ESTIMATION AND DESIGN OF FORMWORK AND SCAFFOLD FOR G+4 BUILDING

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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MAY 2022

STUDENT'S DECLARATION

We hereby declare that the work presented in the Project report entitled **Estimation and Design of Formwork and Scaffold for G+4 Building** submitted for partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Mr. Akash Bhardwaj**. This work has not been submitted elsewhere for the reward of any other degree/diploma. We are fully responsible for the contents of our project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **Estimation and Design of Formwork and Scaffold for G+4 Building** in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by Yamit Dhalaik (181602) and Ritik (181663) during a period from August, 2021 to May, 2022 under the supervision of **Mr. Akash Bhardwaj** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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ACKNOWLEDGEMENT

We would like to express our gratitude towards our supervisor **MR. AKASH BHARDWAJ** for guiding us throughout the project. We also feel thankful and express our kind gratitude towards our course In Charge **DR. SAURAV** for helping us in my project that is **Estimation and Design of Formwork and Scaffold for G+4 Building.**

The mentioned project was done under the supervision of our supervisor and mentor. We are very thankful to our mentor for throughout guidance and support.

This project is not copied and is based on real time site investigation and data collection.

Thank You

Yamit Dhalaik

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(Alphabetically)

- API Application programming interface
- BIM Building information modelling
- CAD Computer Aided Design
- c/c Centre to centre
- ft. Feet
- Km Kilometres
- mm Millimetres
- Nos. Numbers

CHAPTER 1
INTRODUCTION

This project aims on the most serious phase in the building of any structure. Formwork and the use of BIM in project planning, which makes these tasks considerably simpler. Later in the project, the Scaffoldings are discussed, which are another sort of temporary construction that is prone to accidents and requires a lot of attention.

We will assess how successfully planning and scheduling enable a smoother and safer project delivery in this project.

Suppose we have to construct a structure. Before arriving on site, we establish blueprints, timetables, and then go to work. All works, from little to huge, are pre-designed and then implemented. However, when it comes to temporary constructions, planning is neglected, resulting in accidents. Unplanned Temporary Construction Structures cause thousands of such tragedies.

1.1 Formwork

Formwork is a critical component in the building industry, and it is defined as a temporary or permanent shape into which concrete is poured and hardened. Concrete constructions require careful planning, design, placement, and removal of formwork. However, concrete construction has a dismal safety record, accounting for around a quarter of all building failures.

Lack of supervision during formwork construction and communication uncertainty among stakeholders are other key contributors to formwork failures. It is clear that methods for improving formwork design quality and facilitating interactions and collaborations are critical for site safety.

Being of so importance, still is not given enough attention. Lately many researches have been done as for safety of formwork where BIM appeared as solution that plans, schedules and decides all critical constraints.

Building information modelling (BIM) has transformed the way buildings are planned, built, and operated, as well as traditional workflows and project delivery methods.

Temporary structures, on the other hand, are frequently not precisely defined and planned in architectural drawings or BIM models, and the majority of previous study efforts have focused on permanent structures.

Knowing the importance of concrete formwork and being aware of the fact that designing and planning temporary buildings involves a lot of human labour, a BIM-based solution that may help designers automate the design process while also benefiting planners and other stakeholders is in high demand.

Hence, the BIM proved to be all over good solution for all problems.

1.2 Scaffoldings

Also talking about other temporary structure, Scaffolds. Another problem for safety and installation constraints. Here also BIM established its way out.

Scaffolding, sometimes known as staging, is a temporary construction that allows people to operate at height or in difficult-to-reach areas while standing on a solid platform. Working on temporary structures such as scaffolding comes with its own set of risks. It is dangerous as is quite high above ground, and is thus disastrous sometimes.

Scaffold must meet a wide range of requirements:

- establishing secure and effective working environments
- granting higher-level access to working locations
- transporting point and/or area loads

1.3 BIM

Building information modelling is a software modelling approach that allows architects, engineers, and contractors to cooperate on the design, construction, and operation of a structure.

Unlike a simple drawing, BIM software is used to produce a realistic model of a building that is aware of all of the building's features. BIM entails not just the use of three-dimensional intelligent models, but also major changes to workflow and project delivery methods.

Building information modelling allows for real-time cooperation among all parties engaged in a building project, resulting in significant economic, safety, and efficiency savings. As a consequence, BIM has become one of the main important building developments in recent years.

BIM is a method for producing and managing information about a building project over its entire life cycle. As part of this method, a coordinated digitized description of every element of the generated asset is constructed using a set of appropriate technologies. This digital description is likely to comprise a combination of data-rich 3D models and structured data such as product, execution, and handover information.

CHAPTER 2

LITERATURE REVIEW

- As per John V McCarthy and Dr. Keith Hampson the goal of study was to create a prototype scaffold system design that incorporates construction and safety limitations as structural configuration rules and incorporates schedule, cost, and lifecycle management data into scaffolding models. Published as 'Using Building Information Modelling (BIM) For Smarter and Safer Scaffolding Construction' in year 2016.

- From 'BIM For Temporary Structures: Development of a REVIT API Plug-In for Concrete Formwork', by Ziyu Jin and John Gambatese in year 2019 the study presents a framework for designers to use when developing and planning temporary structures to include the concrete formwork design process and safety regulations with BIM authoring tools.

- As per Prof. Ramakant Koshti, Sandip Bhorkar, Ganesh Makashe, Vishal More, Nana Saheb Gaikwad, from 'Importance of BIM In Formwork Design' year 2021; Formwork systems are an important aspect of cast-in-place concrete construction, and automated design of formwork systems could speed up the process while also improving visualization and documentation.

- As per Jorge collao and Jose Turmo year 2021 from 'BIM Visual Programming Tools Applications in Infrastructure Projects' BIM improves architectural and infrastructural projects by digitizing processes across their life cycle phases, such as design, management, construction, operation and monitoring.

- In 'Formworks for concrete structures' 2011 by Robert L. Peurifoy and Garold D. Oberlender; they explained the principles and procedures for analyzing and designing concrete formwork.

- As per Kyungki Kim and Yong Cho in 'BIM-Based Planning of Temporary Structures for Construction Safety' they talk about need of advancement in BIM based tools for safety concerns.

- As per K. Wua, B. García de Sotoa, F. Zhangb and B.T. Adeya from research paper 'Automatic Generation of the Consumption for Temporary Construction Structures Using BIM: Applications to Formwork' this paper describes a generic architecture for automatically generating TCS consumption using BIM and consumption criteria, as well as an application for determining formwork consumption in a sample project. The information on the amount of resources required, as well as the cost breakdown, was generated quickly.

- As in ‘4D-BIM-Based Workspace Planning for Temporary Safety Facilities in Construction SMEs’ the report contributes to the study of the advantages and disadvantages of construction SMEs in enforcing safety regulations. The relevance of automated workspace planning for TSFs to SMEs applications has been established by the research. In this research, we suggested a WPT method for generating prioritised TSF suggestions for schedule-based spatial and temporal scheduling.

- Using ‘How to Calculate and Measure Formwork’ it says, the shape of the concrete form you're supporting determines how tough it is to calculate formwork. While a square or rectangular shape is simple to compute and suited for modular formwork, round or irregular forms are more difficult to calculate and need specialised fabrication.

- Niall is devoted to assisting AEC professionals get a high degree of functional expertise in Revit in the shortest amount of time feasible through his blogs. After many years of working with BIM tools and processes, he realised that there is still a significant skills gap, therefore he made it my aim to fill that gap while also learning a lot about Revit and other BIM technologies.

CHAPTER 3

ABOUT FORMWORK AND SCAFFOLDINGS

3.1 Formworks

In concrete construction, formwork (shuttering) serves as a mould for a structure into which fresh concrete is poured and then hardened. Concrete formwork construction differs depending on the formwork material and structural element.

Formworks can also be termed according the type of structural element they are used in, like slab formwork for slabs, beam formwork for beams, and column formwork for columns, and so on.

Formwork construction takes time and can cost up to 20% to 25% of the total building cost, if not more. The form of these temporary constructions is based on cost considerations. Process of removing formwork is Stripping.

It is possible to reuse stripped formwork. Panel forms are reusable forms, while stationary forms are non-reusable. For formwork, the most used material is timber. Timber formwork has the disadvantage of warping, swelling, and shrinking. Water-impermeable cost applied on the surface of wood negates these flaws.

3.1.1 Characteristics of Good Formwork

- The formwork should be built in such a way that it allows the removal of various elements in the order requested without damaging the concrete.
- To keep its shape, it should be built tightly and propped and braced effectively both horizontally and vertically.
- The formwork joints should be sealed to prevent cement grout leaking.
- The formwork should be made of inexpensive, easily available materials that may be reused.
- It must be capable of withstanding all forms of dead and live loads.
- The formwork should be tough enough to withstand activities such as reinforcing installation, concrete pouring and vibration, and form removal.

- It must be constructed and planned to allow for maximum reuse, lowering concrete work costs. While avoiding risky or ineffective procedures, appropriate planning should be done from the beginning to build a feasible reuse strategy, utilising member pieces and sizes that need little material cutting, waste, and assembly.
- The formwork must be designed to protect permanent structures and workers. It must have enough lateral and diagonal bracing.

3.1.2 Types of Formworks

a) Timber Formwork

Timber formwork is among the most commonly utilised in the construction industry, and it is made on site from wood. It's simple to make, but larger buildings take longer. The longevity of plywood face is limited.

Timber is lightweight, easy to install, and remove. Timber shuttering are the most adaptable sort of shuttering; they may be utilised for any shape or size. The following requirements should be met by wood shuttering:

- Well-seasoned
- Termite-resistant
- Simple to Use
- Lightweight

Advantages-

- Timber shuttering is simple to build in any form, size, or height.
- It's cost-effective for little jobs.
- It may be built into any form or size with ease.
- It can be built out of locally available wood.
- In comparison to steel or aluminium, it is lightweight.

Fig. 3.1 Timber Formwork

b) Steel Formwork

This comprises of panels made of thin metal sheets with tiny steel angles stiffening the edges. Suitable clamp or nuts and bolts can be used to hold the panel units together. The panels may be made in any modular size or shape in vast quantities. Steel forms are commonly employed in big projects or in situations where the shuttering may be reused several times. This shutter is best suited for constructions that are round or curved.

Advantages-

- These formworks are extremely durable and load-bearing.
- They are simple to repair.
- Its form and surface are identical.
- It is used in larger quantities.
- They last longer than wood formworks.
- High initial cost but are reusable.

Disadvantage

- They're more costly than wood.
- Handling is tough due to the increased weight.
- They are restricted in size and form.

Fig. 3.2 Steel Formwork

c) Plastic Formwork

Plastic formwork is an impenetrable surface that provides a nice finish to the concrete. Formworks of this sort could be reinforced or unreinforced. It is less sturdy than steel formworks, but it is lighter.

Advantages-

- It is more lightweight.
- With woodworking, it is simple to cut and nail.
- The formwork damage may be easily repaired.
- They're especially useful for intricate forms and unique characteristics.

Disadvantages-

- It is expensive.
- They have a limited load carrying capability.
- Plastics are damaged by heat.

Fig. 3.3 Plastic Formwork

d) Aluminium Formwork

Formwork, reinforcement, support, and auxiliary systems are all part of the aluminium formwork system. Instead of typical plywood, the basic formwork system is composed of aluminium alloy profiles, which are light, strong, and easy to assemble and disassemble, allowing for repeated usage.

Advantages-

- Plastering is not necessary.
- Without disturbing the props, the floor slab forms were removed.
- The whole system is responsible for the entire concrete structure.
- The panels can be reused.

Fig. 3.4 Aluminium Formwork

3.1.3 Important points of Formwork

- Time Management: A good formworks system aids in the reduction of the project's floor-to-floor construction cycle time and indirect expenses.
- Safety: A modern formworks system provides solutions to all superimposed loads, ensuring structural safety.
- Quality: The quality of formwork determines the surface finish of any concrete.
- Human resources: All levels of workers involved in formworks require specialised skills. As a result, adequate skill evaluation, training, and measurement of efficacy are ongoing requirements to enhance labour productivity.
- Capital Management: Any construction company's formwork material belongs under the asset category and is transferred from one project to the next.

3.1.4 Safety Precautions

- The material used to construct the formworks must fulfil the requirements.
- The formwork is solidly and accurately installed.
- To avoid vandalism of the formworks, the development area must be secured.
- To prevent people who may harm the formworks from entering the area where it is erected, warning signs must be placed within the area.

3.2 Scaffoldings

Construction workers require a platform to transport goods and themselves while doing their work. A scaffolding is used in this situation. It's a makeshift structure composed of wood or steel with platforms of various heights. Scaffolding is necessary for all sorts of building projects. Because the difficulties of building work vary, several types of scaffolding systems are required.

It's critical to select the correct scaffolding system for your building project in order to ensure maximum worker safety. Because improper scaffolding causes 35 to 40% of all accidents on construction sites, and as a result, people fall from great heights, close monitoring should be exercised when scaffolding is erected according to conventional methods.

3.2.1 Parts of Scaffoldings

- **Standards:** Vertical poles
- **Ledgers:** These are the horizontal elements that run parallel to the wall.
- **Braces:** The system of bracing.
- **Putlogs**: These are horizontal elements that run parallel to the wall.
- **Transoms:** Putlogs with both ends supported on double scaffolding ledgers.
- **Bridle:** A member used to span gaps.
- **Boarding:** Workmen stand on planks.
- **Guard rail:** A barrier installed at a height of about 1 m to protect the men working on the boarding.
- **Toe boards:** These are boards that are put parallel to boarding near the wall to protect employees.
- **Base plate or sole plate:** Plates that support standards on the ground.

3.2.2 Types of Scaffoldings

a) Single Scaffolding

This scaffolding is typically used for brickwork and comprises of an exterior row of verticals

(Called standards) to which longitudinal components are linked at various degrees of working. The cross members (putlogs) are attached to the standards on the outside and rest on the interior walls. The platform is supported by putlogs.

The putlog level cannot be placed on the wall if it corresponds with an opening in the wall. As a result, it should lie on a crossover piece (known as bridle tube) attached to the neighbouring putlogs' wall ends.

For lateral stability, cross brace in the two perpendicular between the verticals will be used.

If the vertical posts cannot be set on foundation plates or in holes dug in the ground, they should be arranged and braced appropriately for lateral stability.

In such instances, a frequent solution is to embed the vertical pillar in a steel frame.

Fig 3.5 Single Scaffolding

b) Double Scaffolding

This is a plastering support system used by masons.

It features two pairs of verticals (inner and outer). Rather of being supported by the wall, the putlogs are supported by an interior system of verticals and longitudinal.

When utilised for multistorey buildings, the thin and tall framework is attached to the building at intervals to provide extra lateral support.

Fig. 3.6 Double scaffolding

c) Cantilever Scaffolding

Cantilever scaffolding avoids unneeded scaffolding at lower levels, allowing room for cars, etc., during the construction of the upper half of a tall residential structure.

It's identical to the twin scaffold, except at the bottom it's supported by a cantilever prop.

Fig 3.7 Cantilever Scaffolding

d) Birdscage Scaffolding

It's utilised for interior work and comprises of a basic cage with four vertical supports from which people can operate.

It can be readily transferred from one location to another.

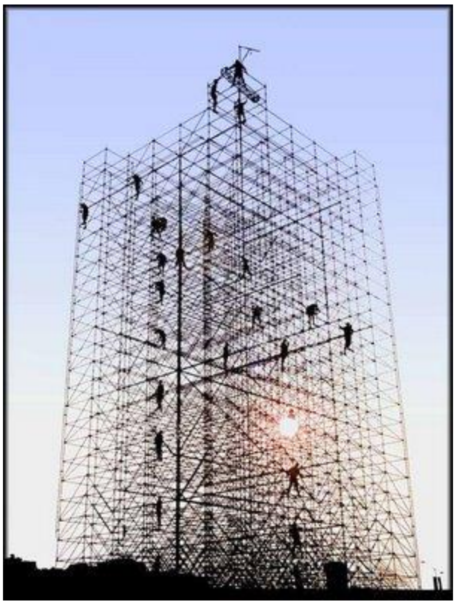

Fig 3.8 Birdscage Scaffolding

e) Suspended Scaffoldings

It is easier and more cost effective to hang the working platform above the earth than to maintain it from the ground in tall structures for work at high elevations, such as painting tall buildings. This is particularly true when the height exceeds 30 metres. There are three varieties of suspended scaffolds: fixed, pulley-operated, and winch-operated.

Fig. 3.9 Suspended Scaffoldings

3.2.3 Important points in Scaffoldings

- For heavy work like brickwork, the uprights (standards) should be no more than 1.8 m (6 ft) apart, and no more than 3 m (10 ft) apart for light work like painting.
- Each board should be 50 mm (2 inches) thick and 200 mm (8 inches) wide for the putlog spacing of 1.5 m or more. It can be 38 mm (11/2 inches) thick for 0.9 to 1.5 m and 25 mm (1 inch) for less than 1.5 in putlog spacing's.
- Single scaffolding putlogs should bear effectively on the wall opening. Putlogs should not be made of short members fastened to the wall.
- The platforms must be sufficiently large. If the height is greater than 1.8 metres, the breadth should be at least 17 inches (425 mm).
- The plank should be free of flaws. The grain of the timber used should be no more than 10 degrees with the span of the plank to prevent rapid collapse.
- All scaffolding should be correctly strutted to prevent them from laterally falling away from the wall. In the same way, it should be steady throughout time.
- Workman should avoid working under Scaffolds.
- To access the scaffolding, safe ladders should be supplied.
- If the scaffolding is higher than 2 metres, protection rails should be installed.

CHAPTER 4

DESIGN OF G+4 BUILDING

This project is about how the design of formwork can be done using BIM tools.

Building Information Modelling (BIM) is one of the most promising breakthroughs since it allows the design process to be automated.

Because BIM fosters collaboration and allows for easy information interchange among multiple stakeholders, it has been widely embraced by designers and contractors during the early stages of construction projects.

BIM has revolutionised the way buildings are designed, built, and operated, as well as traditional workflows and project delivery procedures.

Temporary structures, on the other hand, are frequently not precisely defined and planned in architectural drawings or BIM models, and the majority of previous study efforts have focused on permanent structures. Only a small amount of research has been done on temporary structures including fall protection rails, temporary stair towers for roof construction activities, and scaffolding layouts.

The project entails the design of formwork and scaffolding for a G+4 residential structure.

Formwork is developed and installed first, followed by a step-by-step progression from footings to plinth, plinth to columns, columns to beams, beams to slab, and so on.

Then scaffolding is used on the same structure.

4.1 PROJECT PLAN

The project is in various stages of completion. Planning and scheduling are essential for any endeavour. The planning and scheduling of a project covers how tasks must be prioritised and completed.

The project was divides into 6 stages-

1. Planning- At this point, planning and work were set in motion.
2. Dimensions- At this point dimensions were set and assigned.
3. Preparation- At this stage plans were made.
4. AutoCAD- Following the creation of the plans, the following stage was to translate them into AutoCAD with precise proportions.
5. Revit- After finishing with AutoCAD, the following step was to convert the designs into a 3D model using Revit.
6. Quantity Estimation- Finally Quantities are to be estimated and conclusion is to be made.

Following above steps, the project was followed.

4.2 DIMENSIONS

Table 4.1 Dimensions

Serial Number	**Component**	**Dimensions ( )**		
		Length	**Width**	**Height/ Thickness**
1.	Footing	5’	5’	2’
2.	Plinth Columns	1’	9”	8’
3.	Plinth Beams	15’	9”	1’
4.	Columns	1’	9”	12’
5.	Beams	15’	9”	1’3”
6.	Slabs	15’	15’	8”

4.3 Building Design

4.3.1 AutoCAD

The word CAD (Computer Aided Design) refers to a group of systems that allow users to generate electronic drawings, blueprints, and designs. AutoCAD is one such tool, and its greatest claim to fame is that it is reasonably simple to use, that it can make both 2D and 3D drawings, and that it is widely used. AutoCAD is used by 70% of all CAD users on the planet.

AutoCAD is a computer-aided drawing tool that may be used for a variety of design tasks. Its primary function is to allow users to sketch using electronic versions of traditional drafting equipment. Measurements and computations, 3D components, and data exchange are all aided by digital precision.

The software's ability to cover a wide range of design tasks accounts for a big portion of its success.

The usage of AutoCAD aids in the creation of plans for engine valves and engine replacement parts for precise manufacture. The designed basic structure will be carried with the job from start to finish between the production teams, quality teams, and machine handling teams, who will review the design for any problems of understanding and proceed machining with the help of blueprint drafters. Wiring diagrams and surface model diagrams can be used in the manufacturing, assembling, and repairing of parts. It's also used to keep track of how many orders were completed in a certain amount of time.

All designing and modelling was done manually before the development of AutoCAD. This was a lengthy effort that resulted in several costly blunders. However, with the introduction of AutoCAD, the modelling and design process was digitalized and simplified. Most designers, engineers, and architects have found a solution in this technology.

In order to display measurements and designs of footings, columns, and structure, AutoCAD was used extensively in this project.

The primary skill of AutoCAD software is 2D design.

Below is starting screen of AutoCAD.

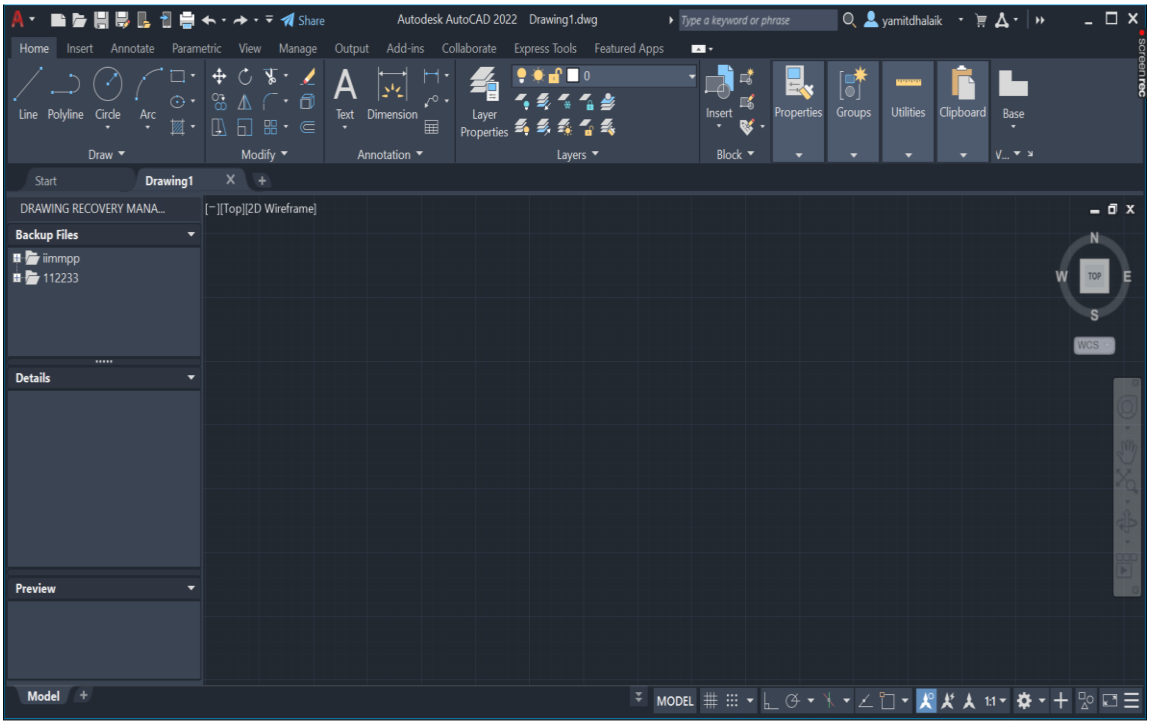

Fig 4.1 AutoCAD page

There are various sections to the AutoCAD programme window:

a) Application menu
b) Access toolbar
c) Info enters
d) Ribbon
e) Drawing tabs
f) Drawing area
g) UCS icon (User Coordinate System icon)
h) Viewport Controls
i) View Cube
j) Navigation bar
k) Command window
l) Status bar

The following plans and drawings were created throughout the project using AutoCAD:

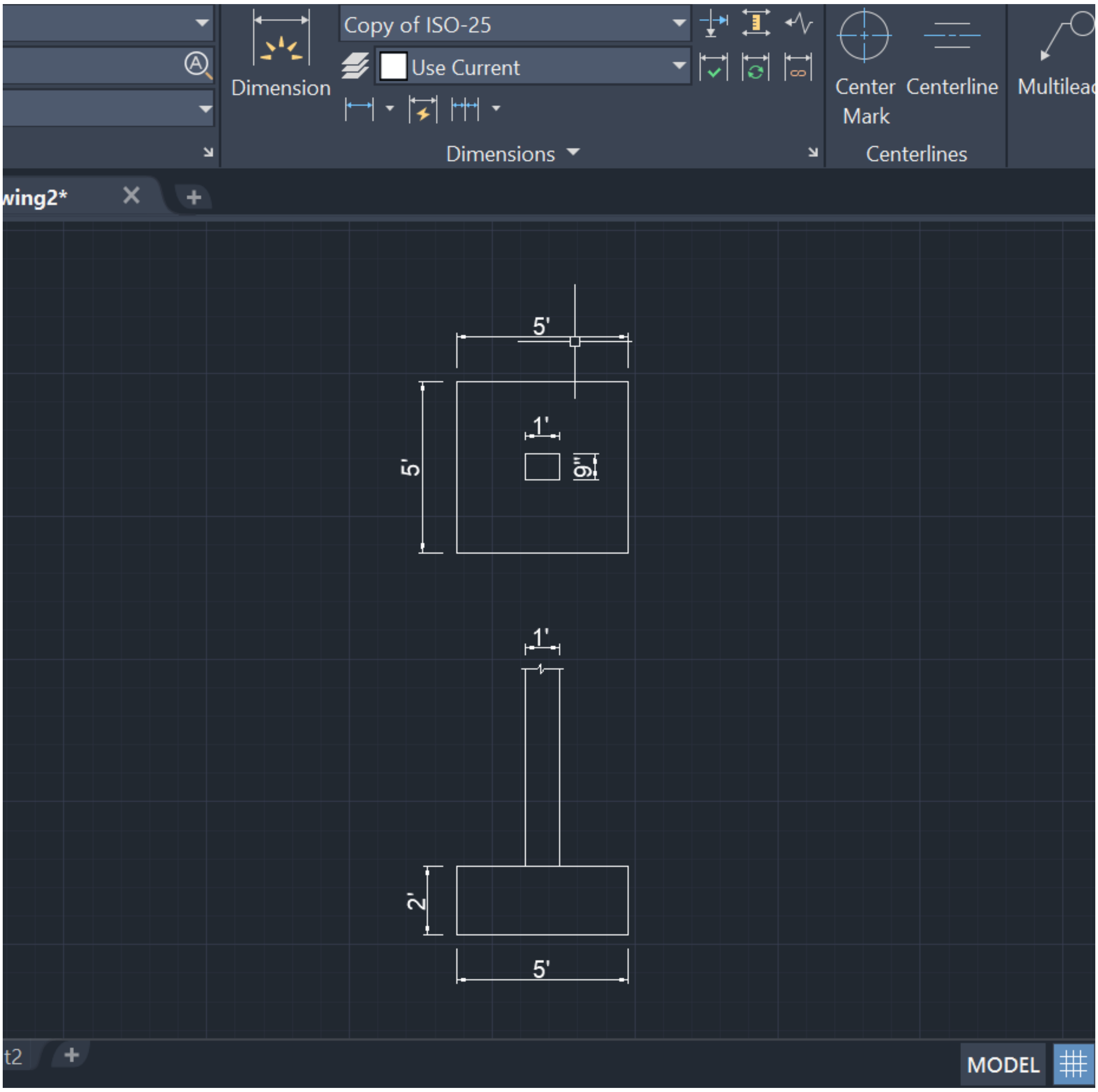

Fig 4.2 Footing Plan

Above shows the plan of footing and elevated plan of footing.

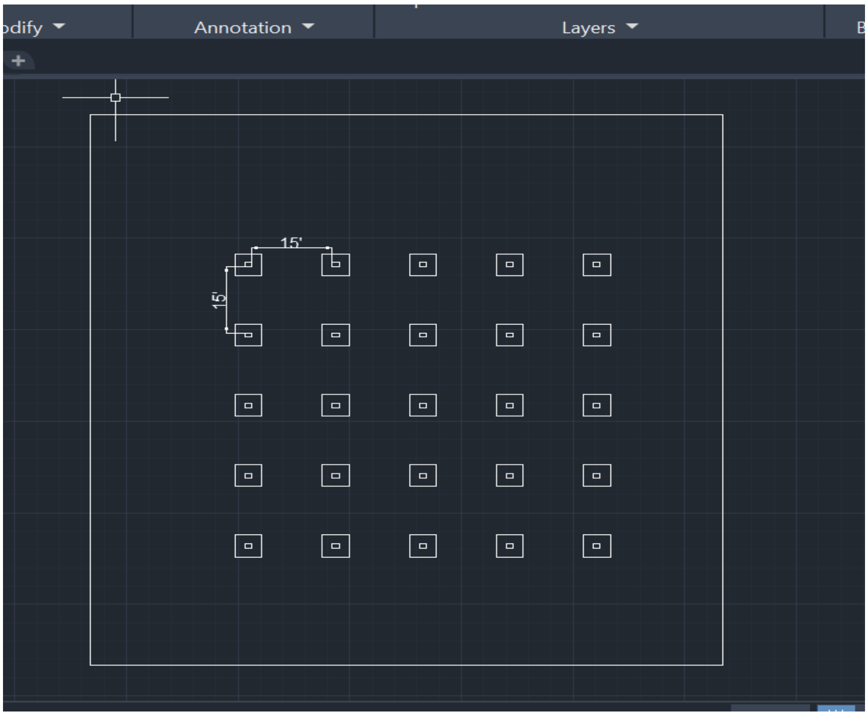

Fig 4.3 Area of footing

The plan view of the footings is shown above, and the depiction with beams is shown below.

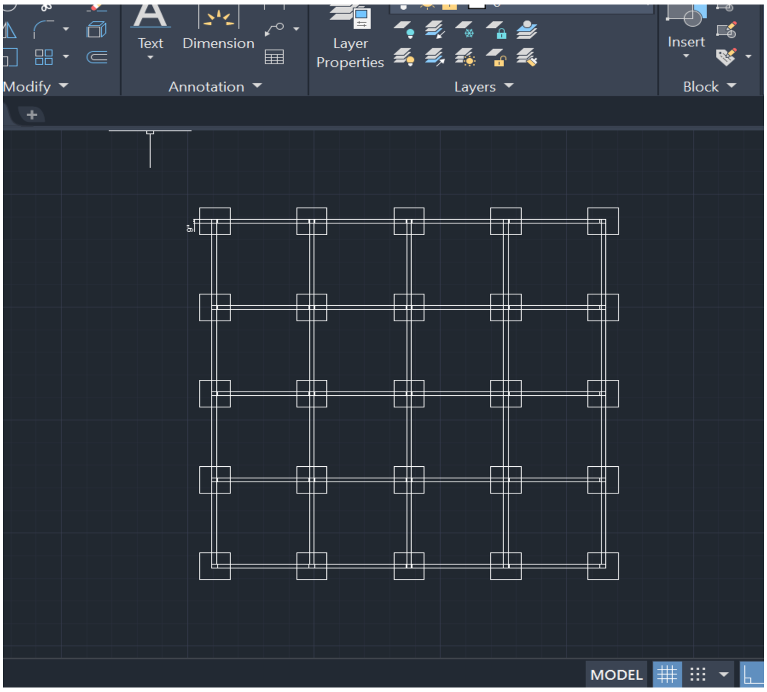

Fig 4.4 Beams and Column

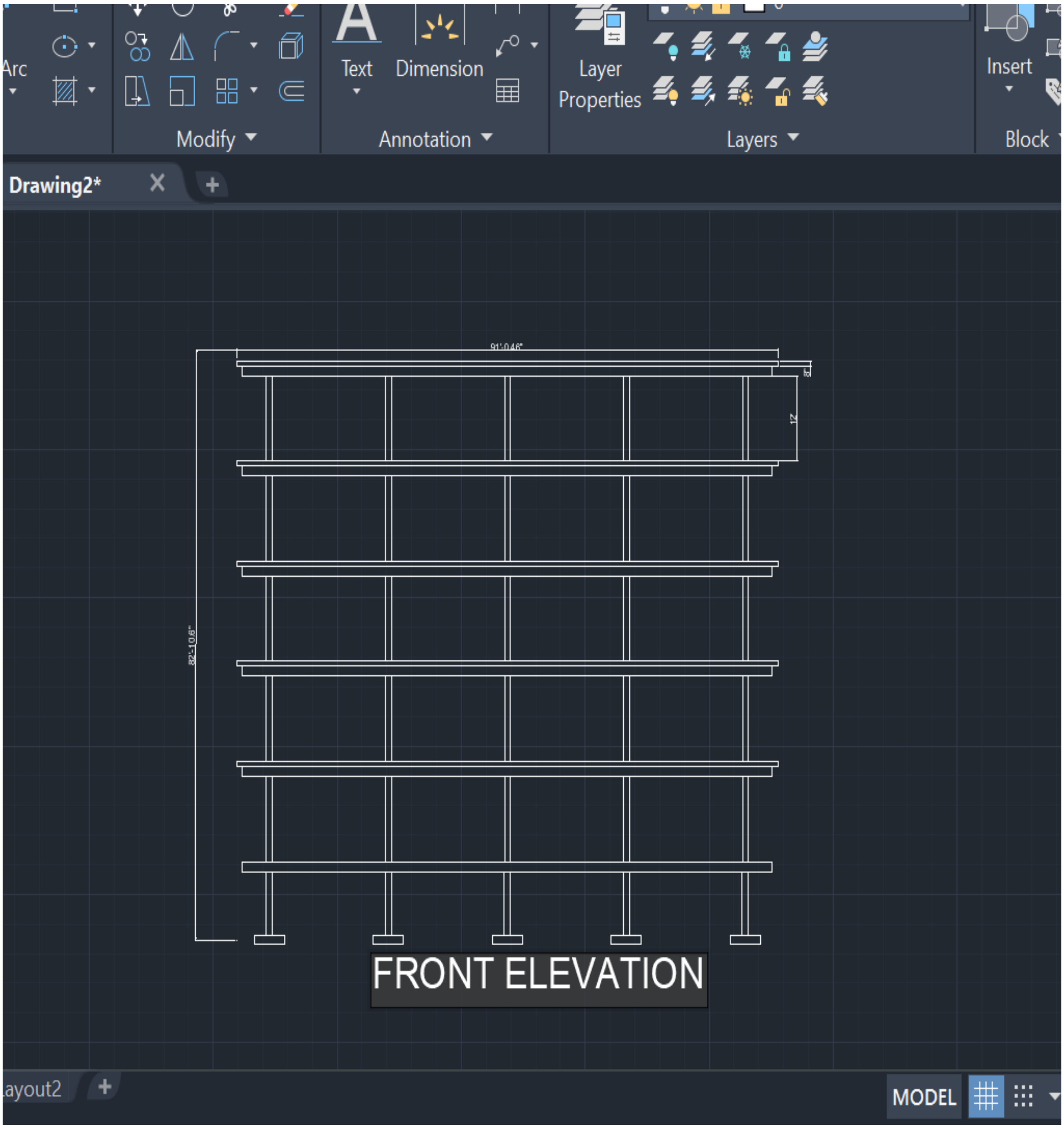

Fig 4.5 Building front elevation

The image above depicts an elevated view of a building with many levels, beginning with the foundation, plinth level, columns, beams, and slab.

4.3.2 Revit

Revit is a design and documentation tool that helps with the design, drawings, and schedules needed for BIM (BIM). When you need it, BIM gives information on project design, scope, quantities, and stages.

Every design sheet, 2D and 3D view, and schedule in the Revit model is a visual representation of data from the same virtual building model. Revit is a multidisciplinary and collaborative design and construction software programme. Architectural design, MEP, structural design, detailing, engineering, and construction all use Revit BIM construction software.

Revit gathers information about the building project as you work on the building model and coordinates it across all different project representations.

Revit enables architects, engineers, and construction professionals to create model-based plans for buildings and infrastructure that are uniform, coordinated, and comprehensive. It's a multi-disciplinary BIM programme enabling more collaborative, high-quality designs.

Changes to model views, drawing sheets, schedules, sections, and plans are automatically coordinated by the Revit parametric change engine.

Revit allows you to develop model-based designs that are coordinated, consistent, and comprehensive. From conceptual design, visualisation, and analytics to fabrication and construction, Revit® can help you improve efficiency and accuracy.

Begin sculpting in 3D with precision and accuracy.

As your model evolves, automatically change floor plans, elevations, and sections.

Allow Revit to automate regular and repetitive processes so you may concentrate on higher-value work.

Benefits of Revit-

a) The term "parametric modelling" refers to the development of 3D models based on a set of criteria. Revit employs parametric modelling in the form of "families."
b) A single database has all of the data required to generate a Revit model. This implies that the database is updated anytime you make a modification to the model.

c) One of the key distinctions between Revit and AutoCAD is that Revit allows several users to work on the same model at the same time, whereas AutoCAD only allows one user to make changes to a.dwg file at a time.

d) Revit includes various valuable capabilities for coordination across multiple models, file kinds, disciplines, and trades, whether it's as part of the architectural design process or for completing constructability assessments from users in the construction sector.

e) In the same way that a Revit model acts as a single database for all of the model's data, Revit scheduling reduces the time required by traditional processes.

f) In the design business, using various pieces of software for rendering and presenting materials is a time-honoured practise. Even so, Revit delivers all of the tools needed to develop these materials in one place.

Basic Revit page looks like-

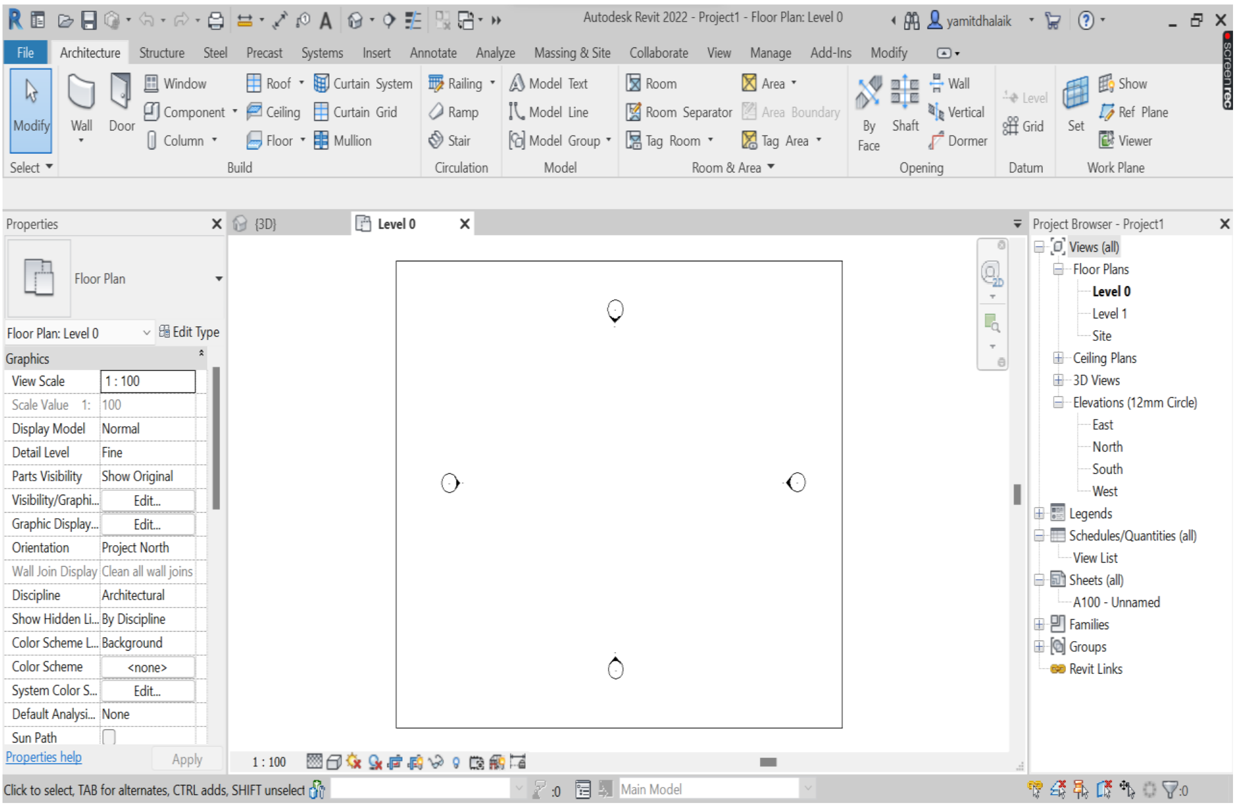

Fig. 4.6 Revit Screen

The job with Revit was to export the AutoCAD file and then import it into Revit to work on the 3D construction.

Now when the file was imported foundation was to be designed.

Firstly, the levels were drawn as follows-

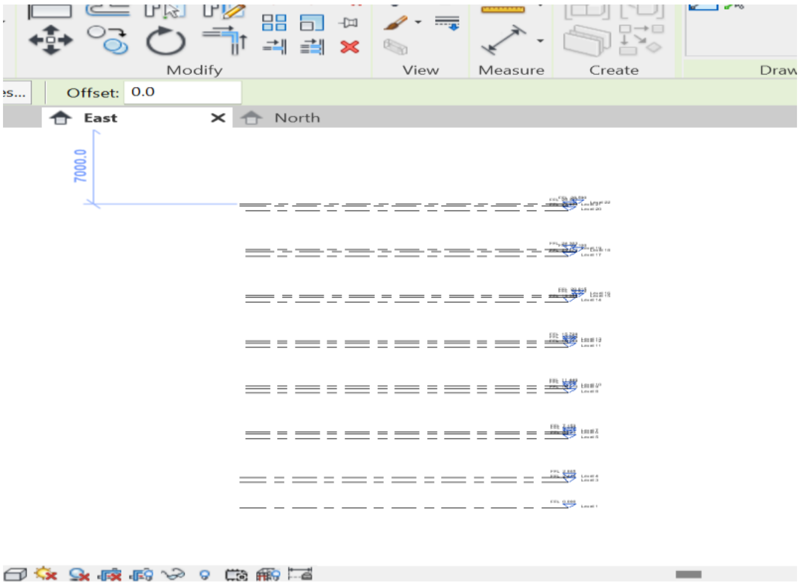

Fig. 4.7 Level Plan

The grids were then created with a 5x5 type dimension at a distance of 15 ft.

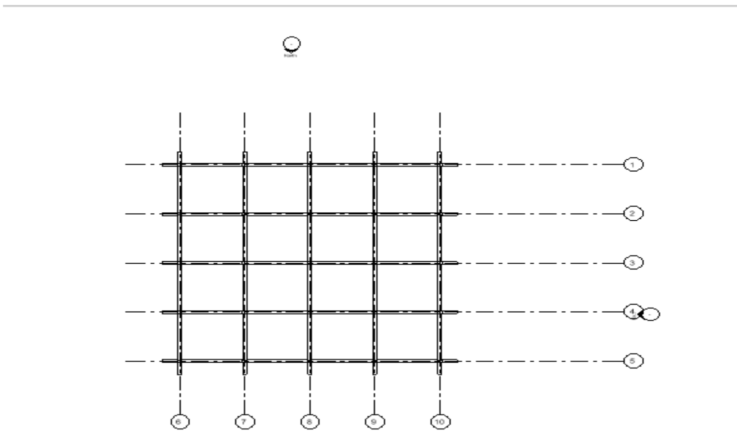

Fig. 4.8 Grids

Starting with a single footing, built 25 columns in a 15-ft. radius from corner to corner.

Depiction below-

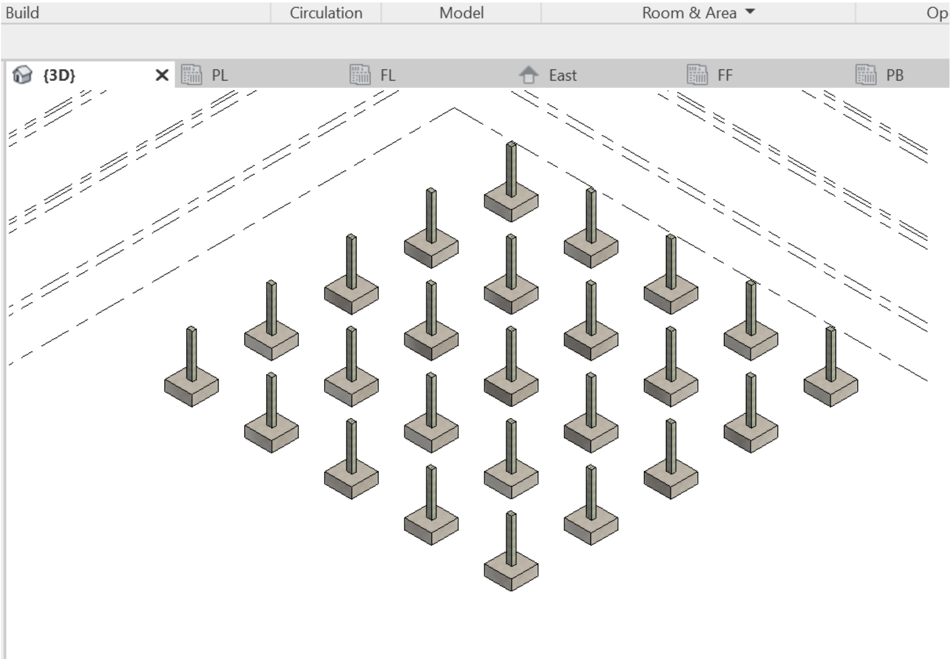

Fig. 4.9 Footings

After columns Plinth beams were designed.

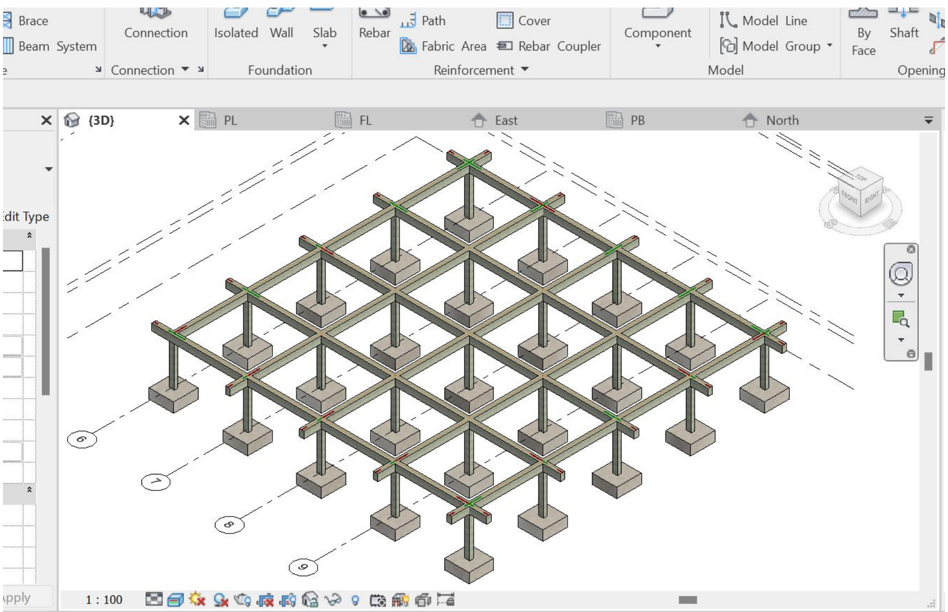

Fig. 4.10 Plinth beams

On effectively designing Plinth, shifting on to Columns then Beams respectively.

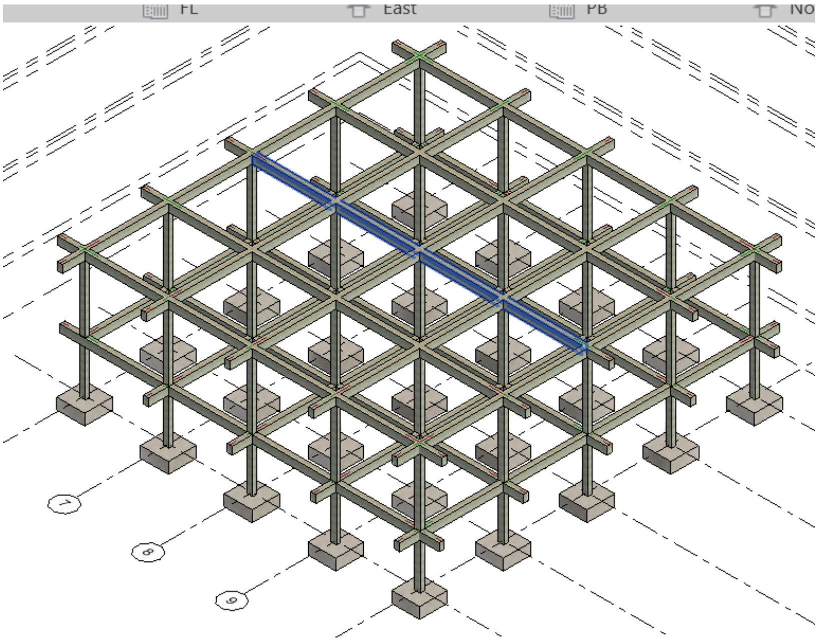

Fig. 4.11 Columns and beam First floor

Then providing slab for the same.

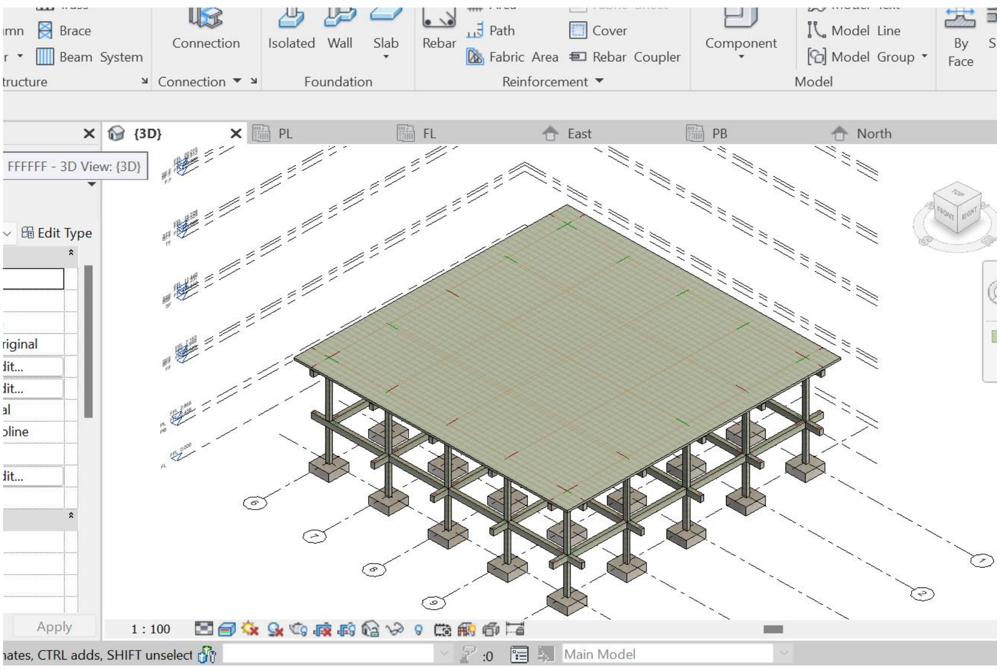

Fig. 4.12 Slab First floor

With the same procedure as above, the complete building was designed.

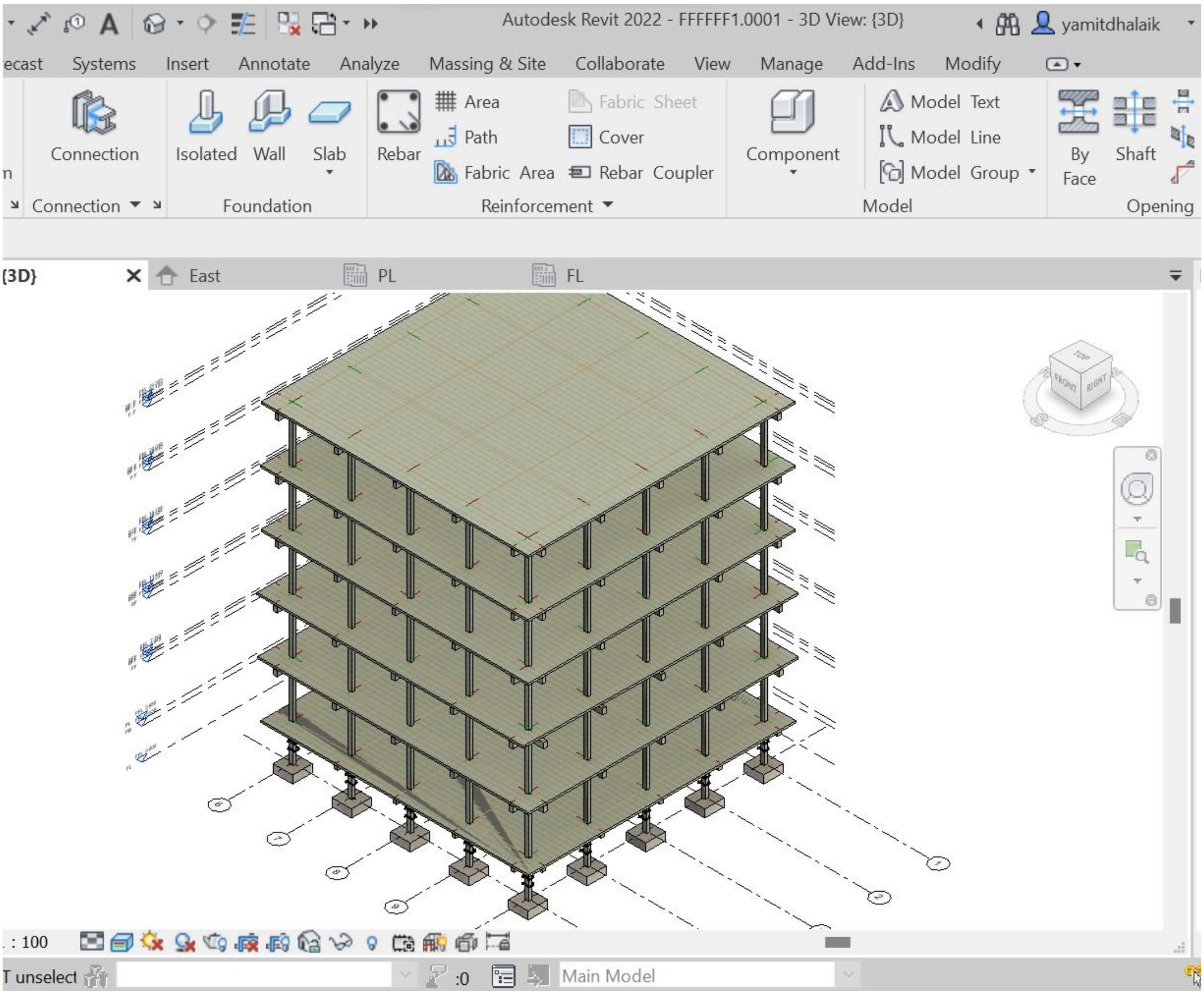

Fig. 4.13 Complete Building

Revit allows us to design the entire structure before moving on to the formwork.

So, the entire structure had been planned, and now it was time to create the formwork for it.

CHAPTER 5

FORMWORK AND SCAFFOLDING DESIGN

5.1 Formwork Design

Moving on to the Formwork section, the foundations are first formed, then the footing is completed.

Braces are provided so as to keep formwork stable.

Formwork in Revit is created using following steps-

1. Go to Structure tab.
2. Click Component.
3. Select Model in Place Component.
4. Find generic Models from Options.
5. Name the Generic Model.
6. Choose Extrusion.
7. Set Plane.
8. Check Level (Where formwork is to be applied).
9. Select line or rectangular option and draw a formwork for structure in Plane view.
10. Select material to be used from Families.

Same procedure is applied for columns too.

When applying on Beams, the circular braces are preferred and available as on site.

After Beams, Wooden plywood are used for Formwork of slab.

Timber formwork has been used in this project.

Slabs require proper alignment of Braces for rigidity and support.

In this project foe 5x5 ft footing, Formwork was designed and depth was kept as 2ft.

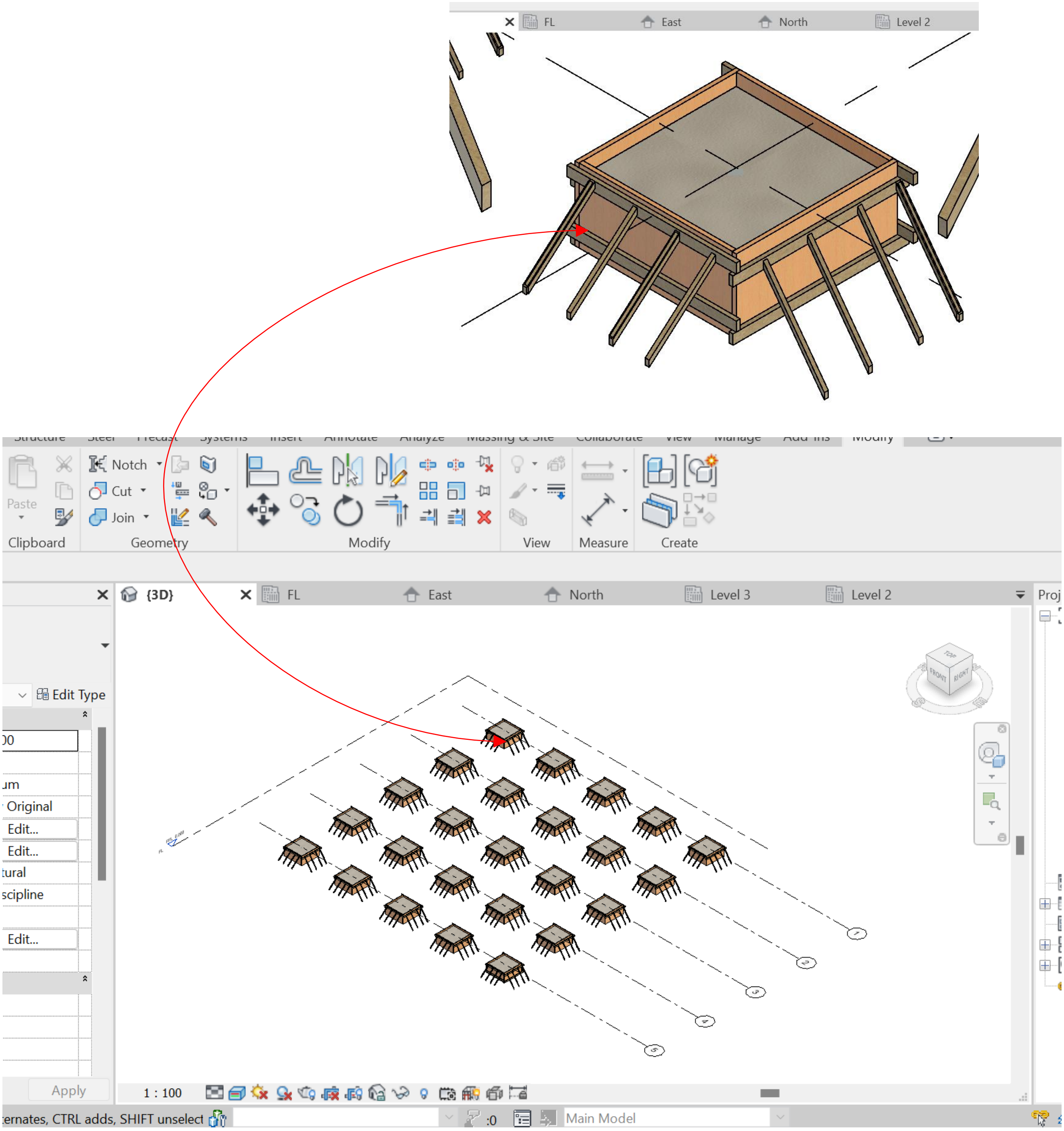

Fig. 5.1 Footing Formwork

Then footing was completed with Column.

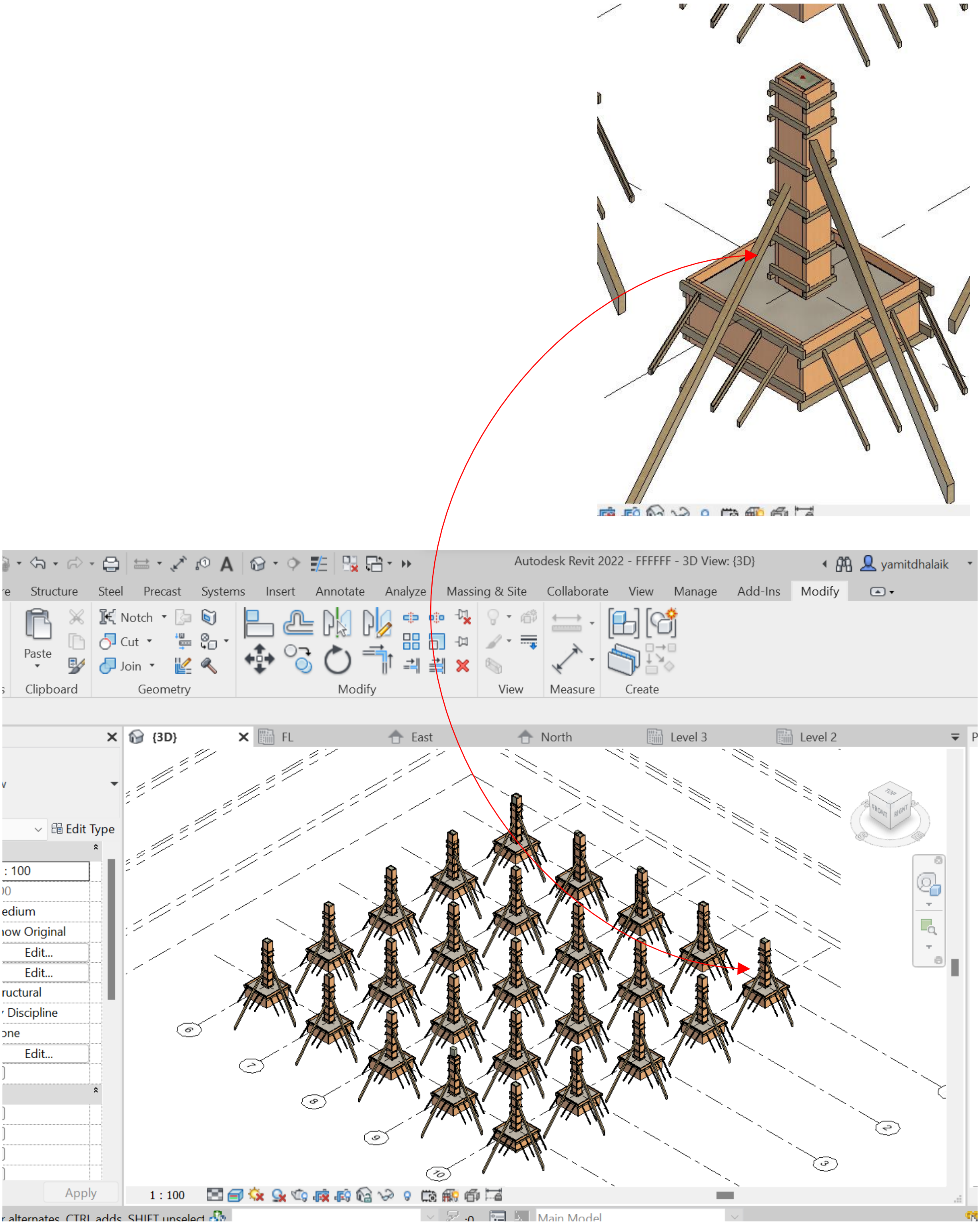

Fig. 5.2 Complete footing

Similarly for beams Formwork was applied.

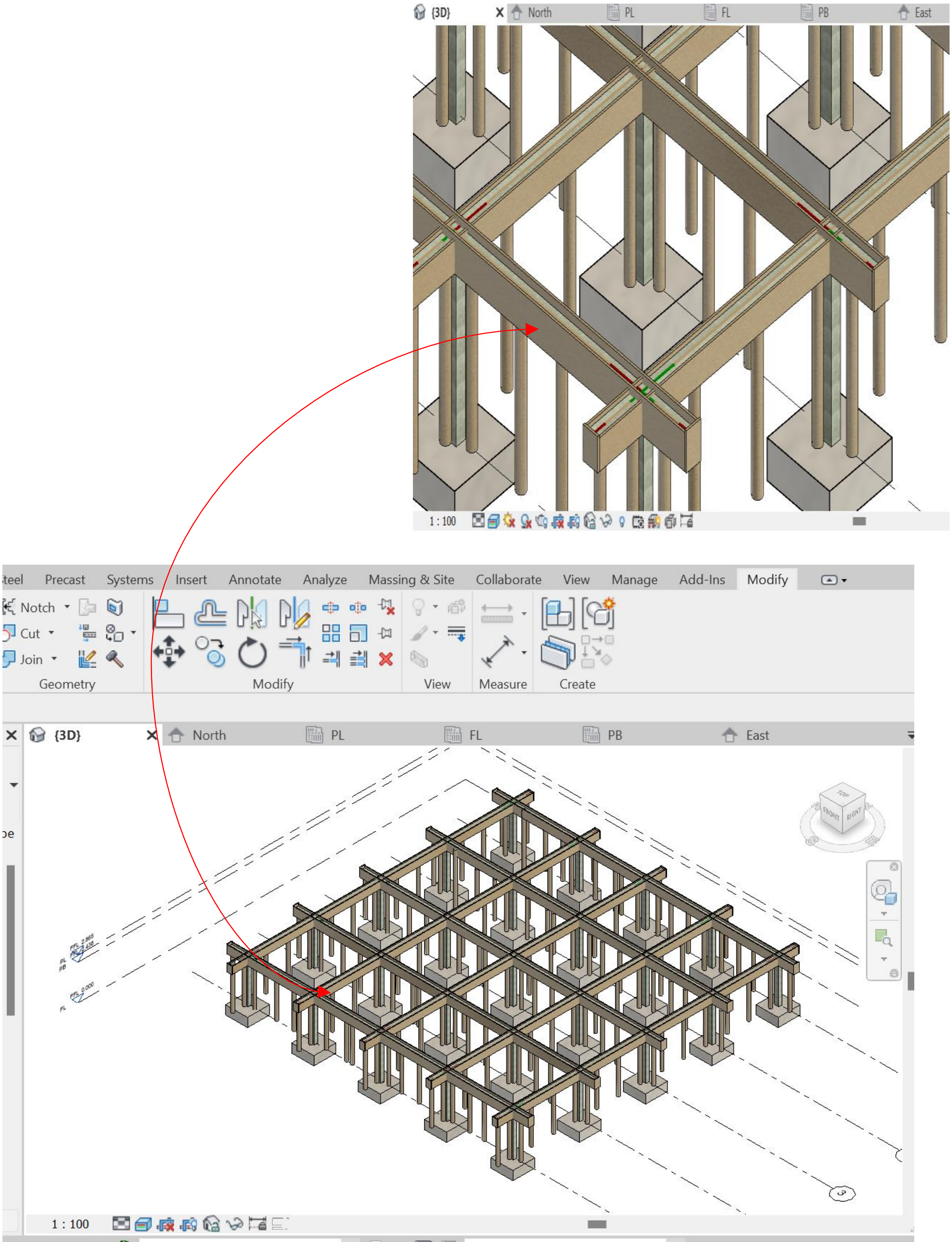

Fig. 5.3 Plinth Beams formwork

While moving towards formwork for slab, most important part is application of braces so that the formwork is rigid and stiff.

Using same procedure, we can follow the slab formation.

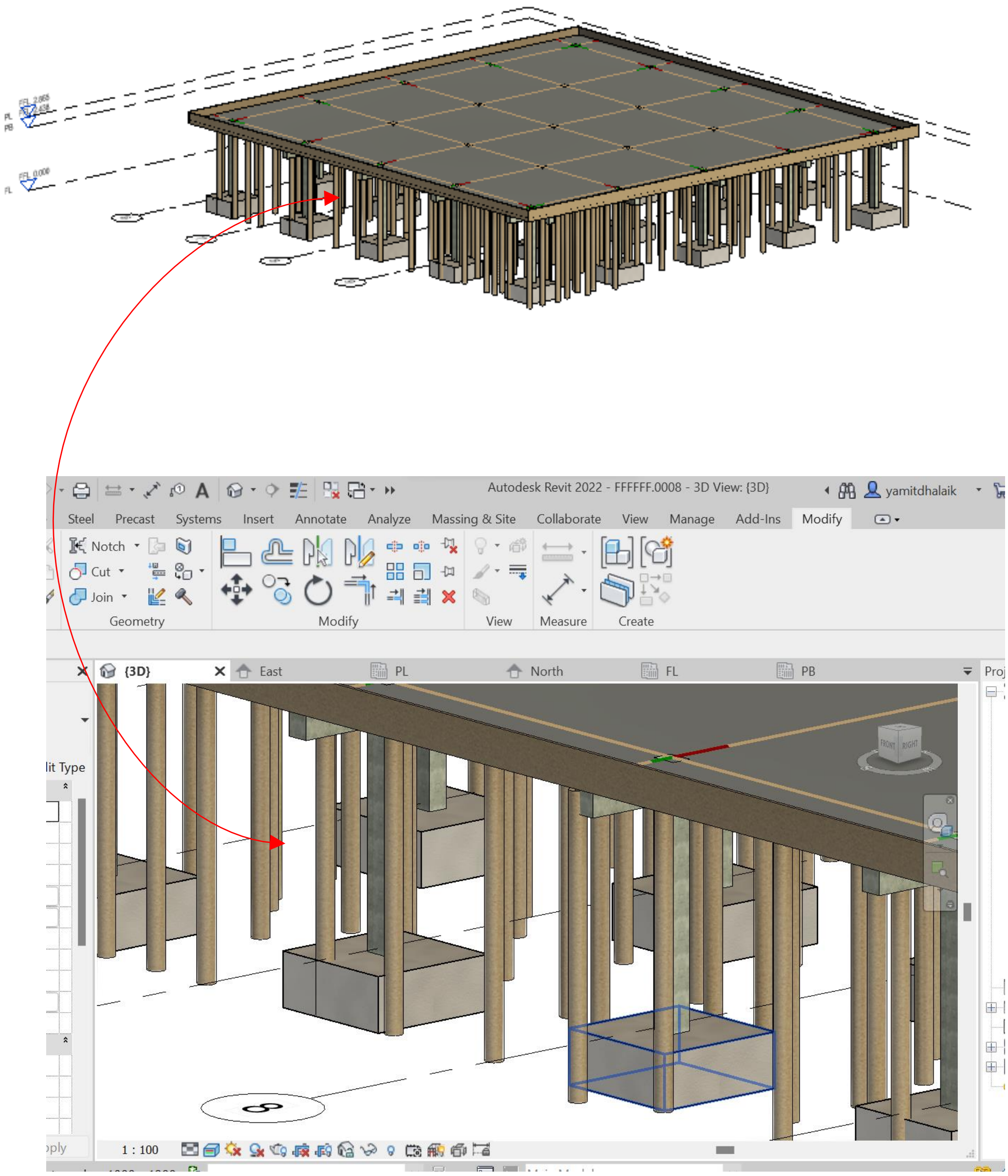

Fig. 5.4 Slab formwork

After done with plinth level, now considering Ground Level.

From Ground Level onwards Height of Column was 12ft.

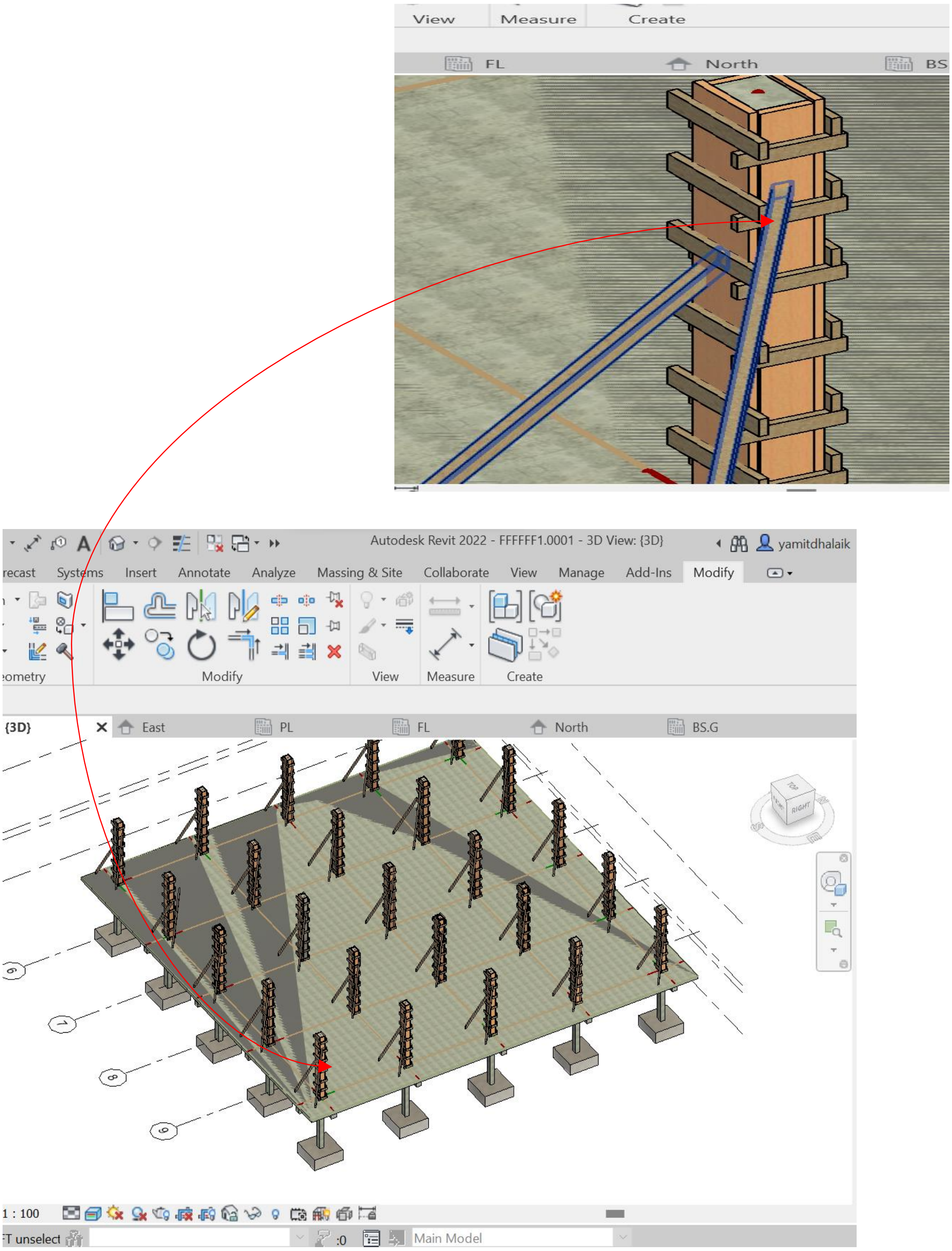

Fig. 5.5 Column formwork for ground floor

Similarly beams and Slab.

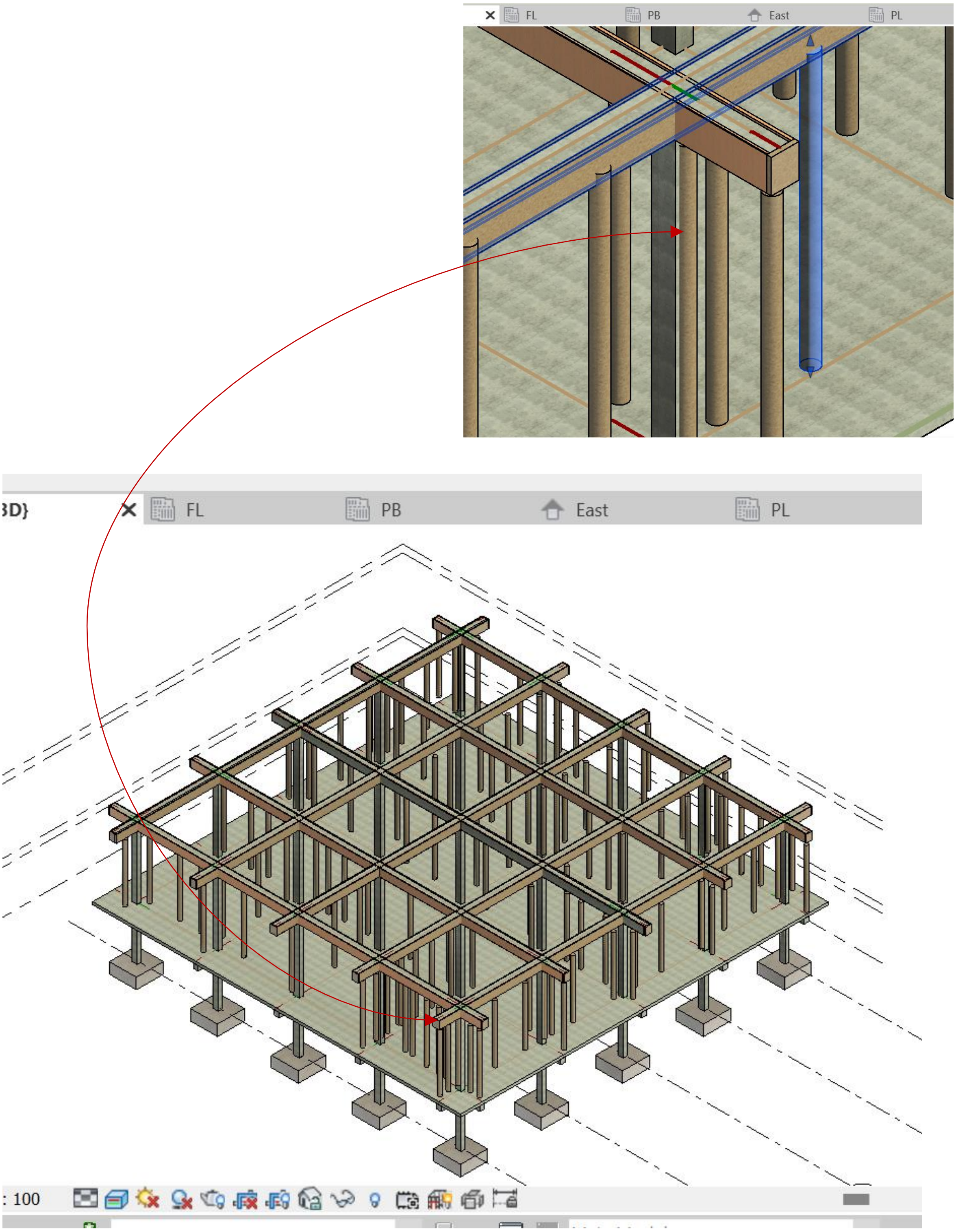

Fig. 5.6 Beams Formwork for ground floor

Ground floor slab-

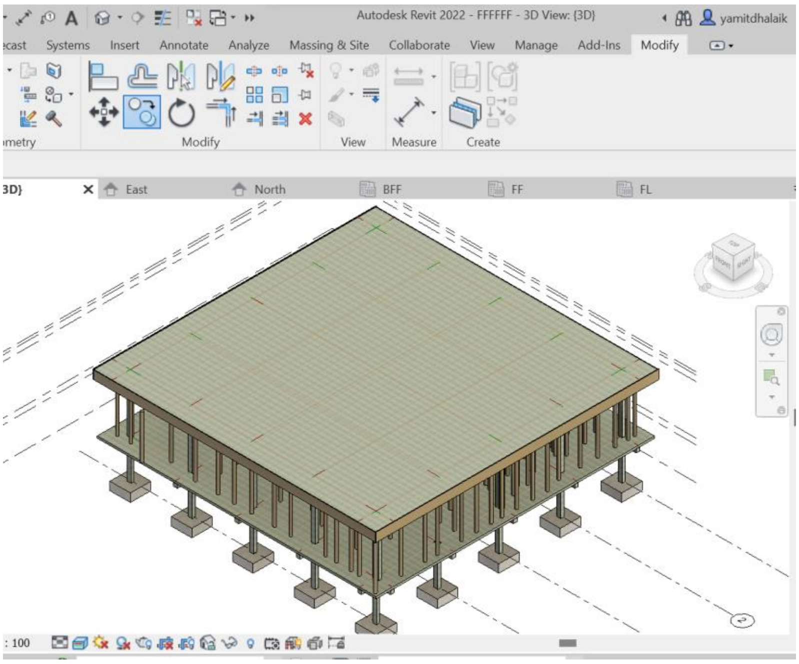

Fig. 5.7 Slab Formwork ground floor

Column Formwork for First Floor-

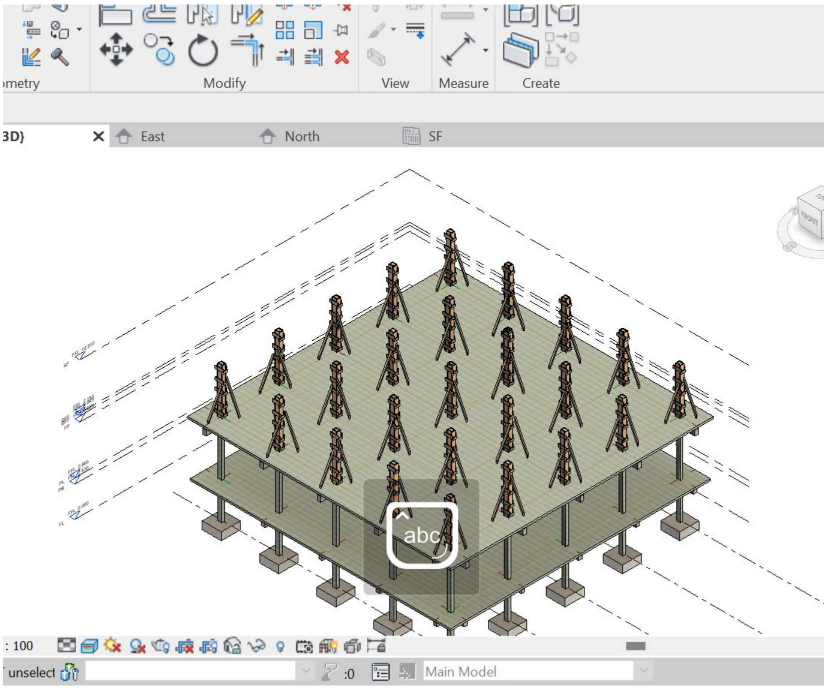

Fig. 5.8 Column Formwork 1st floor

Beams for First Floor

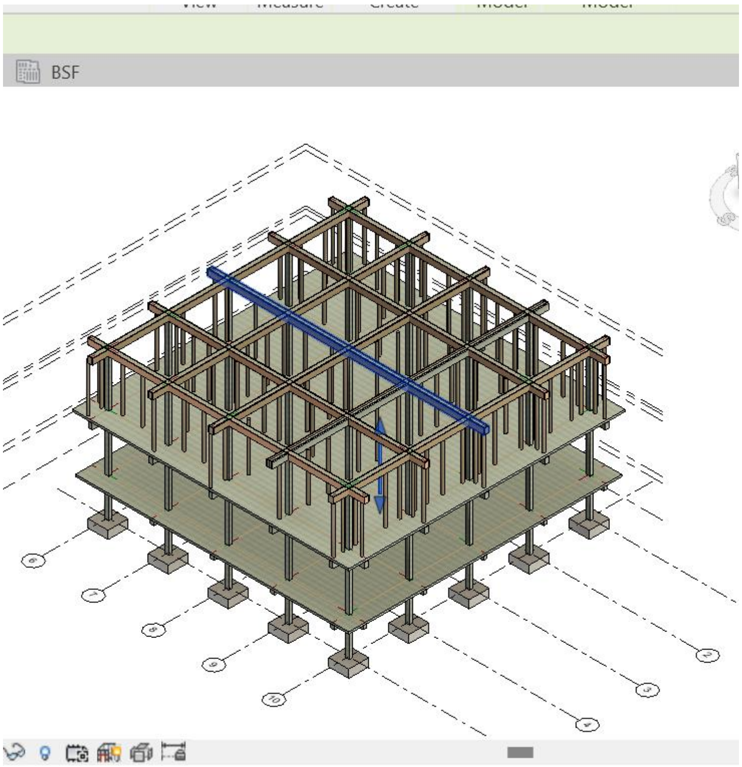

Fig. 5.9 Beams Formwork 1st floor

Slab for First Floor

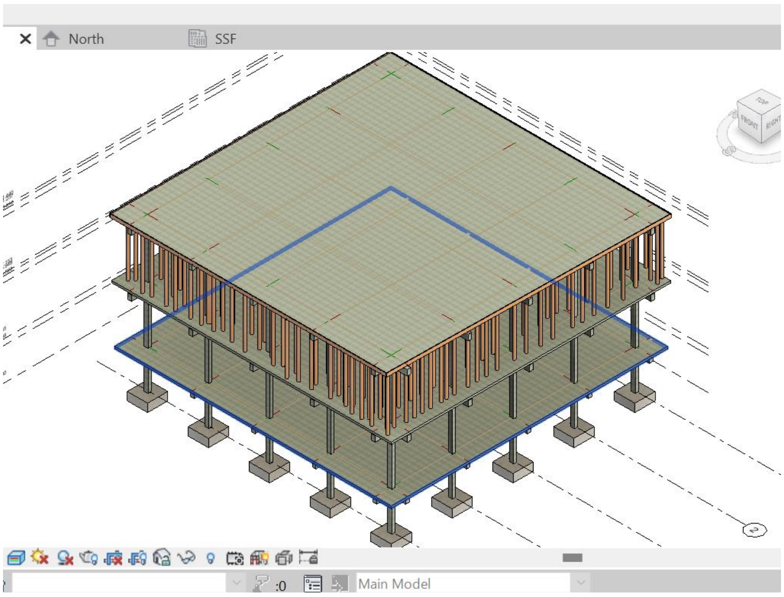

Fig. 5.10 Slab Formwork 1st floor

Column Formwork for Second Floor

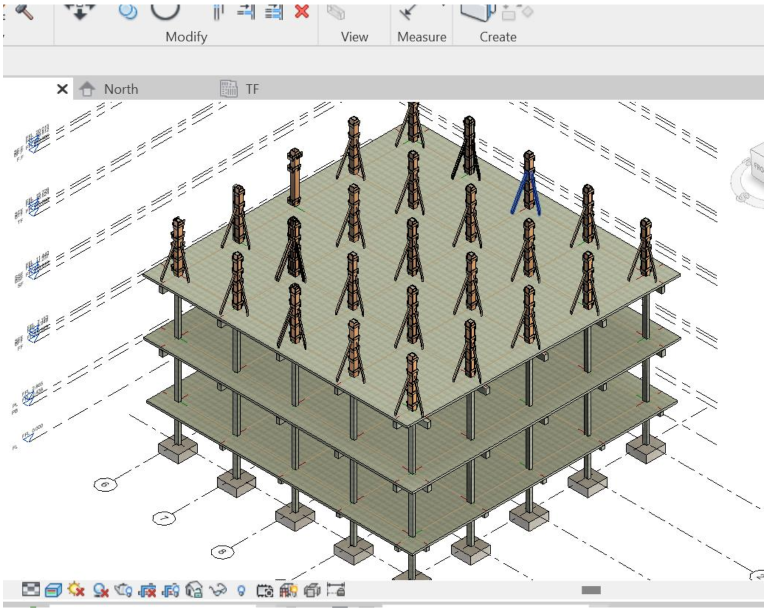

Fig 5.11 Column Formwork 2nd floor

Beam Formwork for Second Floor

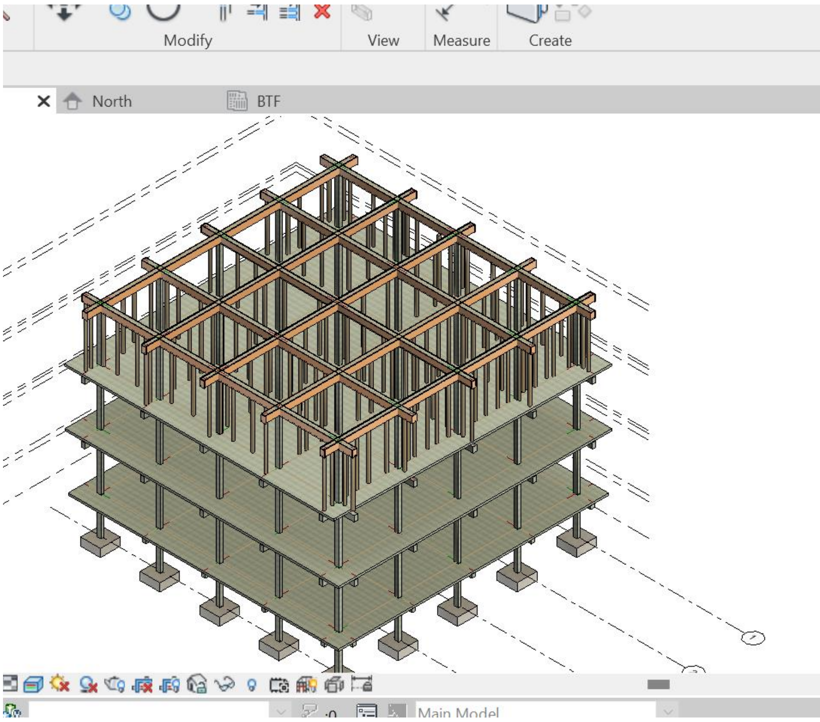

Fig. 5.12 Beams Formwork 2nd floor

Slab for Second Floor

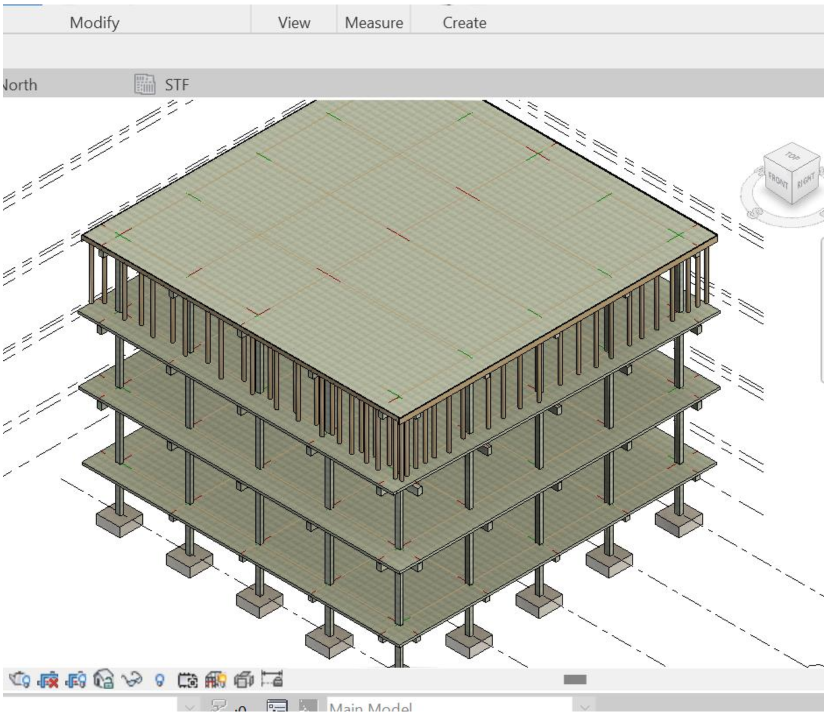

Fig. 5.13 Slab Formwork for 2nd floor

Similarly, Column for Third floor

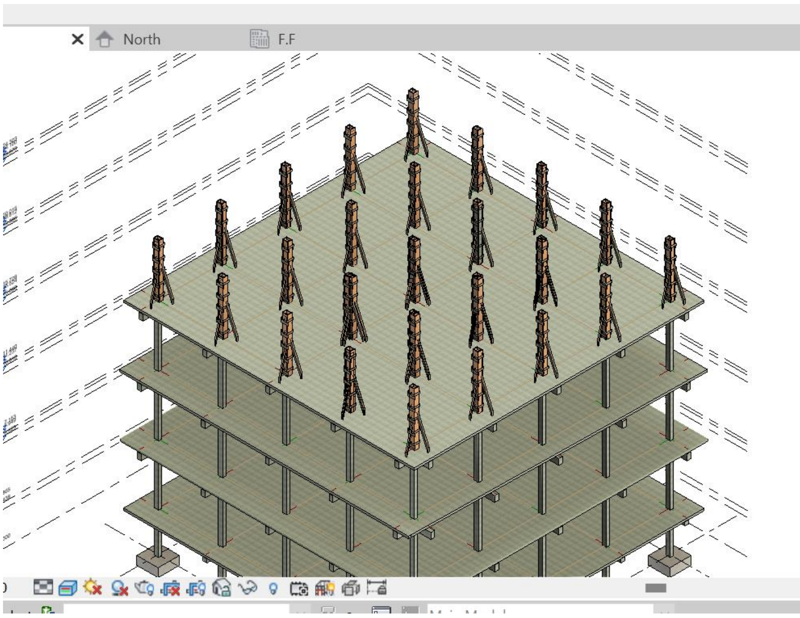

Fig. 5.14 Columns for 3rd floor

Beams for Third Floor

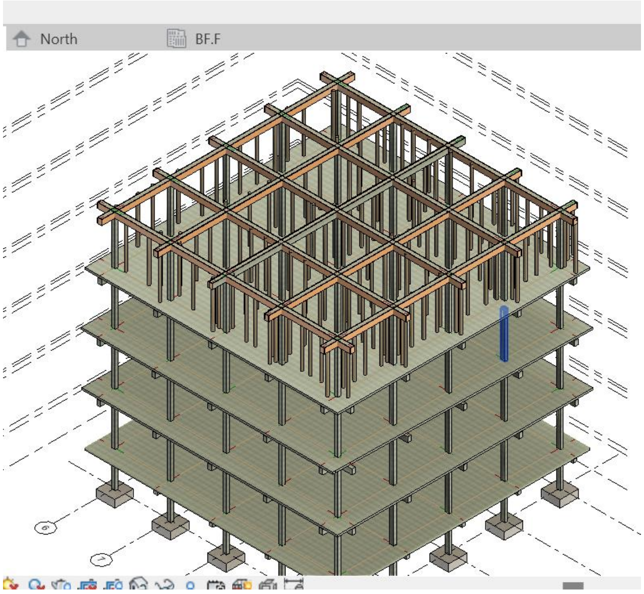

Fig. 5.15 Beams Formwork for 3rd floor

Slab for Third floor

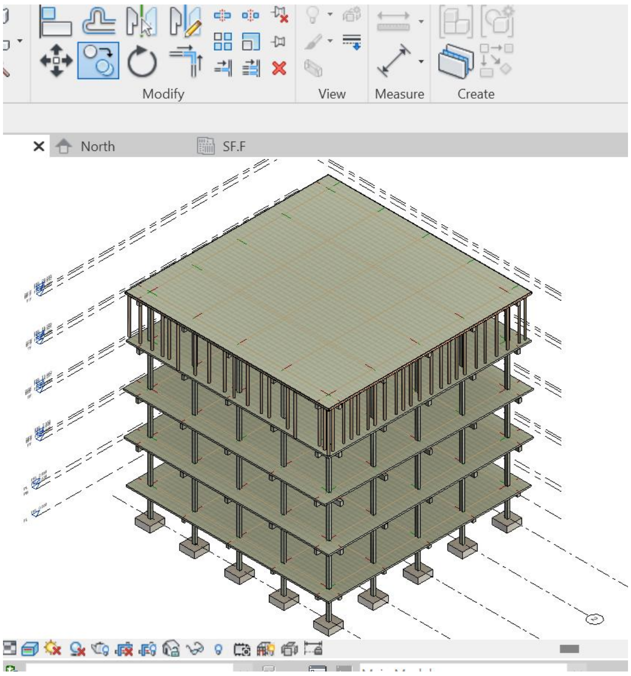

Fig 5.16 Slab Formwork for 3rd floor

Column for Fourth Floor

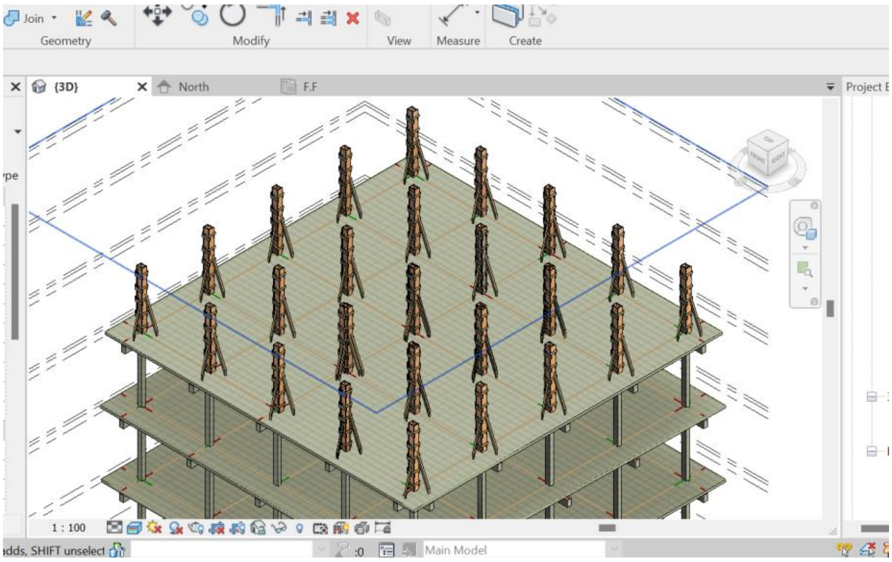

Fig 5.17 Column Formwork for 4^{th} floor

Beams for Fourth Floor

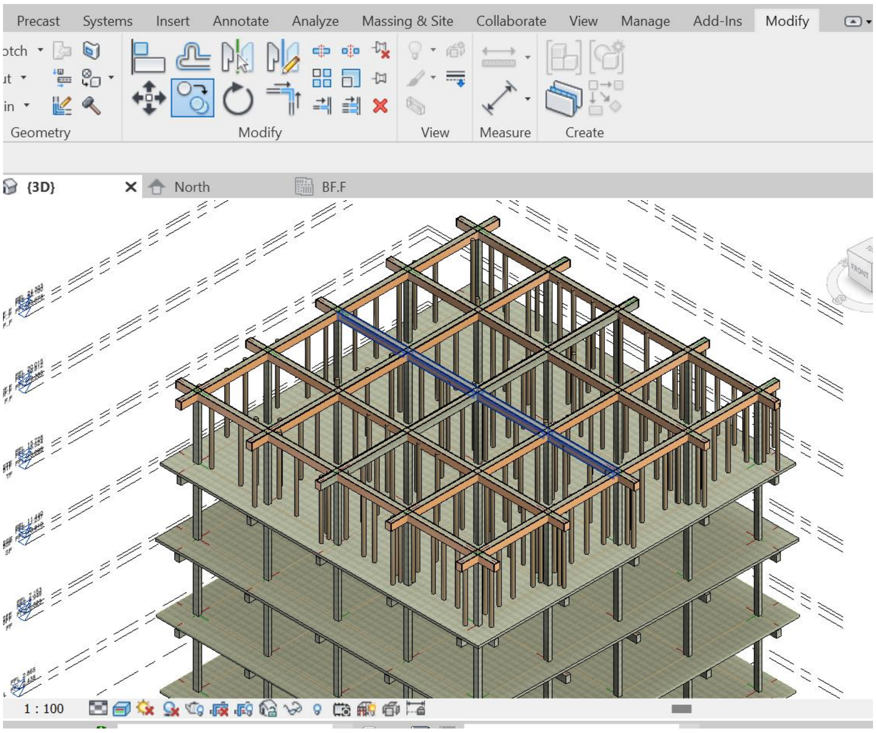

Fig. 5.18 Beams Formwork for 4^{th} floor

Slab for Fourth Floor

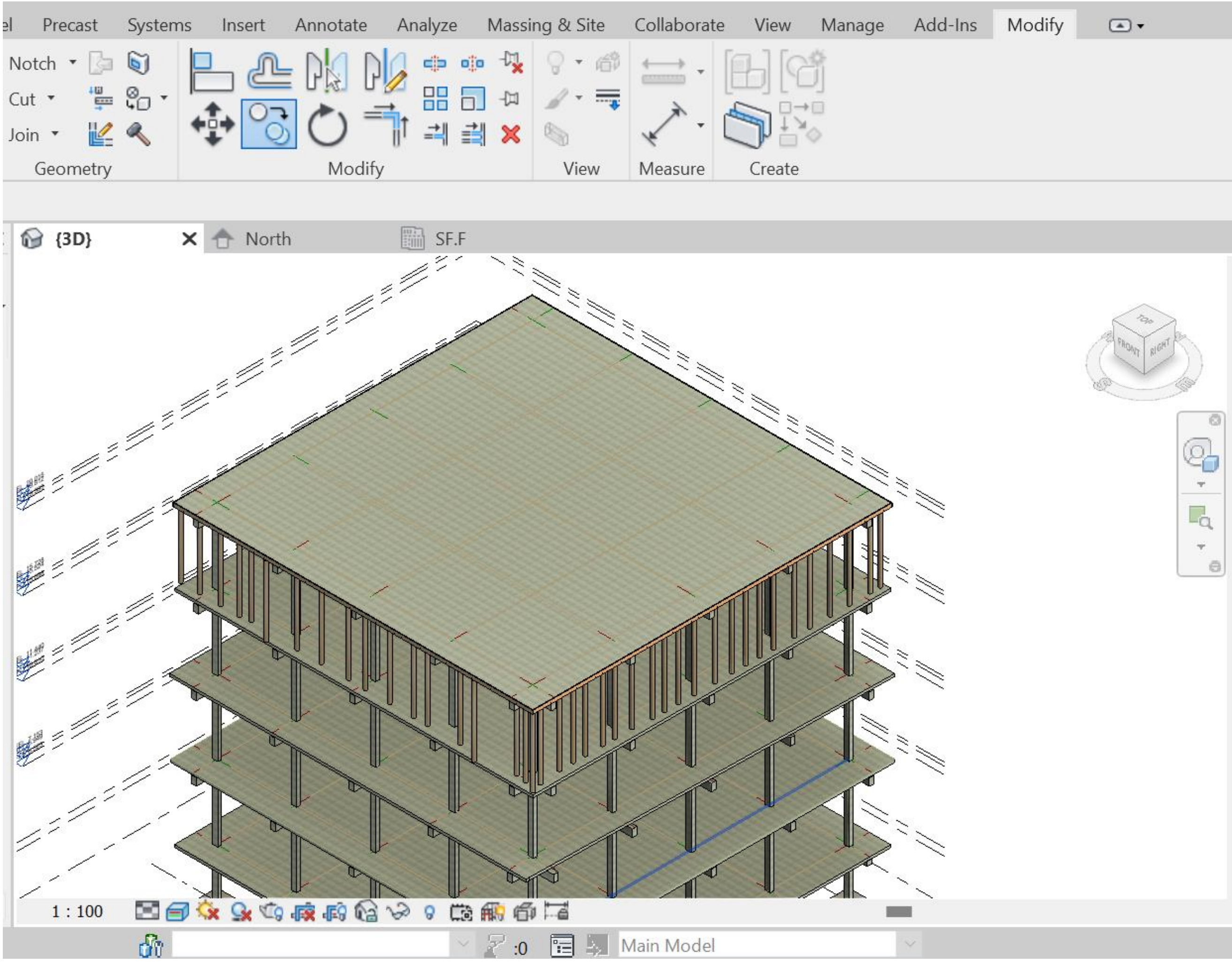

Fig. 5.19 Slab Formwork for 4th floor

This way we deign Formwork for G+4 Building.

5.2 Scaffolding Design

For Scaffolding Design, the building is considered as whole and here double scaffolding is used.

5.2.1 Typical Scaffolding Design

- A typical scaffold consists of Standards, Ledgers, Transoms, Scaffold Tubes, Scaffold Couplers, Adjustable Base Plates, Diagonal Braces, Toe Boards etc.

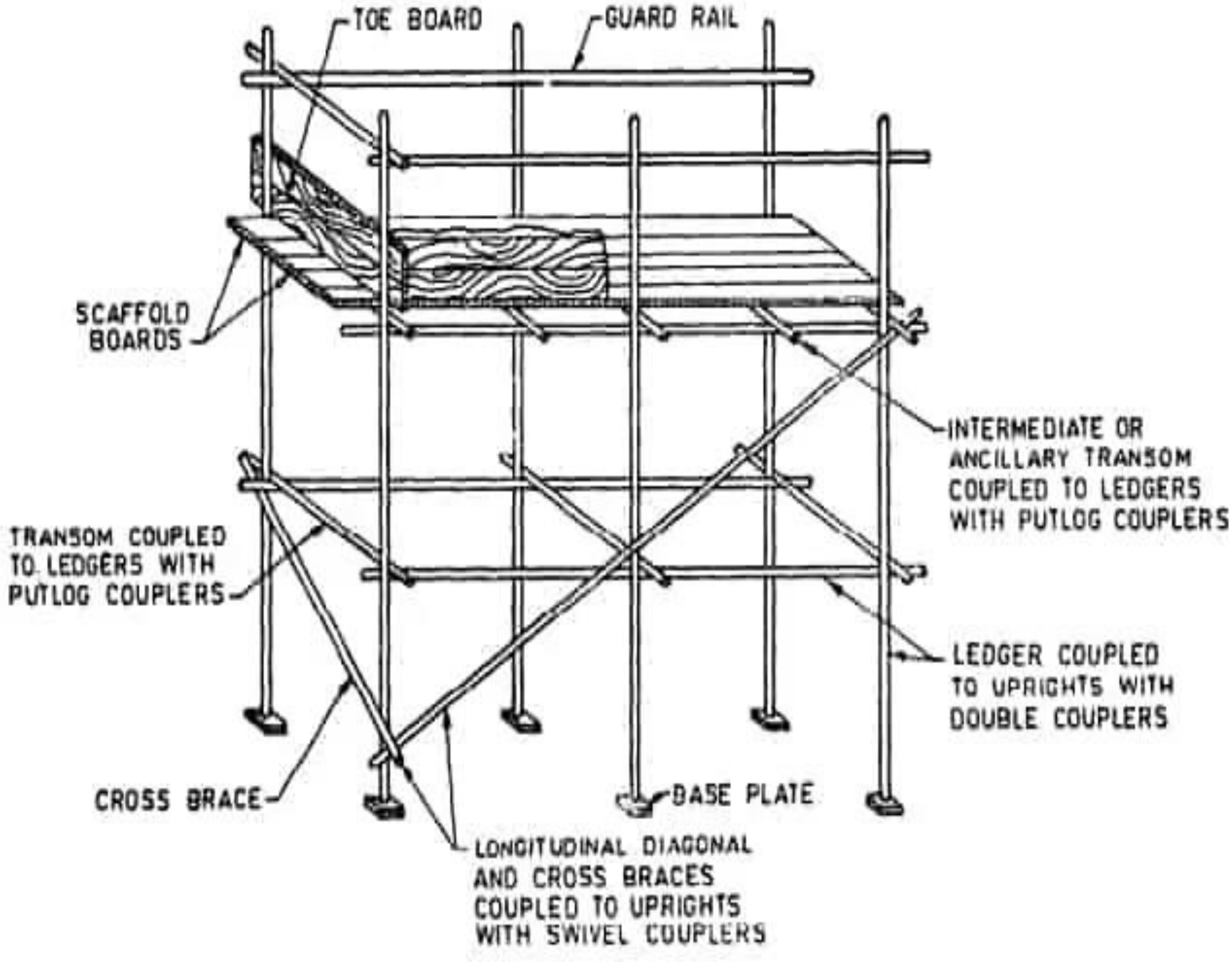

Fig. 5.20 Double Scaffolding Structure

Scaffold design begins with base plate for support accompanied by ledger uprights with double couplers and ledgers putlog couplers.

5.2.2 Stepwise approach of formation of Scaffold

a) Forming Base structure

The most important part of any scaffold is base, it responsible for rigid structure and stability.

Starting phase is shown below

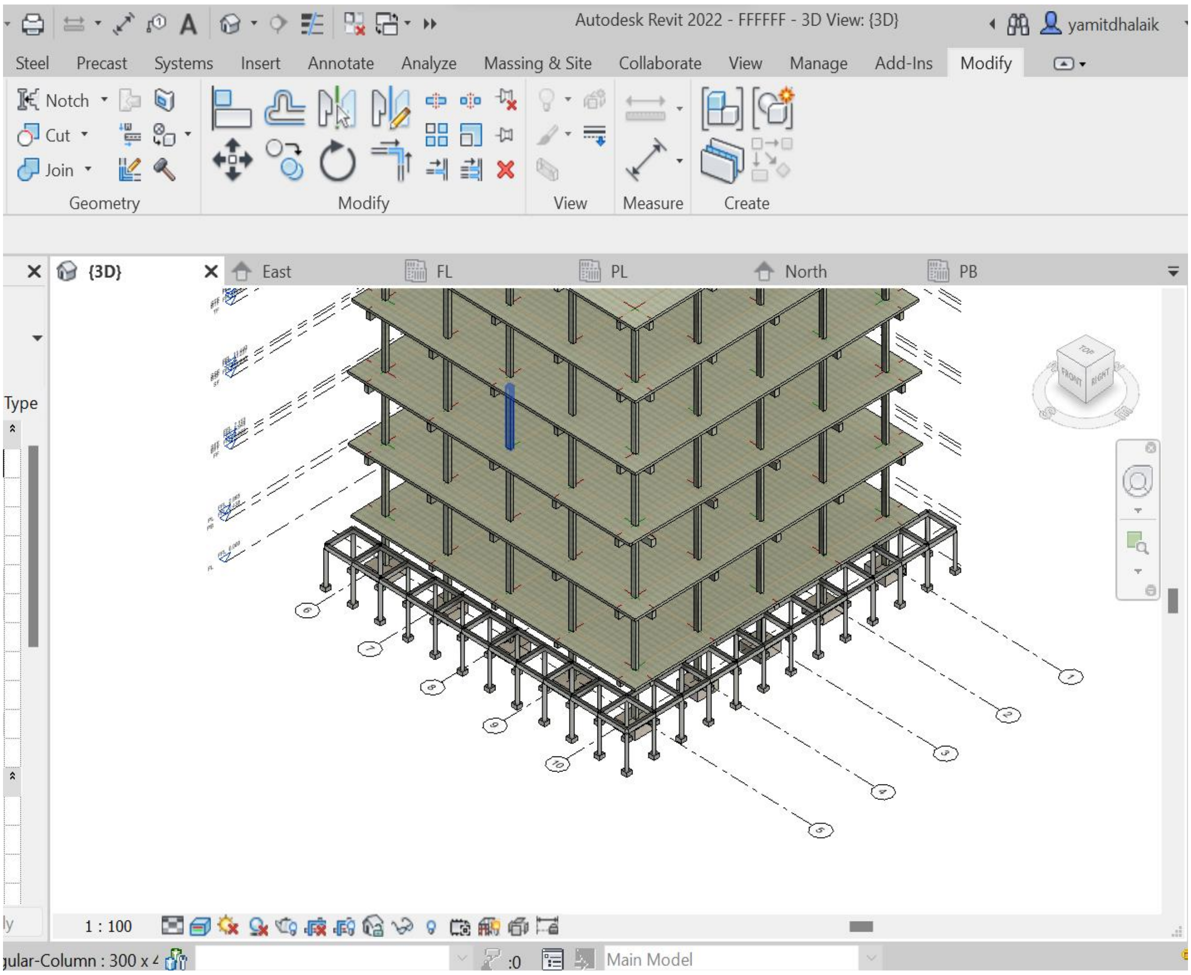

Fig. 5.21 Scaffolding

Base plates are firstly installed and the vertical ledgers accompanied by horizontal ledgers. After which boards are used.

For higher lengths of vertical member, diagonal braces are also given.

Same procedure is followed for whole structure.

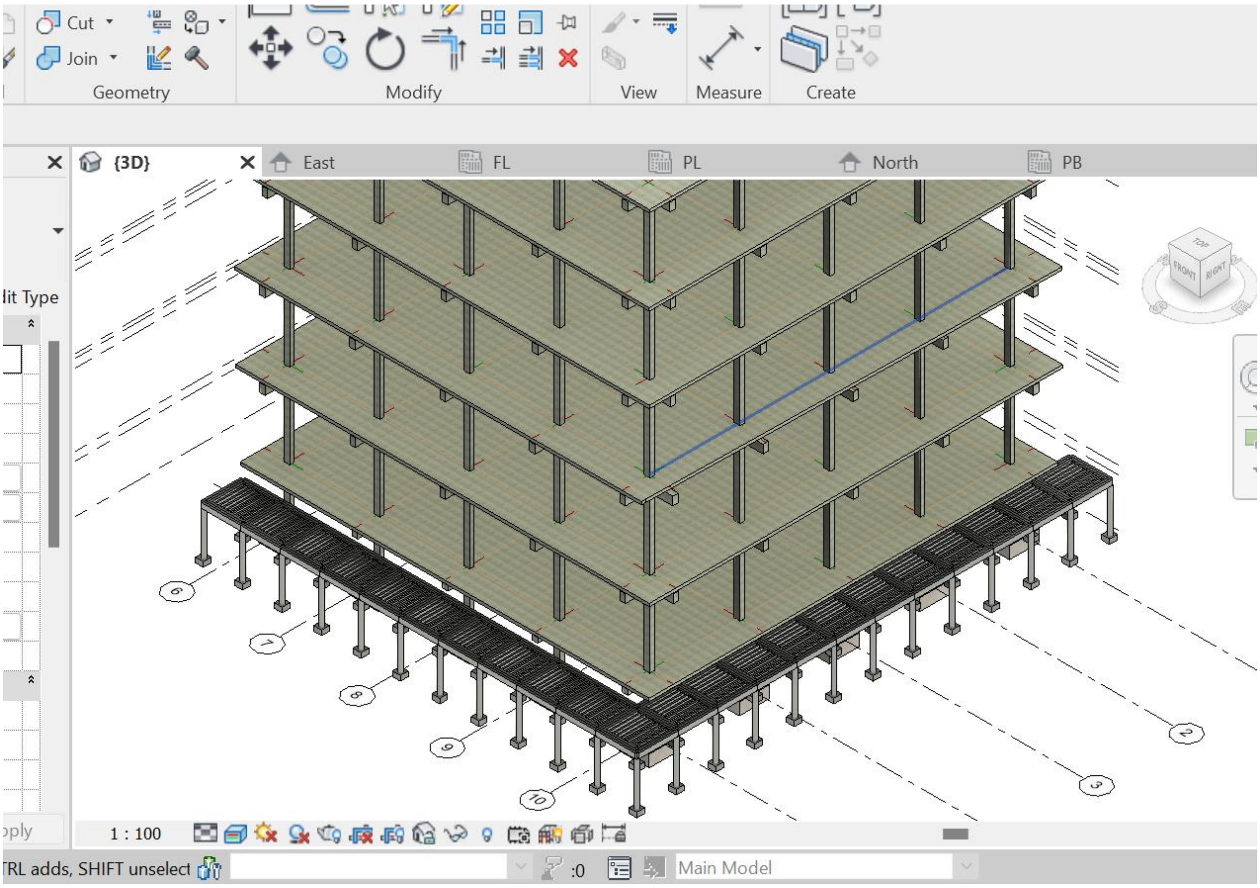

Fig. 5.22 Scaffold with board

b) Top structure

Top structure is followed in similar manner as-

1 Component

2 Model in Place

3 Generic model

4 Extrusion

5 select a component to make

6 set dimensions

7 Align

8 Copy for whole Level.

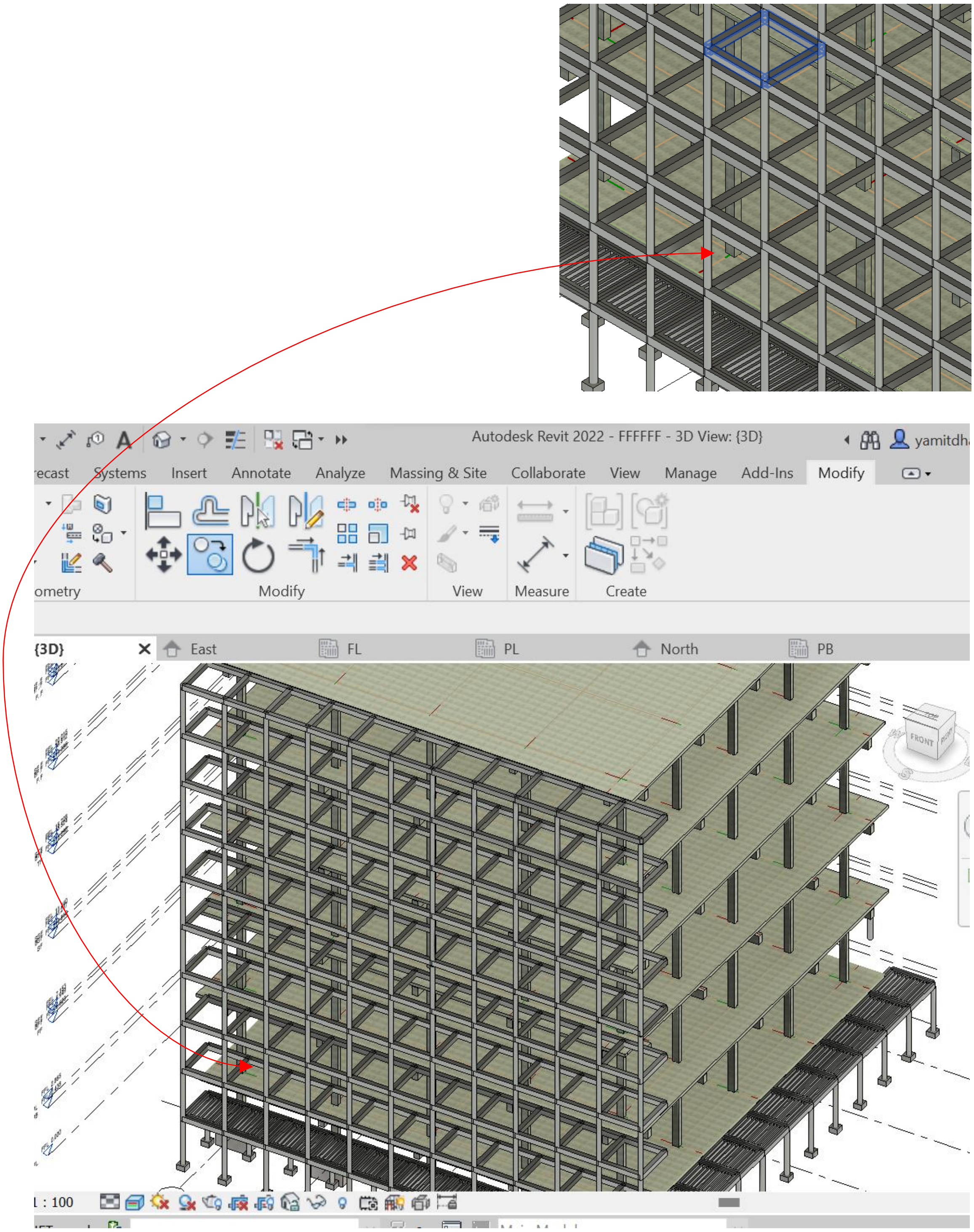

Fig. 5.23 Scaffold at one side

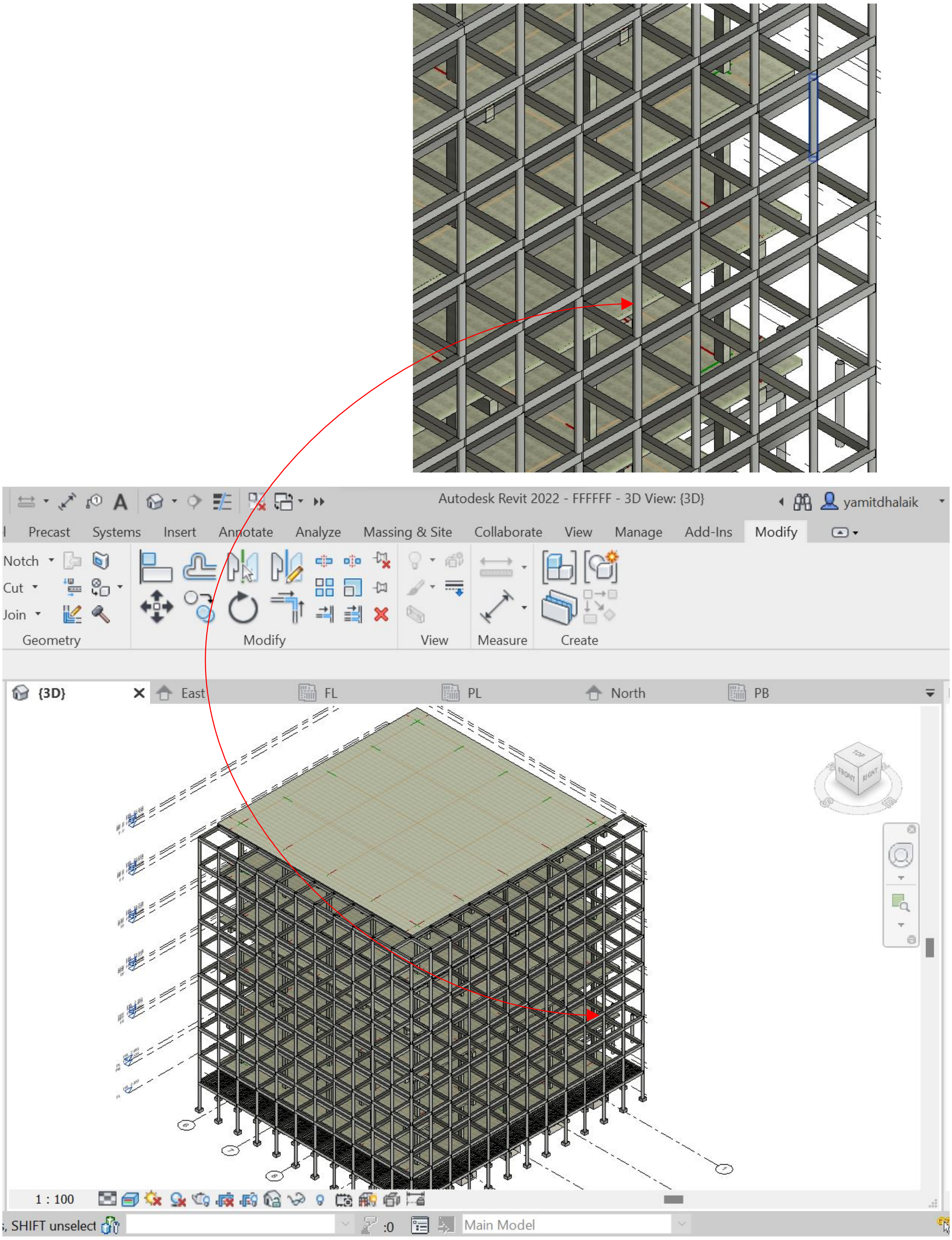

Fig. 5.24 Scaffold on both sides

5.3 Quantity Estimation

5.3.1 For Formwork

While concrete is ordered in volume, shuttering is ordered by area. In particular, the area that would be in direct touch with the concrete. This implies that computations will be made in square metres.

Multiply the perimeter / circumference of the structure by length or height of the structure to determine the area of formwork required to support the concrete installation. Each side of the concrete will require its own formwork calculation, with much more complicated or irregular shapes requiring more complicated computations.

The formwork or shuttering quantity for the member is measured as per the code of BIS – IS 1200:1982, Part 5- Method of Measurement of Building and Civil Engineering Works.

a) **Dimensions of Plywood:**

Length of plywood (L) = 4ft. = 1.22m

Breadth of plywood (B) = 8ft. = 2.438m

Thickness of Plywood= 12mm

Area of Plyboard = LxB

= 1.22x2.438 = **2.974m^2**

Area of Plyboard = 2.974m^2

b) **Estimation for Footings**

Square Footing:

Number of footings = 5x5 =25

Length of footing (L) = 5ft. = 1.524m

Breadth of footing (b) = 5 ft. = 1.524m

Depth of footing (D) = 2ft. = 0.610m

Shuttering Area (A) = 2x (L+B) x D

= 2x (1.524+1.524) x 0.610

= 3.719 m^2

Total Area = Shuttering Area x No. of Footings

= 3.719 x 25

= 92.975 m^2

Number of Plyboards Required = Total Area / Area of Plyboard

= 92.975 / 2.974

= 31.263

Note-

Allowable wastage here = 8% - 10%

Now,

No. of plyboards required = 31.263 + (10 x 31.263)/100

= 34.39

Number of Plyboards Required = 35 Numbers **...(**Roundoff)

c) Estimation for Plinth Columns

Length of Column (L) = 1ft. = 0.305m

Breadth of Column (B) = 9inches = 0.229m

Height of Column (H) = 8ft. = 2.438m

Shuttering Area (A) = 2x(L+B)xH

= 2x(0.305+0.229)x2.438

= 2.604 m^2

Total Area = Shuttering Area x No. of Columns

= 2.604 x 25

= 65.1 m^2

Number of Plyboards Required = Total Area / Area of Plyboard

= 65.1 / 2.974

= 21.889

Number of plyboards required = 21.889 + (0.1 x 21.889) =24.077

after allowable wastage

Number of plyboards required = 24.077

Number of Plyboards Required = **25 Numbers** (Roundoff)

d) Estimation for Slab and Beams

Total Length Slab = 72ft. = 29.946m

Width of Slab = 72ft. = 29.946m

Flat Area of Slab = 29.946 x 29.946

= 481.627 m^2 (Beam Bottom Included)

Length of Beam (L) = 15ft. = 4.572m

Breadth of Beam (B) = 9inches = 0.229m

Thickness of Beam (T) = 1ft.3inches = 0.381m

Note

For Beam side 25% to 30 % Of total Slab area is taken

Shuttering area = Slab Area + 30% for Beam Sides

= 481.627 + (0.3 x 481.627)

= 626.115 m^2

Number of Plyboards Required = Total Area / Area of Plyboard

= 626.115 / 2.974

= 210.52 Numbers

Number of plyboards required after = 210.52+(0.1 x 210.52)

Allowable wastage

= 231.594 Numbers

Number of Plyboards Required = 232 Numbers (Roundoff)

e) Estimation for Columns

Length of Column (L) = 1ft. = 0.305m

Breadth of Column (B) = 9inches = 0.229m

Height of Column (H) = 12ft. = 3.658m

Shuttering Area (A) = 2x(L+B)xH

= 2x(0.305+0.229)x3.658

= 3.907 m^2

Total Area = Shuttering Area x No. of Columns

= 3.9067 x 25

= 97.675 m^2

Number of Plyboards Required = Total Area / Area of Plyboard

= 97.675 / 2.974

=32.843 nos.

Number of plyboards required = 32.843+ (0.1 x 32.843) =36.127 after allowable wastage

Number of plyboards required = 36.127

Number of Plyboards Required = **37 Numbers** (Roundoff)

f) Estimation for Vertical Props

For Beam Bottom-

Beam bottom is 15% of Flat Area Spacing = 481.627 x 0.15

= 72.245 m^2

= 72.145/0.229

= 315.044

Placed at 600mm c/c Spacing

= 315.044 / 0.6

= 525.037 nos.

= 526 Numbers

For Slab-

Area = Flat Area of Slab- Beam bottom is 15% of Flat Area Spacing

= 481.627 – 72.245

= 409.382 m^2

Considering 900mm c/c Spacing

Area = 0.9 x 0.9

= 0.81

Numbers of Vertical props required = 409.382 / 0.81

= 505.409

= 506 Numbers

Total Vertical Props = 506 + 526

Total Vertical Props = 1032 Numbers

g) Estimation for Battens

For Beams and Slab-

Normal Size = (2” x 3” x 8’) OR (2” x 3” x 10’) Units in Inches and feet

Taking size = (2” x 3” x 8’) = (0.050 x 0.762 x 2.438)m

1 plyboard requires 7 number of battens

Number of Batten = No. of plyboards required for beams and slab x 7

= 232 x 7

= 1624 Numbers

Total CFT = 0.050 x 0.076 x 2.438 x 1624

= 15.045

1 cum = 35.31 CFT

= 15.045 X 35.31

= 531.239 CFT

For Footing-

Number of Batten = No. of plyboards required for beams and slab x 7

= 35 x 7

= 245 Numbers

Total CFT = 0.050 x 0.076 x 2.438 x 245

= 2.27

1 cum = 35.31 CFT

= 2.27 X 35.31

= 80.153 CFT

For Plinth Columns –

(3” x 4” x 8’) = (0.076 x 0.101 x 2.438)

Number of Batten = No. of plyboards required for Plinth columns x 7

= 25 x 7

= 175 Numbers

Total CFT = 0.076 x 0.101 x 2.438 x 175

= 3.274

1 cum = 35.31 CFT

= 3.274 X 35.31

= 115.64 CFT

For Columns-

(3” x 4” x 8’) = (0.076 x 0.101 x 2.438)

Area = 481.627 / 0.9

= 535.141 nos.

CFT = 0.076 x 0.101 x 535.141 x 2.438 x 35.3

= 353.518 CFT

h) Estimation for Nails

(2”, 3”, 4”)

Taken 3 kg to 4 kg per Plyboard = 0.35

For Footing = 0.35 x 35

= 12.25 Kg

For Plinth Column Part = 0.35 x 25

= 8.75 Kg

For Columns = 0.35 x 37

= 12.95 Kg

For Beam and Slab Area = 0.35 x 232

= 81.2 Kg

i) Estimation for Binding Wire

Taken 0.03 Kg per Square meter of Flat Area

For Footing = 92.975 x 0.03

= 2.79 Kg

For Plinth Columns = 65.1 x 0.03

= 1.953 Kg

For Columns = 97.675 x 0.03

= 2.930 Kg

For Slab and Beams = 626.115 x 0.03

= 18.784 Kg

j) Estimation for Shuttering Oil

Taken as 1ltr. For (12-15) m^2

For Footing = 92.975 / 12

= 7.747 lit.

For Plinth Columns = 65.1/ 12

= 5.425 lit.

For columns = 97.675 / 12

= 8.139 lit.

For beams and Slab = 626.115 / 12

= 52.176 lit.

5.3.2 For Scaffoldings

Standard scaffolding for residential use is 29 inches wide to fit through most doorways, although 54-inch double-wide scaffolding is also available.

The most usual scaffolding lengths are 4, 6, 8, or 10 feet, but if you need them longer, you may utilise extensions. Scaffolding comes in a variety of heights, but if you get over 16 feet, you'll need outriggers for added support.

Here we have Taken Double Scaffolding.

The lengths and heights of double scaffolding are comparable to those of single scaffolding; it's only broader. It's usually 54 inches broad, which makes it tough to go past doorways.

As a result, using double-wide scaffolding for a residential project would almost always be for outside work.

The greater width of the scaffold also provides for a larger load capacity and more manoeuvring area.

In this project we have used 8ft. Scaffolding and width as 8ft.

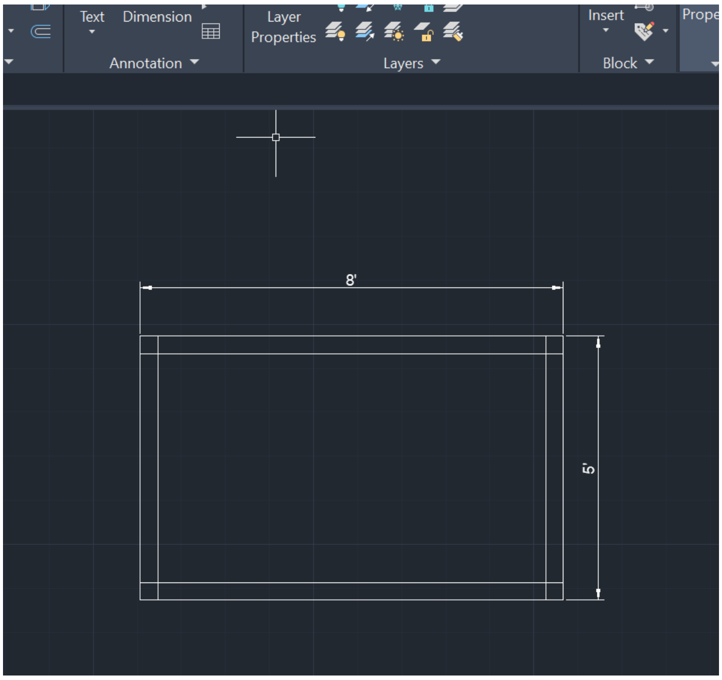

Fig 5.25 Top View Scaffold Dimensional view

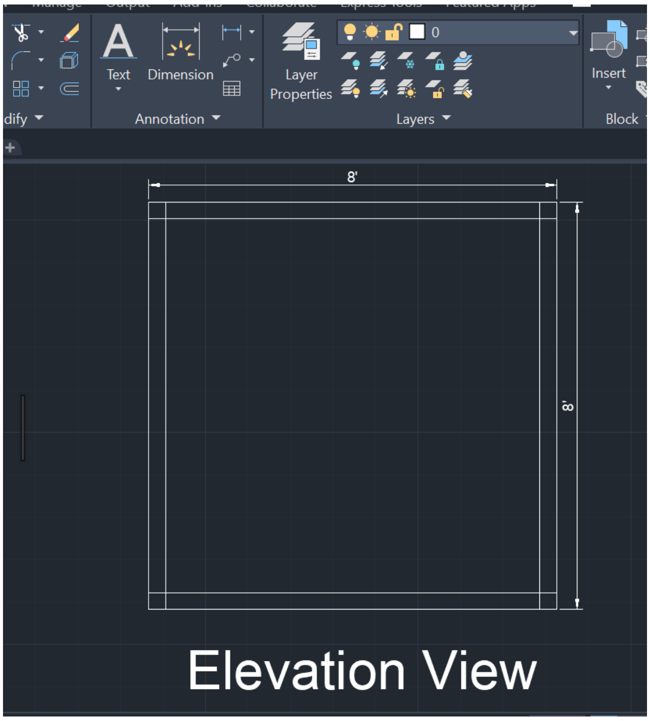

Fig 5.26 Front Elevation

a) **Estimation For Standard**

Standard required for 1 Floor = Length / Distance Between two Standards

= 72 / 8

= 9 Standards

Total No. of Standards = Standard required + 1

= 10 Numbers

For 5 Floors = 10 x 5

= 50 Numbers

b) **Estimation For Ledger**

Ledger required for 1 Floor = No. of Standards -1

= 10 - 1

= 9 Numbers

For 5 Floors = 9 x 5

= 45 Numbers

c) **Estimation For Transom**

Used 5ft Length

Number of Transoms = Number of Standards

For 5 Floors = 50 Numbers

d) **Estimation For Board**

Used 8’ x 5’ board

Number of boards = 9

For 5 Floors = 9x5

= 45 Numbers

Similarly for Other sides also

Same Number will be required

e) **Estimation For Clams and Couplers**

Used at every joints

Total clamps requires for 1 floor = 10

For 5 floors = 50 Numbers

CHAPTER 6

CONCLUSION

Formwork is generally used in concrete construction to sustain permanent concrete shaping and curing till the structure can sustain itself, and to support construction live loads.

The success of concrete projects depends on the proper design, planning, placement, and removal of formwork. However, concrete construction has a terrible safety record; concrete construction accounts for around a quarter of all building failures.

Furthermore, temporary work in the business has received little attention.

Worksite safety may be enhanced if designers put enough care into designing formwork or even other temporary structures, according to studies.

Construction is a vital aspect of India's growth and one of the country's most important industries. India's urban population is now the world's second biggest, and its continued growth will raise demand for housing. To address this issue, India must urgently prepare for land acquisition and speedy home construction.

Architectural planning, engineering, and construction are all aspects of construction. In a wooden system, the installation and takedown times are quite long. Steel formwork systems attain high levels of precision in their work, but because of their large weight, they require a crane for lifting, which takes time. They also provide contextual principles and methods for using BIM as a simple and engaging tool for calculating the 4D Schedule and 5D Cost of concrete formwork systems.

BIM enables easy delivery and better presentation, also enables better planning and scheduling.

For Scaffoldings also BIM has proved to be best option of all.

Scaffolding systems are necessary on construction sites to help workers transfer and position bulk goods and equipment. Traditional scaffolding design methods rely primarily on documentation, which has obvious drawbacks such as being less effective, reactive, and labour consuming. It's also worth noting that the restricted amount of design automation can lead to code-of-practice, design standards, workplace health and safety, and other difficulties. Given the benefits of BIM and the widespread adoption of BIM technologies throughout the construction project life cycle, including the design, construction, and operational phases, this study tentatively recommends a BIM-automated approach to minimize or remove the above said compliances in scaffolding engineering.

In order to improve robust scaffolding design and prevent from severe incidences, this study believes that BIM technology are promising to address those challenges, as demonstrated by BIM-based approach and case study to facilitate smarter and safer scaffolding design. At present, the prototype is awaiting to capture practical knowledge related to scaffolding construction and safety guidelines by encoding design configurations from different construction settings.

It provides decision-support by presenting user choices as explicitly-defined input parameters that allow the design intent and assumptions behind a particular scaffolding solution to be communicated amongst different project stakeholders, establishing a shared understanding of project-specific requirements and constraints.

Even with recent advances in Building Information Modelling (BIM), possible scaffold safety concerns must be manually recognised, and a small number of scaffold layouts must be constructed and reviewed. There is a need for innovation that aids with the decision-making process for generating safe scaffold plans in order to eliminate manual labour and potential human mistakes.

The conclusion also acknowledges that the advent of BIM has ushered in a new era of design, construction, facility management, and maintenance that is completely digital: using 3D graphical models to recreate a virtual and interactive site scene in which time, cost, and other associated dimensions could be easily added, monitored, and managed.

The created system creates several scaffolding layouts automatically and analyses them quantitatively in terms of safety, cost, and length. The framework was tested using a real-world building project and integrated in a BIM software package.

The test findings show that the suggested framework may help users effectively reduce scaffolding-related safety concerns while maintaining construction workflow efficiency, cost, and length.

6.1 Results from Quantity estimation

Table 6.1 Results Quantity estimation Formwork

	Footing	Beams and Slab	Plinth Columns	Columns	Total
Plyboards (Numbers)	35	232	25	37	**329**
Vertical Props (Numbers)	-	1032	-	-	**1032**
Battens (CPT)	80.153	531.239	115.64	353.518	**1080.55 =1081**
Nails (Kg)	12.25	81.2	8.75	12.95	**115.15 =116**
Binding Wire (Kg)	2.79	18.789	1.953	2.93	**26.462 =27**
Shuttering oil (Litre)	7.747	52.176	5.425	8.139	**73.487 =74**

For this Building We require 329 Plyboards, 1032 Vertical props, 1081 Battens, 116 Kg Nails, 27 Kg Binding Wires and 74 Litres Shuttering Oil.

Similarly for Scaffold we require 50 Standard (8ft.), 50 Transom (5ft.), 45 Ledgers and 45 Boards (8' x 5').

And if we wish to work on 2 sides simultaneously, we require 100 Standard (8ft.), 100 Transom (5ft.), 90 Ledgers and 90 Boards (8' x 5').

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