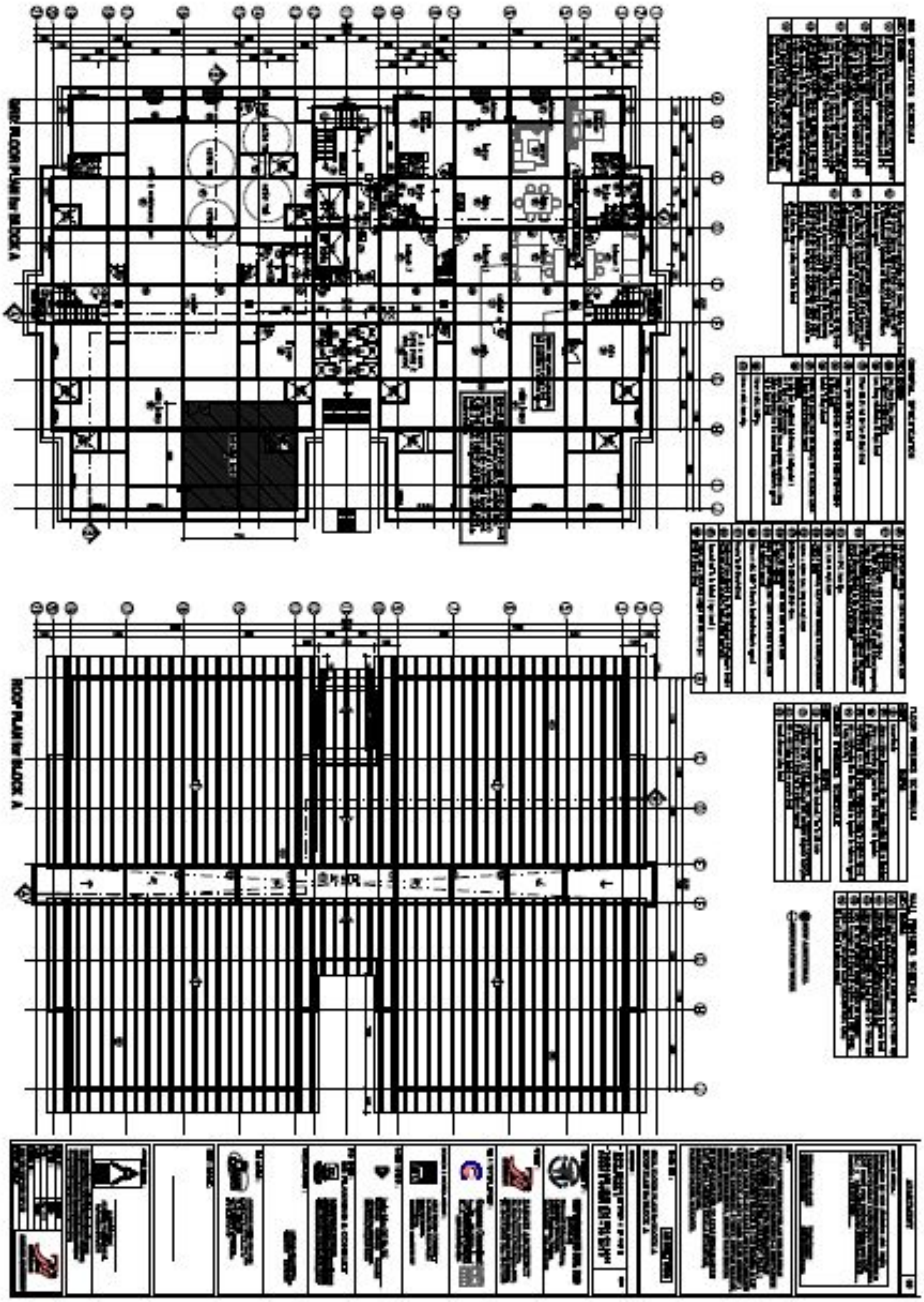
GROUND FLOOR PLAN



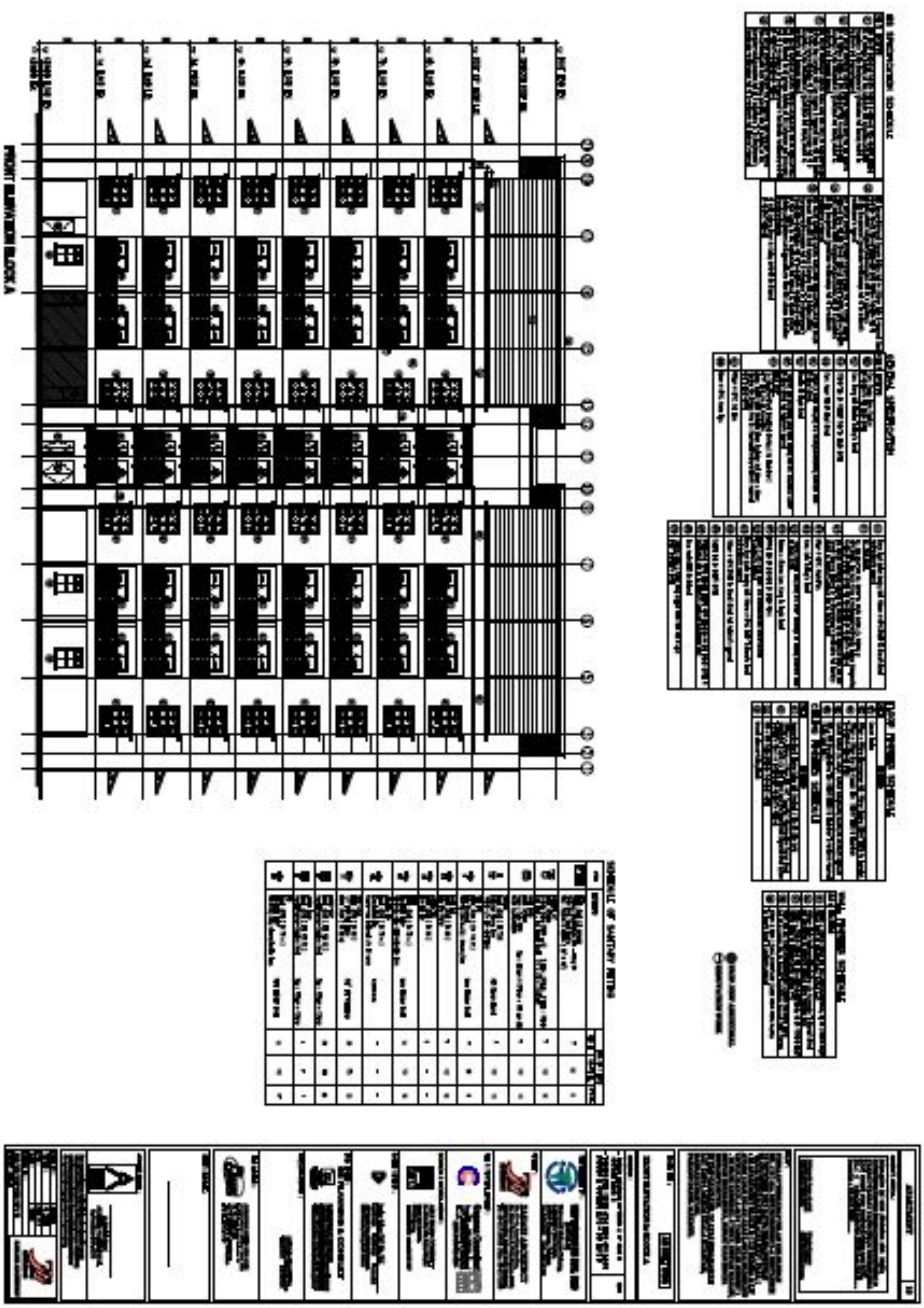
1 TO 8TH FLOOR PLAN



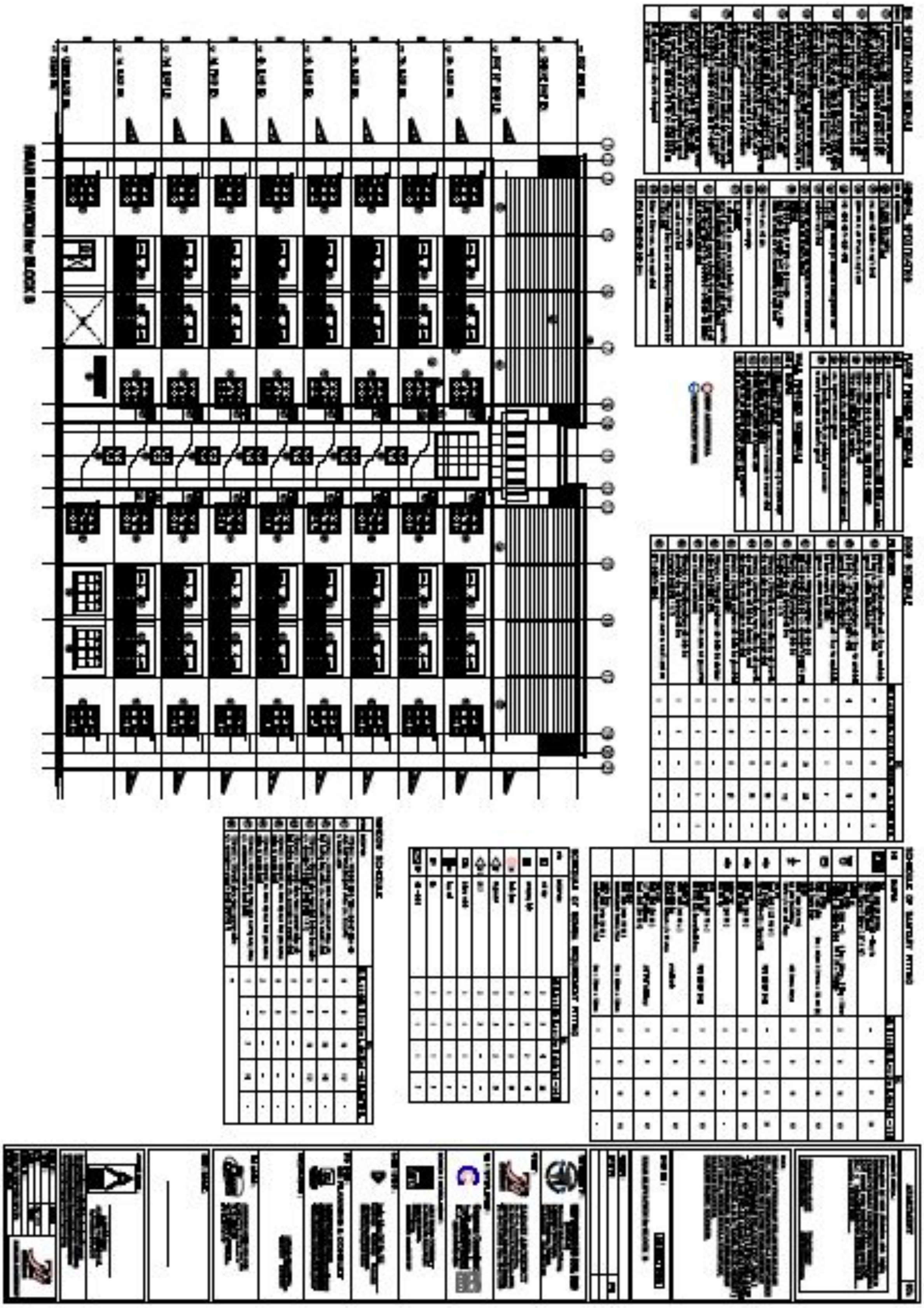
ROOF TOP PLAN



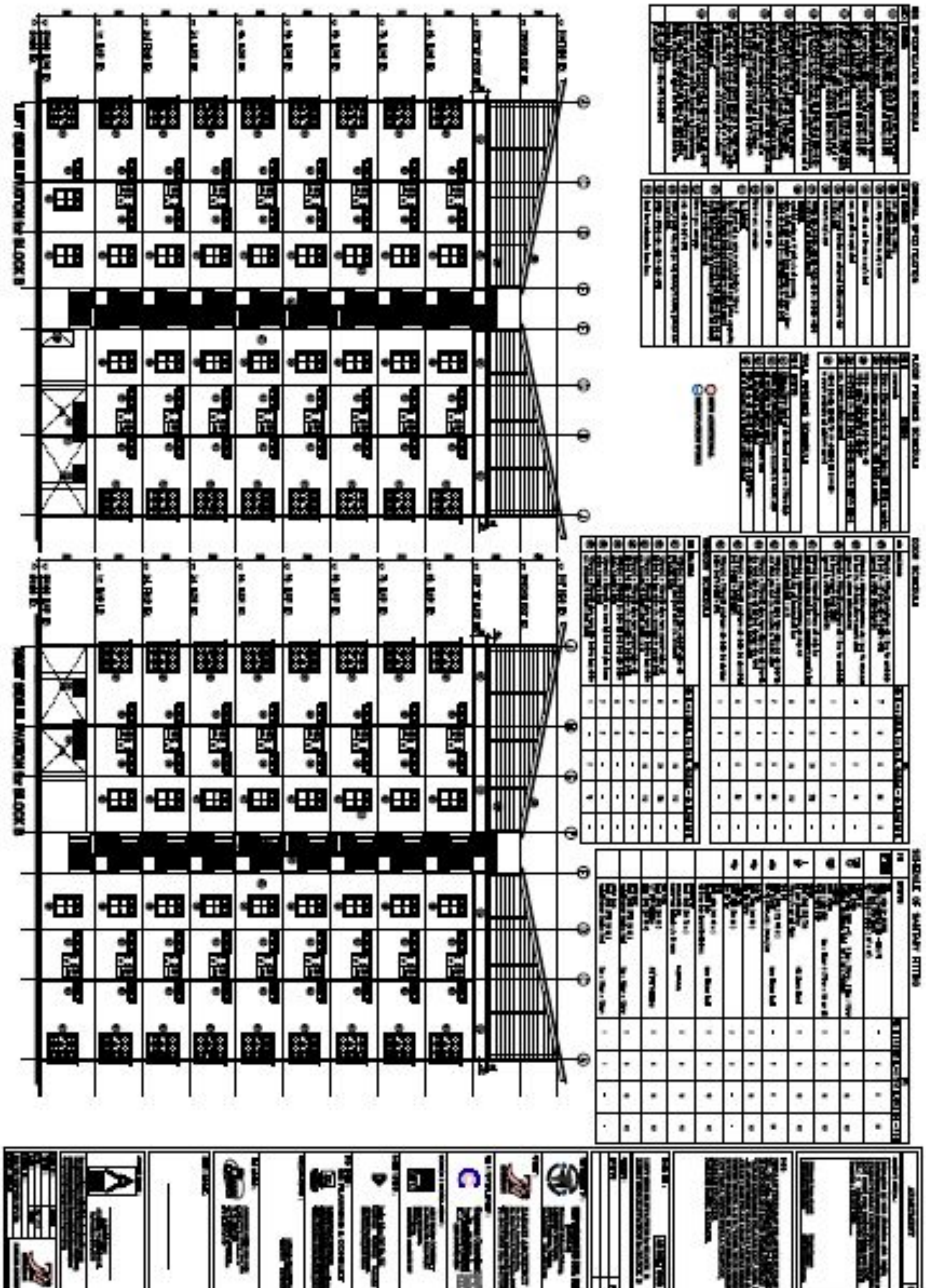
FRONT ELEVATION



REAR ELEVATION

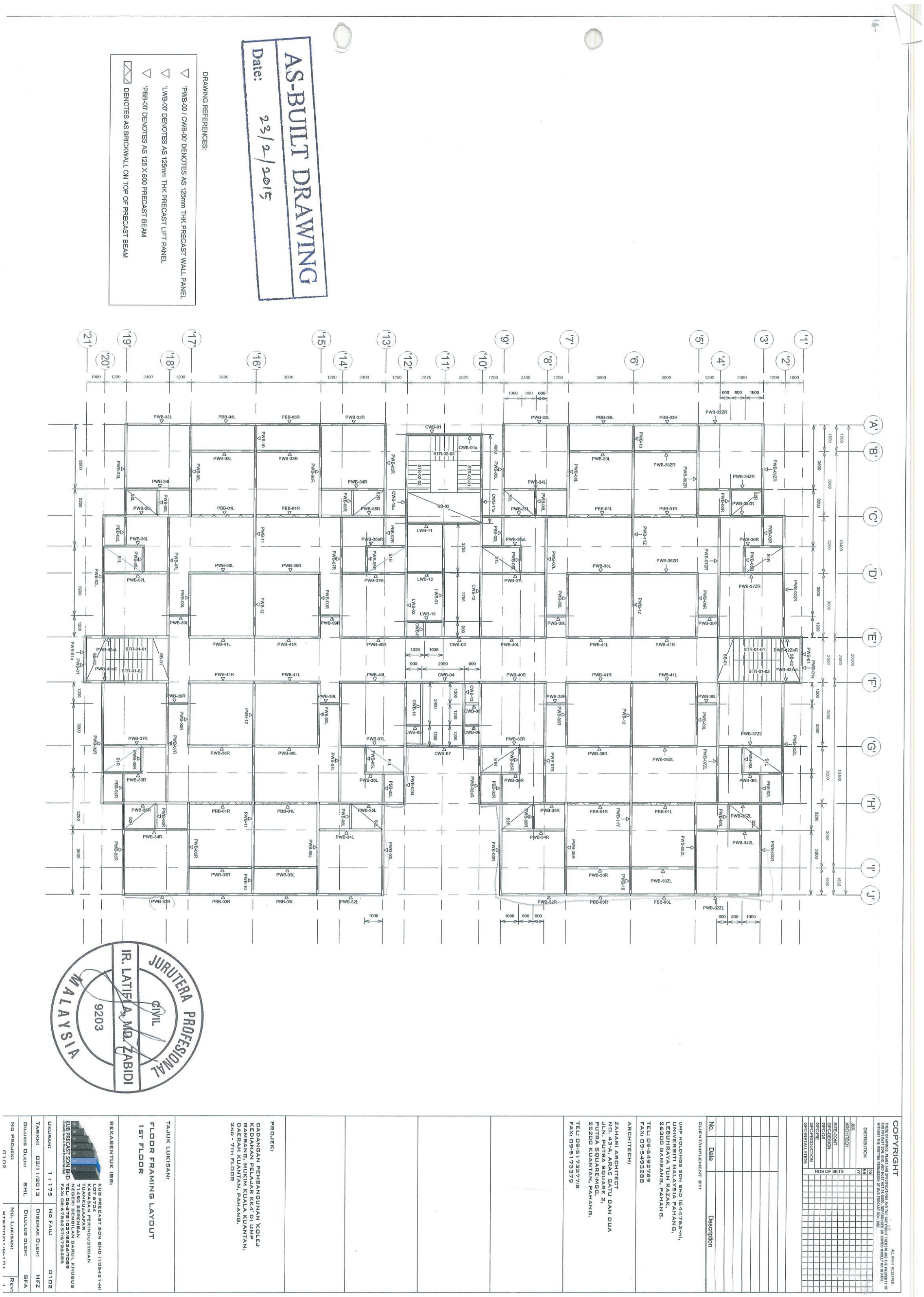


LEFT AND RIGHT ELEVATION

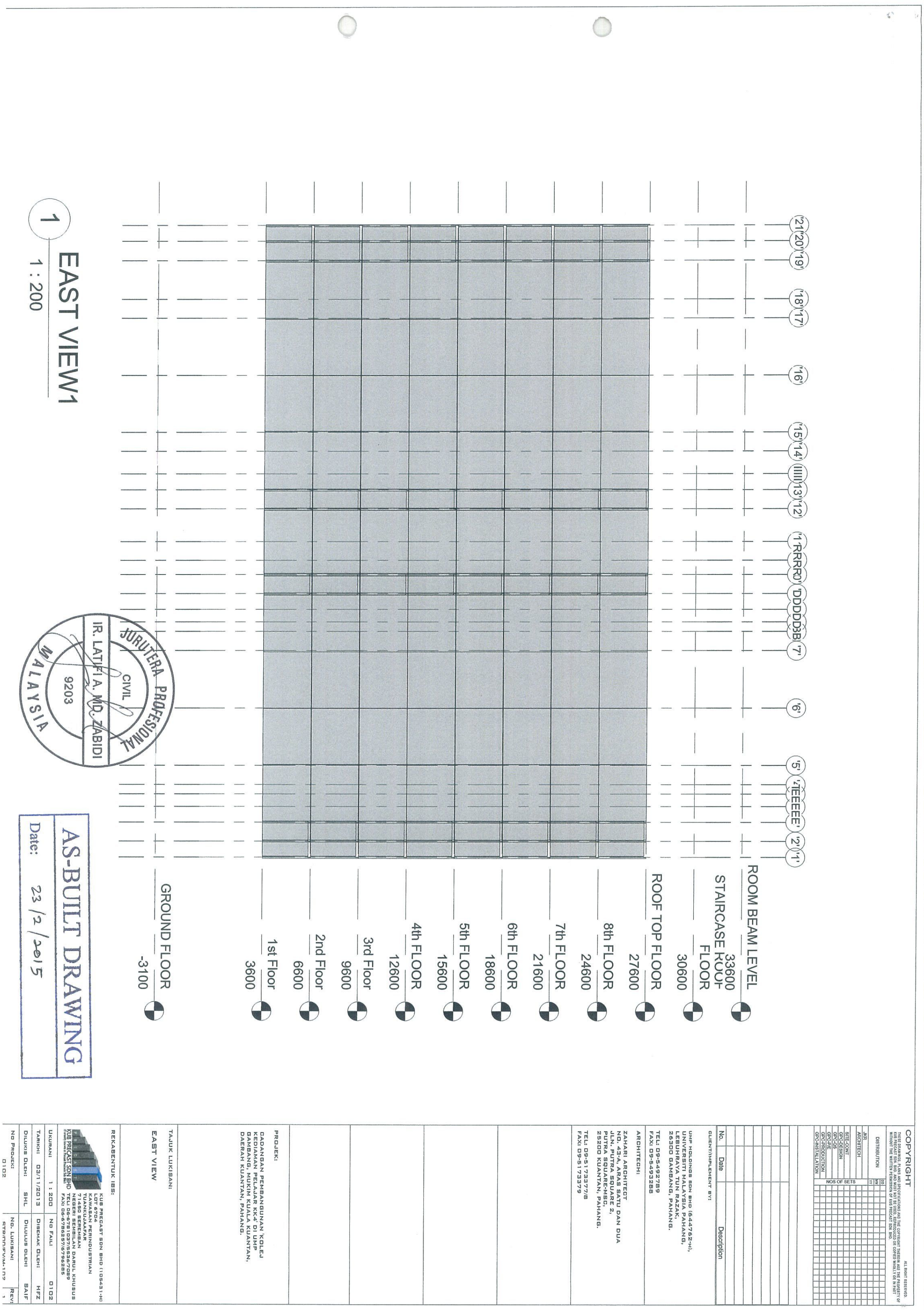


APPENDIX B
SAMPLE APPENDIX 2

BEAM



PRECAST WALL



PILE FOUNDATION