# Efficient Design for Multi-story Building Using Pre-Fabricated Steel Structure by Integrating It with BIM Application

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**Abstract -** *Pre-fabricated steel structures used in a construction of buildings to overcome the problems like natural hazards, wastage, safety and to improve the productivity through saving cost and time. In this adequate structural design and effective manufacturing are both integral process for the efficient steel structure. The steel structure design significantly reduces the overall cost, increase the safety, sustainability, productivity and reduces the construction time. The use of Building Information Modelling (BIM) in this structure increases the product quality and this also provide the accurate quantity to take off and improve the scheduling and provide cost saving techniques. BIM helps to represents the different dimensions like 2D, 3D, 4D & 5D models to stimulate the planning, design, construction, and operation. It helps AEC (Architects, Engineers & Constructors) to visualize what is to be built in stimulated time and identify the operational problems. So, the project report extends us to know the designing of the pre-fabricated steel structure using Indian Standard Code in the STAAD.pro software for structural analysis, for 2-Dimensional plan Autodesk's AutoCAD software is used and to represent the drawing in 3-dimensional Autodesk's Revit software is used and later for the 4 Dimensional i.e., scheduling of the works is done in Autodesk's Navisworks in this time management is done and clashes were also detected. This BIM application made the work easy during the construction and avoid the delay and proper management is done due to which there is no conflict of interest between the Client & Contractor.*

***Key Words*: BIM, Pre-fabricated steel, Navisworks, AEC, Scheduling, Clash Detection.**

## 1.INTRODUCTION

### 1.1 Prefabricated Steel Structure

A Prefabricated steel structure is basically a structure that is made up of steel. These structures are engineered at the factory and get assembled at the site. In prefabricated steel structure construction framing will be fabricated completely at the factory and transported to the site for the assembling.

Multi-storied steel structure is typically fabricated with the structural frames which are fabricated out of steel. It consists of columns and beams which are customized with respect to the building and most of the nodes are rigidly connected. The frame structure is the most common among the steel structured multi-storied building. The frame structure is the typically vertical load bearing structure.

### 1.2 Building Information Modelling

Building information modeling is the digital prestation of physical and functional characteristics of the building. BIM integrates the structured and multi-disciplinary data for the assistance throughout the lifecycle i.e., from planning, designing to construction and operations (AEC-Architect, Engineering & Construction industry).

The concept BIM was first started in late 1970s. The software tools emerged during late 1970s and early 1980s for the modeling buildings were GLIDE, RUCAPS, SONATA, ArchiCAD, REFLEX & GABLE 4D Series. The term BIM was first used in the papers in 1985 by Simon Ruffle. BIM is officially recognized by international standard in 2013 by giving an ISO code ISO- 16739 and later in 2019 depending on the UK papers ISO published series as ISO-19650.

In India IBIMA (India Building Information Modeling Association) is a national level society which represents the entire BIM community. In India due to population growth and economic growth there is expand in the construction market. Indian government officials gave a statement that BIM could save around 20% of the construction time and give a scope for the wider infrastructure development.

It was observed that due to increase in the population and demand in the infrastructure development today there is a big fault line due to which AEC (Architect, Engineering and Construction) community are unable to full fill the demand on time. The fault lines might be due to the budget constraints or also might be because of the availability of the area etc. So, we need to design the structure in more efficient way like budget friendly, good utilisation of space and reducing the construction time with good durability of the structure.

## 2. METHODOLOGY

This project provides the information and demonstration of the designing of the five-story steel building i.e., prefabricated steel structure for the multi-purpose work space and understanding how BIM (Building Information Modelling) can be utilised in the building design to make the building more efficient. The plot area considered for the construction of the building is 100 x 60 meters i.e., 6000 sqmt of plot area. The methodology considered in this project is firstly we design the building and integrate it with BIM. The basic stages involved in this are:

- First stage the building planning is done through AutoCAD software and the structural design is also done in this level only, through Staad Pro V8i software, sections are designed and analysed through which we get the structural stability of the building.
- Second stage after knowing the plan, section, and structural design of the building the 3D model of the building is created in Revit architecture software and for the structural member the Revit structure software can be used.
- Now in third stage the 4D modeling of the building is done i.e., time management through the software called Autodesk Navisworks.

The design codes are to be used as per the Indian standards:

- IS 875 – Code of Practice for Design Loads
- IS 1893 – Criteria for Earthquake Resistant Design of Structures
- IS 800 – General Construction in Steel
- Building Bye-Laws 2017 – Government of Karnataka

## 3. MODELLING & DESIGN PROPERTY

3.1 Geometrical properties:

| Sl. No | Parameters | Specification |
|---|---|---|
| 1. | Type of structure | Shopping Complex. |
| 2. | Number of storeys | Stilt + 4 Story |
| 3. | Plot Size | 100 x 60 m |
| 4. | Size of the building | 88.46 x 44.46 m |
| 5. | Height of Floors | 3.3m |
| 6. | Height of the Building | 16.5 m |
| 7. | Walls | 230mm thick brick wall |
| 8. | Size of Steel Beam and Column | IW 550400x1632 &<br>IW 550400x2040 |
| 9. | Thickness of slab | 150mm |
| 10. | Material | Steel, Concrete, Aluminium |
| 11. | Loads | Indian Standards |
| 12. | Soil type | Hard Soil |
| 13. | Seismic Zone | Zone II |

**Table 1** *General Properties*

3.2 AutoCAD 2-Dimensional Drawings

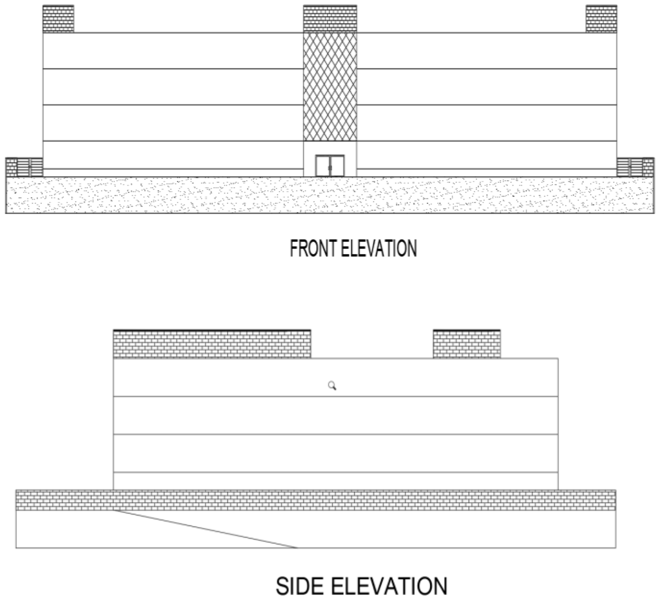


**Fig. 1** *Elevations of the Structure*

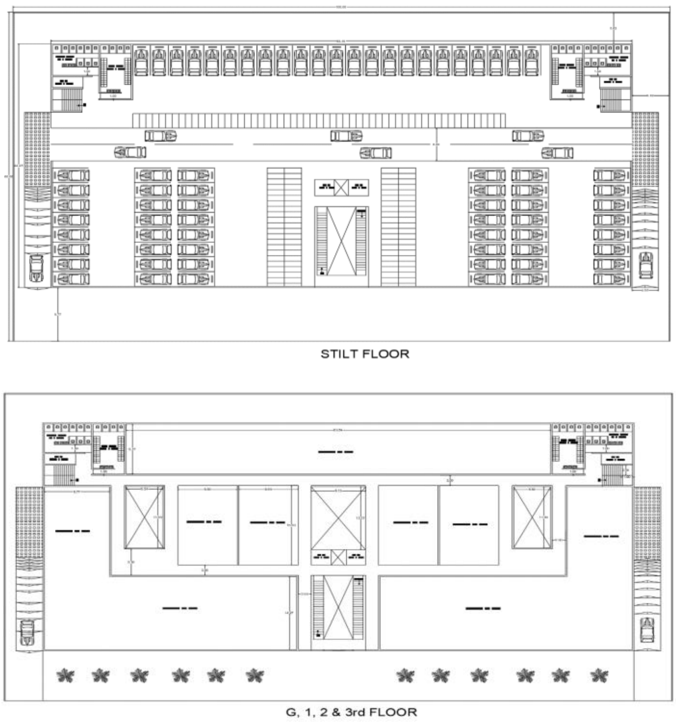


**Fig. 2** *Floor Plan of the Structure*

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## 4. STRUCTURAL DESIGN AND ANALYSIS IN STAAD.PRO

### 4.1 Introduction to Staad.Pro

The structural analysis programme STAAD.PRO is renowned for its analysis, variety of applications, compatibility, and time-saving features. In order to perform 3D structural analysis and design for both steel and concrete structures, structural engineers use STAAD.

An analytical model for structural analysis can be built from a physical model created in the structural design programme. To ensure that the structural design complies with local laws, STAAD incorporates a number of design code standards.

### 4.2 Designing and Analysis Procedure in Staad.Pro

1. Open STAAD.Pro V8i Software the select the space option the select the length sppecification meter and kilonewton then select next and finish option
2. Job Information is created for the specified
3. Modelling is done by adding and joing nodes with respect to the distance and shape of the building later joined it with beam option from the top toolbox and layered to different floors and keeping in mind of providing the expansion joint.
4. Now add plate section to each floor as the slab, for that go select the 4 node plate option from the top tool box later select the plate cursor then draw the plate for all the floor.
5. Now to assign the section data base for the beam and column go to general and select the property the select the section database there select the steel column and go to Indian select the w section and specify the beam and column specifications and add it.
6. Now to select the thickness and add slab thickness od 150mm i.e 0.15 then click on add
7. Now associate all the beams, columns and slab to the members and render to see the steel building.
   For the following steel building the specification is given:
   Beams = IW550400x1632 (Steel)
   Columns = IW550400x2040 (Steel)
   Plate = 150mm (Concrete)
8. Now to give a support go the general and select support and select create support select the fixed support select ok the add the support to the structure.
9. Now to add the Loads go to general and select the Loads and Definition select the load case details add Dead Load, Live Load, Wall Load & Select Autoload Combination for the other loads.
   Dead Load = Self weight -1 KN/$m^2$
   Live Load = 5 KN/$m^2$
   Wall Load = 5.37 KN/$m^2$
   Load Combination
10. Now to add materials go to general and select the materials and assigned materials will be observed if not assign it.
11. Now to do the analysis go to Analysis/Print option click on apply and go to post processing here we can observe the displacement, reactions of nodes and forces, stresses of beam and contour of plates.
12. Now need to design the steel and concrete member to do that go to modelling and select the design and choose the steel member, change the code to the Indian standards i.e IS 800 2007 LSD and select the parameters I.e Track & Yield Strength of 550000kn/$m^2$ and define the parameters to the steel members and give the command of check code, member take off, select & take off. Now assign the steel members i.e beams and columns for all the parameters.
13. Now choose concrte design and select the IS 456 and select the parameters of Clear cover, Compressive strength & Yield strength and define parameters of 0.025m, 30000kn/$m^2$ & 550000kn/$m^2$ repectiviely now go to command and select design elemets and take off after assign the slabs.
14. Now select Analysis/Print option and click on apply and later run analysis and go to post processing and check for the output file

### 4.3 Output of the design and analysis in Staad.pro

All Relative Displacement | Max Relative Displacements

| Beam | L/C | Length m | Max x mm | Dist m | Max y mm | Dist m | Max z mm | Dist m | Max mm | Dist m | Span/Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 111 | 1 DEAD LOA | 10.000 | 0.001 | 8.333 | -0.002 | 6.667 | -0.000 | 0.333 | 0.002 | 6.667 | >10000 |
| | 2 LIVE LOAD | 10.000 | 0.001 | 9.167 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 9.167 | |
| | 7 WALL LOA | 10.000 | 0.001 | 9.167 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 9.167 | |
| | 3 GENERATE | 10.000 | 0.001 | 8.333 | -0.003 | 5.833 | -0.000 | 0.333 | 0.004 | 5.833 | >10000 |
| | 4 GENERATE | 10.000 | 0.001 | 8.333 | -0.002 | 4.167 | -0.000 | 0.333 | 0.002 | 4.167 | >10000 |
| | 5 GENERATE | 10.000 | 0.001 | 8.333 | -0.003 | 4.167 | -0.000 | 0.333 | 0.003 | 4.167 | >10000 |
| | 6 GENERATE | 10.000 | 0.001 | 8.333 | -0.002 | 5.833 | -0.000 | 0.333 | 0.002 | 5.833 | >10000 |

**Fig. 3** *Maximum Relative displacement in Beam 111 of the Structure*

All | Summary | Envelope

| | Beam | L/C | Node | Fx kN | Fy kN | Fz kN | Mx kNm | My kNm | Mz kNm |
|---|---|---|---|---|---|---|---|---|---|
| Max Fx | 47 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 47 | **232.24417E** | -79.004 | 493.422 | 0.378 | 3386.609 | -8286.664 |
| Min Fx | 93 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 112 | **-913.184** | 6911.526 | -22.827 | 3.268 | 154.243 | -18753.756 |
| Max Fy | 779 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 347 | 2961.802 | **18908.877** | 629.442 | -16.679 | -811.339 | -961.727 |
| Min Fy | 787 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 356 | 2937.755 | **-18924.730** | -618.981 | 16.886 | -788.825 | -930.093 |
| Max Fz | 640 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 277 | 56828.035 | -352.441 | **2761.752** | -0.261 | -2282.389 | 4541.117 |
| Min Fz | 601 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 238 | 45427.098 | 1481.676 | **-2437.227** | 0.076 | 1664.765 | -9272.342 |
| Max Mx | 947 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 448 | 2351.231 | 15537.755 | 670.274 | **65.970** | -4925.699 | 2874.899 |
| Min Mx | 890 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 441 | 2351.691 | 15549.119 | -688.685 | **-66.740** | 5056.450 | 2874.825 |
| Max My | 58 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 130 | 139.15545E | 191.102 | 1445.844 | 0.283 | **17507.049** | -13403.118 |
| Min My | 8 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 80 | 94176.156 | -964.880 | -1692.885 | -0.918 | **-19764.906** | 67549.125 |
| Max Mz | 14 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 86 | 155.88653E | -691.429 | 251.028 | -0.161 | 3750.443 | **96091.844** |
| Min Mz | 38 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 110 | 155.89503E | 687.508 | 247.207 | 0.134 | 3765.274 | **-96443.000** |

**Fig. 4** *Summary of Forces acting on Beams*

| | | | Shear | | Membrane | | | Bending Moment | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Plate | L/C | SQX (local) N/mm2 | SQY (local) N/mm2 | SX (local) N/mm2 | SY (local) N/mm2 | SXY (local) N/mm2 | Mx kNm/m | My kNm/m | Mxy kNm/m |
| Max Qx | 1060 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 0.002 | 0.000 | -0.018 | -0.014 | -0.001 | -0.546 | 2.016 | 0.001 |
| Min Qx | 1061 | 2 LIVE LOAD | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | 0.019 | 1.158 | 0.000 |
| Max Qy | 1065 | 2 LIVE LOAD | -0.000 | 0.000 | -0.000 | -0.000 | 0.000 | -1.159 | -0.019 | 0.000 |
| Min Qy | 1029 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 0.000 | -7.123 | 0.001 | 0.000 | 0.000 | -181.625 | -1068.384 | 0.000 |
| Max Sx | 1023 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | 0.000 | 0.006 | 0.006 | 0.001 | -0.002 | -0.002 | 0.000 |
| Min Sx | 1062 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | -0.000 | -0.042 | -0.020 | -0.021 | 0.003 | 0.003 | 0.001 |
| Max Sy | 1007 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | 0.000 | 0.006 | 0.006 | 0.000 | -0.001 | -0.001 | -0.000 |
| Min Sy | 1063 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | 0.000 | -0.022 | -0.041 | 0.021 | -0.004 | -0.004 | 0.001 |
| Max Sxy | 1063 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | 0.000 | -0.022 | -0.041 | 0.021 | -0.004 | -0.004 | 0.001 |
| Min Sxy | 1062 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | -0.000 | -0.042 | -0.020 | -0.021 | 0.003 | 0.003 | 0.001 |
| Max Mx | 1017 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | -0.066 | 0.001 | 0.001 | 0.000 | 0.378 | -0.206 | 0.000 |
| Min Mx | 1029 | 5 GENERATED INDIAN CODE GENRAL_STRUCTURES 3 | 0.000 | -7.123 | 0.001 | 0.000 | 0.000 | -181.625 | -1068.384 | -0.000 |
| Max My | 1060 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 0.002 | 0.000 | -0.018 | -0.014 | -0.001 | -0.546 | 2.016 | 0.001 |
| Min My | 1029 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 0.000 | -7.123 | 0.001 | 0.000 | 0.000 | -181.625 | -1068.384 | 0.000 |
| Max Mxy | 1058 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 0.000 | -0.000 | -0.006 | -0.006 | -0.011 | -0.000 | -0.000 | 0.005 |
| Min Mxy | 1006 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.000 | 0.000 | 0.001 | 0.001 | -0.005 | -0.000 | 0.000 | -0.002 |

**Fig 5** *Summary of Shear, Membrane & Bending Force of plates*

| | | | Principal | | Von Mis | | Tresca | |
|---|---|---|---|---|---|---|---|---|
| | Plate | L/C | Top N/mm2 | Bottom N/mm2 | Top N/mm2 | Bottom N/mm2 | Top N/mm2 | Bottom N/mm2 |
| Max Principal (top) | 1060 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | 0.524 | 0.128 | 0.622 | 0.625 | 0.687 | 0.680 |
| Min Principal (top) | 1029 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -284.902 | 48.434 | 264.039 | 264.039 | 284.902 | 284.902 |
| Max Principal (bottom) | 1029 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -48.433 | 284.902 | 264.039 | 264.039 | 284.902 | 284.902 |
| Min Principal (bottom) | 1060 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -0.163 | -0.552 | 0.622 | 0.625 | 0.687 | 0.680 |
| Max Von Mis (Top) | 1029 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -48.433 | 284.902 | 264.039 | 264.039 | 284.902 | 284.902 |
| Min Von Mis (top) | 1042 | 7 WALL LOAD | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Max Von Mis (Bottom) | 1055 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -48.434 | 284.902 | 264.039 | 264.039 | 284.902 | 284.902 |
| Min Von Mis (bottom) | 1042 | 7 WALL LOAD | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Max Tresca (top) | 1029 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -48.433 | 284.902 | 264.039 | 264.039 | 284.902 | 284.902 |
| Min Tresca (top) | 1042 | 7 WALL LOAD | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Max Tresca (bottom) | 1029 | 3 GENERATED INDIAN CODE GENRAL_STRUCTURES 1 | -48.433 | 284.902 | 264.039 | 264.039 | 284.902 | 284.902 |
| Min Tresca (bottom) | 1042 | 7 WALL LOAD | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Fig 6** *Summary of Principal & Von mis values of plates*

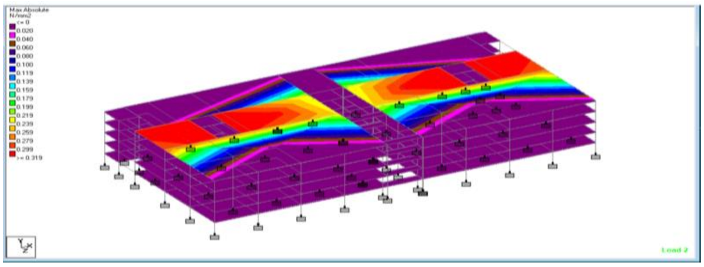

**Fig 7** Max Absolute value of Live Load in Plate

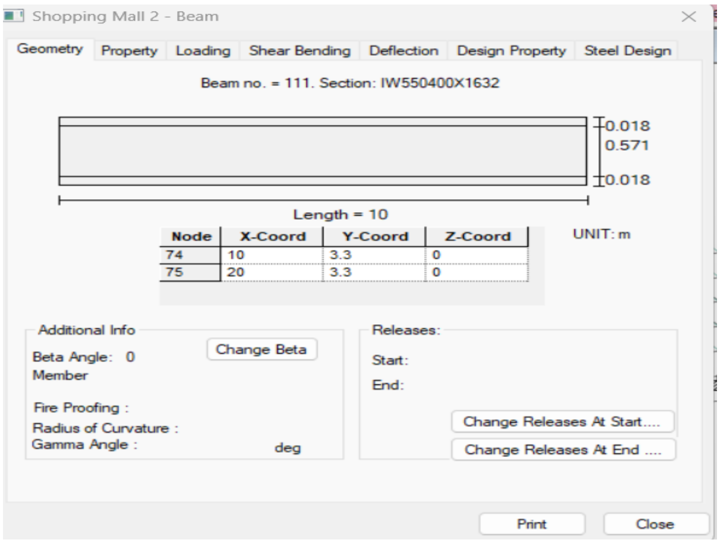


**Fig 8** *Geometry of Beam 111*

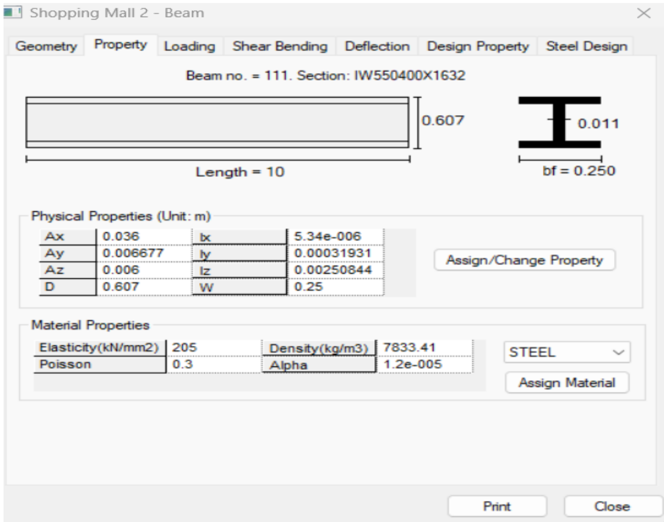


**Fig 9** *Property of Beam 111*

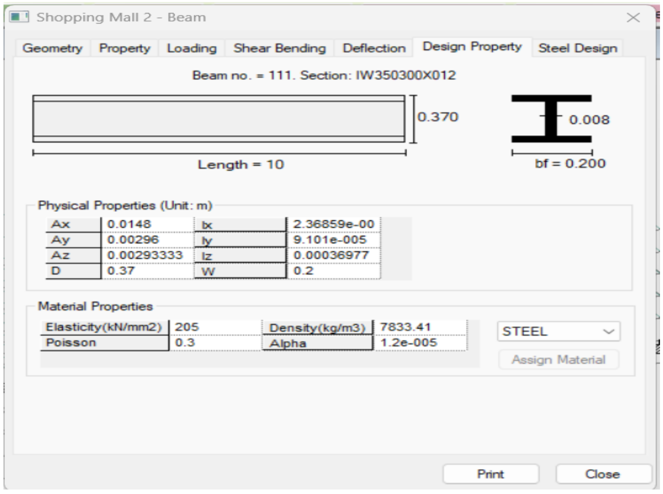


**Fig 10** *Design Property of Beam 111*

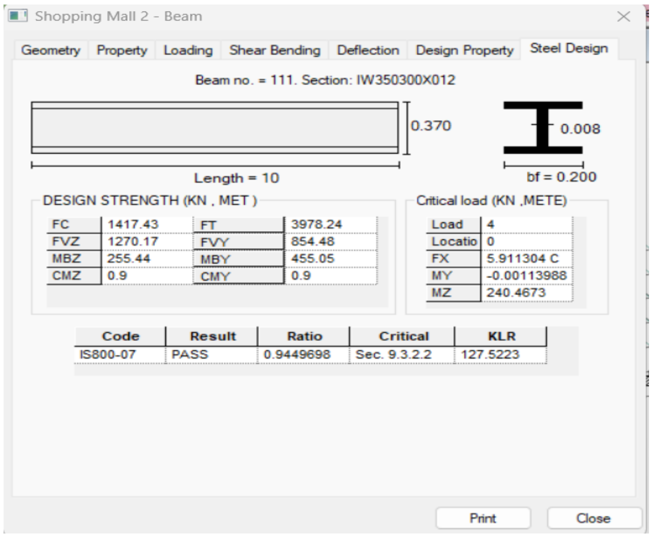


**Fig 11** *Steel Design of Beam 111*

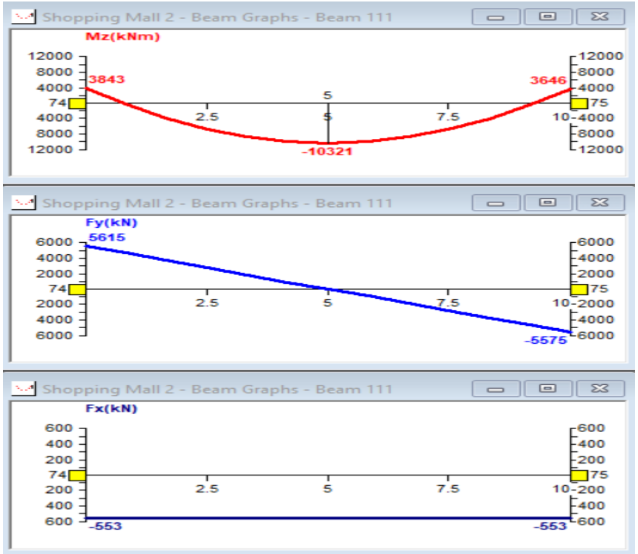


**Fig 12** *Beam Graphs of Beam 111*

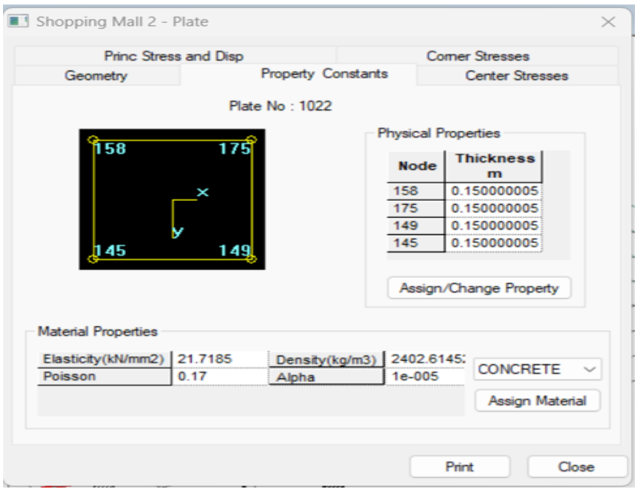


**Fig 13** *Property Constants of Plate 1022*


**Fig 14** *Geometry of Plate 1022*

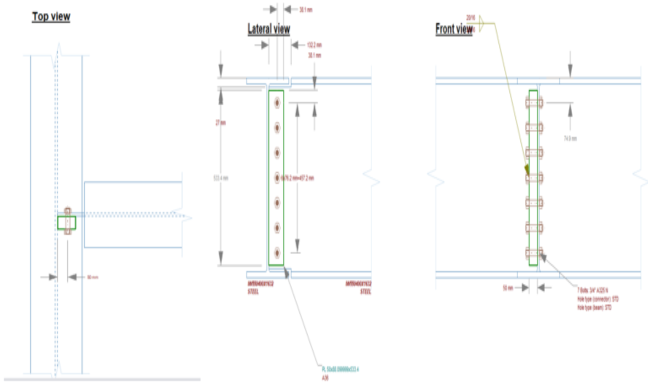


**Fig 15** *Connections of Joints*

## 5. 3- DIMENSIONAL DESIGN IN AUTODESK REVIT

### 5.1 Introduction to Autodesk Revit

For structural engineers, mechanical, electrical, and plumbing (MEP) engineers, designers, and contractors, Autodesk Revit is a building information modelling programme. Charles River programme, a 1997 startup that changed its name to Revit Technology Corporation and was later acquired by Autodesk in 2002, was the company that created the initial programme. The programme enables users to create a building and all its parts in 3D, add 2D drafting elements to the model, and retrieve building data from the building model's database.

### 5.2 Designing Procedure in Autodesk Revit

- Start the Autodesk Revit application and select the templet insert the Autodesk AutoCAD drawing file through going to the inset option in the tool bar and insert the file.
- Create the different Levels by going to elevation and there will get the insert level option in the tool bar and place it at the different levels of building
- Draw the walls along the plan and give the properties to the wall for 6 inch and 9-inch wall and go to the tool bar and place the doors and windows
- Now go to the circulation in the tool bar and draw the staircase path by selecting the type and boundary and pathway.
- Now select the flooring from tool bar and draw the boundary of flooring and enter which kind of flooring by changing the properties.
- Draw the same things to all the rest of the floors and mention the things and later select the ceiling from the tool bar draw the boundary of ceiling and apply the property.
- Now place the lighting, furniture, and plumbing works to all the floors by going to components and loading library then placing it in required places.

- Now go to the view place topography and give the angle for the camera to visual representation of the drawing.
- For the walkthrough option go to the view and select the 3D option from the menu bar and draw the pattern of the walkthrough and exit later render it and export.

### 5.3 Output of the Design in Revit

**Fig 16** *Front view of the model without and with rendering in revit*

**Fig 17** *Angular view of the model without and with rendering in revit*

## 6. 4-DIMENSIONAL DESIGN IN AUTODESK NAVISWORKS

### 6.1 Introduction to Autodesk Navisworks

In this user can evaluate 3D designs using Navisworks. Users of Navisworks can open and combine 3D models, navigate through them in real-time, and review the model using a variety of tools including comments, redlining, viewpoints, and measurements. Navisworks is primarily used in the architecture, engineering, and construction (AEC) industries as a complement to 3D design packages (such as Autodesk Revit, AutoCAD, and MicroStation). Interference detection, 4D time simulation, photorealistic rendering, and PDF-like publication are some of the plug-ins that improve the program.

### 6.2 Designing Procedure in Autodesk Navisworks

- Save the file in NWC file in the 3D modelling software and open it then it creates the cache of Navisworks later save the file in NWF so that to carry on the further usage.
- The General user interface screen opens to carry out the work of 4D modeling and the 3D Model will appear
- Now for the 4D Modelling i.e., scheduling and time management go to the TimeLiner option in the toolbar of the screen and click on it the interface pops on screen
- Now schedule the items from the selection tree and select the date and time of the work which start and end.
- Now to check the clash detectivity go to the toolbar select the clash detection option and later the sub screen pops up and select the structure and run the test. It will detect t the number of works which may overlap and shows the tolerance level and status of difficulty in the progress of work.
- Now go to the simulate and create the animations and sections later export it to BIM360 and share

### 6.3 Output of the Design in Navisworks

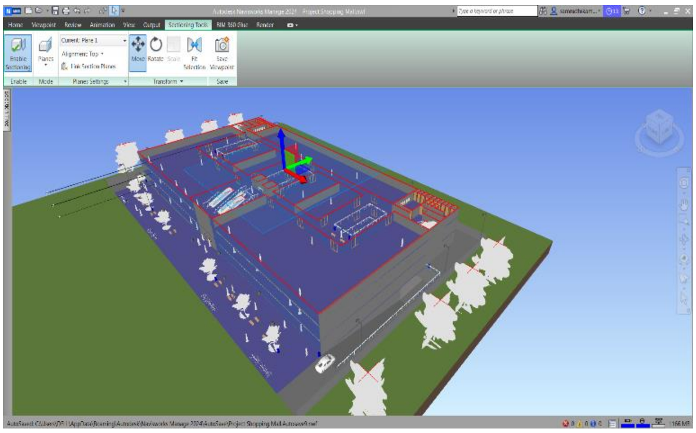

**Fig 18** *Section view from top in Navisworks*

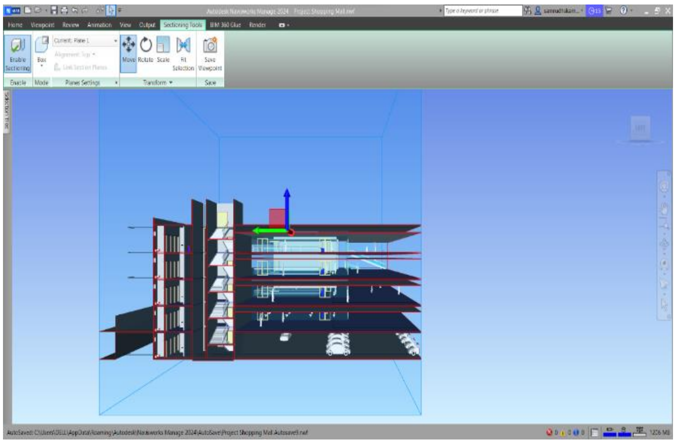

**Fig 19** Section view from side in Navisworks

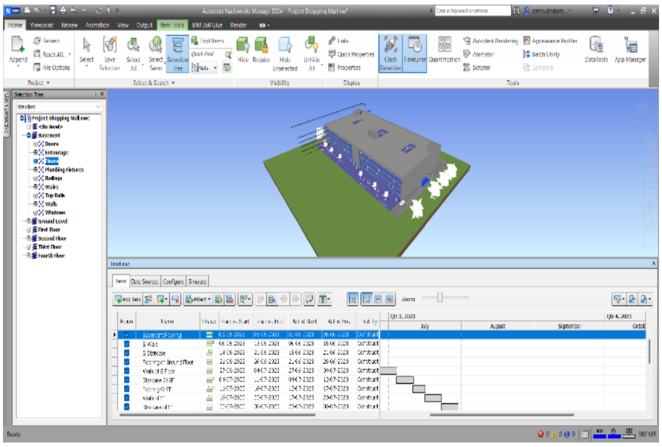

**Fig 20** *Assigning the Items to Schedule*

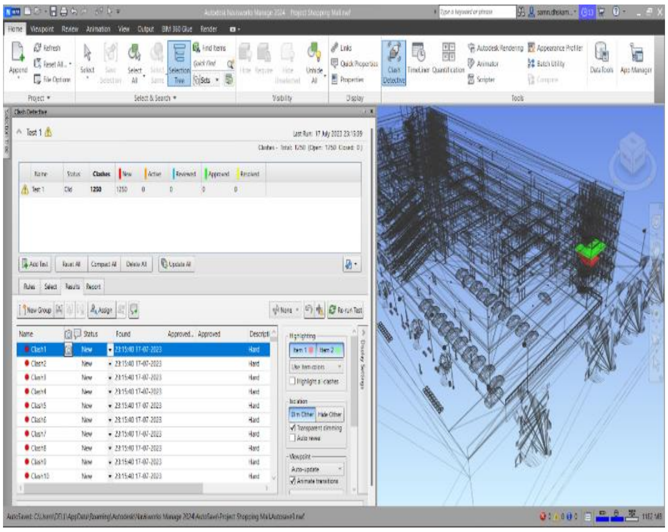

***Fig 21*** *Clash Detection Test*

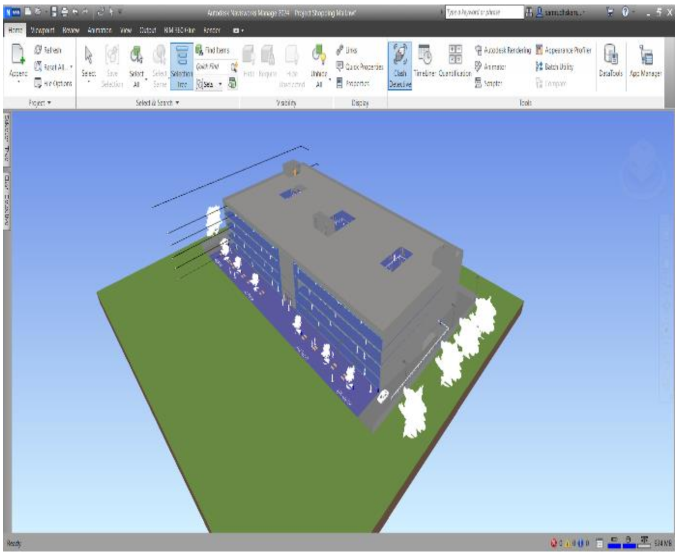

**Fig 22** *View of the Navisworks*

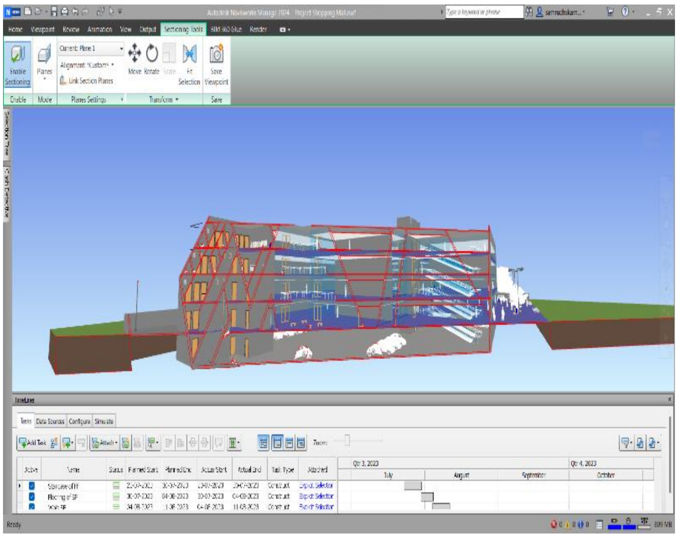

**Fig 23** *Section view Through Angular Rotation in Navisworks*

## 7. OBSERVATION AND DISCUSSIONS

### 7.1 Importance of BIM in AEC Industry

In this it was noted that how BIM helped for digitalized documentation at the pre-construction stage. Also, with this it was noted that BIM reduced the construction time, cost, and compressive checks. It was noted that the error during the construction phase has drastically reduced because of the pre visualisation of the model, simulation of the model and detectivity of the clashes. BIM also keeps the information of all the phases of the project, status of the work and continuity off work. All the team members of that project can access to work irrespective of place where they are, due to which the management and coordination will be great during the construction phase which also reduces the wastage. In this project the 2D, 3D, 4D modelling is done and structural analysis is also done to specify the stability and visualization of the building.

## 7.2 Modelling and Design Properties of the Building.

In this phase of project, the kind of the building was decided to design and got to conclusion that the prefabricated steel structure could be used for the building, it was noted from the literature survey the usage of pre-fabricated steel in the building is more efficient as compared to conventional concrete for beams and columns. By using the prefabricated steel structure, the utility space will also increase and the construction cost and construction time of the building will be reduced. The building is for commercial usage i.e., Shopping Mall complex so the norms for the building design is done with respect to the building bylaws of Karnataka Urban Development Authority. The building is of Stilt + 4 Floors so while designing this building it was considered of the specification of commercial building and designed accordingly for example the passage should be given with the width of 2 meters, provisions of stair case and elevators respectively and provisions of the washrooms and ventilations, many more safety precautions.

## 7.3 Analyzing the Structural Properties of the Building.

In this phase of the project structure of the building is analysed, it was noted that the structural properties are designed with respect to the Indian standards and critical values are taken into consideration for beams and columns of steel to design. The structural analysis and design are done in Staad.pro software which made a to understand the Relative displacement, Forces acting on Beams and Plates, Stresses acting on Beams and Plates, Maximum absolute value of Loading, General Properties, Design Properties, Shear Bending, Steel Design, Moment Connections and Shear Connections many more. In this software the design is done in such a way the structural member should be more efficient for example, by taking the Member-1 details in the analysis part the given property was at the higher node and steel value was also higher but after performing Design analysis the steel value of the same member is designed according the load combination and the quantities are calculated the results page are like,

```
 STAAD SPACE                                            -- PAGE NO.    9

                  STAAD.PRO CODE CHECKING - IS-800-2007-LSD (V2.0)
                 ***************************************************

|-----------------------------------------------------------------------------|
|  Member Number:      1                                                      |
|  Member Section:  ST   IW550400X2040   (INDIAN SECTIONS)                    |
|  Status: PASS  Ratio:   0.456  Critical Load Case:     4  Location:     3.30 |
|  Critical Condition: Sec. 9.3.2.2                                           |
|  Critical Design Forces:  (Unit: KN    METE)                                |
|      FX:       6.903E+03 C     FY:    -26.235E+00      FZ:    -17.886E+00   |
|      MX:     527.636E-06       MY:    -40.416E+00      MZ:     71.846E+00   |
|-----------------------------------------------------------------------------|
|  Section Properties:     (Unit:  CM  )                                      |
|  AXX:     398.000E+00          IZZ:    288.011E+03          RZZ:   26.901E+00|
|  AYY:      68.090E+00          IYY:     35.207E+03          RYY:    9.405E+00|
|  AZZ:      90.000E+00          IXX:    909.000E+00           CW:    4.233E+06|
|  ZEZ:       9.306E+03          ZPZ:      9.666E+03                          |
|  ZEY:       2.817E+03          ZPY:      2.982E+03                          |
|-----------------------------------------------------------------------------|
|  Slenderness Check:     (Unit:  KN    METE)                                 |
|  Actual Length:         3.300E+00                                           |
|  Parameters:     LZ:         3.300E+00  LY:        3.300E+00                |
|                  KZ:             1.000  KY:            1.000                |
|  Actual Ratio:  35.09 Allowable Ratio: 180.00  LOAD:     6 FX:     3.619E+03 C  |
|-----------------------------------------------------------------------------|
|  Section Class:      Compact; Flange Class:      Compact; Web Class:     Plastic|
|-----------------------------------------------------------------------------|
-------------------------------< PAGE 9 Ends Here >--------------------------

 STAAD SPACE                                            -- PAGE NO.   10

                  STAAD.PRO CODE CHECKING - IS-800-2007-LSD (V2.0)
                 ***************************************************

|-----------------------------------------------------------------------------|
|  Member Number:      1                                                      |
|  Member Section:  ST   IW550400X2040   (INDIAN SECTIONS)                    |
|-----------------------------------------------------------------------------|
|  Tension:     (Unit:  KN    METE)                                           |
|  Parameters:     FYLD:      550.000E+03        FU:      420.000E+03         |
|                   NSF:           1.000    ALPHA:            0.800           |
|  Yielding   :  Design Force:       0.000E+00     LC:     0                  |
|                Capacity:          19.900E+03     As per:  Sec. 6.2          |
|  Rupture    :  Design Force:       0.000E+00     LC:     0                  |
|                Capacity:          10.698E+03     As per:  Sec. 6.3          |
|-----------------------------------------------------------------------------|
|  Compression:     (Unit:  KN    METE)                                       |
|  Buckling Class:   Major: a    Minor: b    As per:Cl. 7.1.2.2               |
|  Major Axis:   Design Force:       6.918E+03    LC:     3  Loc:     0.000   |
|                Capacity:          19.890E+03    As per:  Sec. 7.1.2         |
|  Minor Axis:   Design Force:       6.918E+03    LC:     3  Loc:     0.000   |
|                Capacity:          16.869E+03    As per:  Sec. 7.1.2         |
|-----------------------------------------------------------------------------|
|  Shear:    (Unit:  KN  )                                                    |
|  Major Axis:   Design Force:      17.886E+00    LC:     3  Loc:     0.000   |
|                Capacity:           2.289E+03    As per:  Sec. 8.4           |
|  Minor Axis:   Design Force:     -26.235E+00    LC:     3  Loc:     0.000   |
|                Capacity:           1.732E+03    As per:  Sec. 8.4           |
|-----------------------------------------------------------------------------|
|  Bending:     (Unit:  KN    METE)                                           |
|  Parameters:   Laterally Unsupported    KX:   1.00  LX:   3.300E+00  General |
|  Major Axis:   Design Force:     -71.846E+00    LC:     3  Loc:     3.300   |
|                Capacity:           3.709E+03    As per:  Sec. 8.2.2         |

|  Minor Axis:   Design Force:     -40.416E+00    LC:     3  Loc:     3.300   |
|                Capacity:           1.491E+03    As per:  Sec. 8.2.1.2       |
|-----------------------------------------------------------------------------|
|  Combined Interaction:                                                      |
|  Parameters:  PSI: 1.00   CMX:    0.900   CMY:    0.900   CMZ:    0.900     |
|  Section Strength:     Ratio:     0.020    As per:  Sec. 9.3.1.1            |
|                        LC:           2    Loc:       3.300                 |
|  Overall Member Strength (Bending+Compression):                             |
|  Equation 1:           Ratio:     0.456    As per:  Sec. 9.3.2.2            |
|                        LC:           3    Loc:       3.300                 |
|  Equation 2:           Ratio:     0.381    As per:  Sec. 9.3.2.2            |
|                        LC:           3    Loc:       3.300                 |
|-----------------------------------------------------------------------------|
|  Checks                Ratio   Load Case No.      Location from Start( METE) |
|                                                                             |
|  Tension                0.000       0                      0.000E+00        |
|  Compression            0.410       3                      0.000E+00        |
|  Shear Major            0.008       3                      0.000E+00        |
|  Shear Minor            0.015       3                      0.000E+00        |
|  Bend Major             0.019       3                      3.300E+00        |
|  Bend Minor             0.027       3                      3.300E+00        |
|  Sec. 9.3.1.1           0.020       2                      3.300E+00        |
|  Sec. 9.3.2.2 (i)       0.456       3                      0.000E+00        |
|  Sec. 9.3.2.2(ii)       0.381       3                      0.000E+00        |
|-----------------------------------------------------------------------------|

-------------------------------< PAGE 10 Ends Here >-------------------------
 STAAD SPACE                                            -- PAGE NO.   11
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STAAD SPACE -- PAGE NO. 1935

**STEEL TAKE-OFF**

| PROFILE | LENGTH(METE) | WEIGHT(KN ) |
|---|---|---|
| ST IW550400X2040 | 1188.00 | 3632.211 |
| ST IW550400X1632 | 5278.81 | 14598.535 |
| | TOTAL = | 18230.746 |

STAAD SPACE -- PAGE NO. 1953

STAAD.PRO MEMBER SELECTION - IS-800-2007-LSD (V2.0)

```
|--------------------------------------------------------------------------|
| Member Number:      1                                                    |
| Member Section:  ST   IW550350X010     (INDIAN SECTIONS)                 |
| Status: PASS  Ratio:   0.857  Critical Load Case:     4  Location:  3.30 |
| Critical Condition: Sec. 9.3.2.2                                         |
| Critical Design Forces:  (Unit: KN    METE)                              |
|     FX:      6.903E+03 C    FY:    -26.235E+00     FZ:    -17.886E+00    |
|     MX:    527.636E-06      MY:    -40.416E+00     MZ:     71.846E+00    |
|--------------------------------------------------------------------------|
| Section Properties:    (Unit:  CM  )                                     |
| AXX:     229.000E+00        IZZ:     135.282E+03        RZZ:   24.305E+00|
| AYY:      66.770E+00        IYY:      16.479E+03        RYY:    8.483E+00|
| AZZ:      90.000E+00        IXX:     143.000E+00        CW:     3.545E+06|
| ZEZ:       4.763E+03        ZPZ:       4.689E+03                         |
| ZEY:       1.318E+03        ZPY:       1.230E+03                         |
|--------------------------------------------------------------------------|
| Slenderness Check:    (Unit:  KN    METE)                                |
| Actual Length:        3.300E+00                                          |
| Parameters:     LZ:         3.300E+00  LY:         3.300E+00             |
|                 KZ:             1.000  KY:             1.000             |
| Actual Ratio:  38.90 Allowable Ratio: 180.00  LOAD:     6 FX:  3.619E+03 C |
|--------------------------------------------------------------------------|
| Section Class:      Compact; Flange Class:      Compact; Web Class:   Plastic|
|--------------------------------------------------------------------------|
```

STAAD SPACE -- PAGE NO. 1954

STAAD.PRO MEMBER SELECTION - IS-800-2007-LSD (V2.0)

```
|--------------------------------------------------------------------------|
| Member Number:      1                                                    |
| Member Section:  ST   IW550350X010     (INDIAN SECTIONS)                 |
|--------------------------------------------------------------------------|
| Tension:     (Unit:  KN    METE)                                         |
| Parameters:     FYLD:      550.000E+03       FU:     420.000E+03         |
|                  NSF:            1.000    ALPHA:           0.800         |
| Yielding   :  Design Force:      0.000E+00     LC:     0                 |
|               Capacity:         11.450E+03     As per:  Sec. 6.2         |
| Rupture    :  Design Force:      0.000E+00     LC:     0                 |
|               Capacity:          6.156E+03     As per:  Sec. 6.3         |
|--------------------------------------------------------------------------|
| Compression:    (Unit:  KN    METE)                                      |
| Buckling Class:   Major: a    Minor: b    As per:Cl. 7.1.2.2            |
| Major Axis:   Design Force:      6.918E+03    LC:     3  Loc:     0.000  |
|               Capacity:         11.390E+03    As per:  Sec. 7.1.2        |
| Minor Axis:   Design Force:      6.918E+03    LC:     3  Loc:     0.000  |
|               Capacity:          9.340E+03    As per:  Sec. 7.1.2        |
|--------------------------------------------------------------------------|
| Shear:    (Unit:  KN  )                                                  |
| Major Axis:   Design Force:     17.886E+00    LC:     3  Loc:     0.000  |
|               Capacity:          2.462E+03    As per:  Sec. 8.4          |
| Minor Axis:   Design Force:    -26.235E+00    LC:     3  Loc:     0.000  |
|               Capacity:          1.709E+03    As per:  Sec. 8.4          |
|--------------------------------------------------------------------------|
```

```
| Bending:    (Unit:  KN    METE)                                          |
| Parameters:  Laterally Unsupported    KX:   1.00  LX:   3.300E+00  General |
| Major Axis:  Design Force:       -71.846E+00    LC:     3  Loc:    3.300  |
|              Capacity:             1.688E+03    As per:  Sec. 8.2.2       |
| Minor Axis:  Design Force:       -40.416E+00    LC:     3  Loc:    3.300  |
|              Capacity:           615.000E+00    As per:  Sec. 8.2.1.2     |
|--------------------------------------------------------------------------|
| Combined Interaction:                                                    |
| Parameters:  PSI: 1.00   CMX:    0.900   CMY:    0.900   CMZ:    0.900   |
| Section Strength:     Ratio:    0.090    As per:  Sec. 9.3.1.1          |
|                       LC:           4    Loc:       3.300              |
| Overall Member Strength (Bending+Compression):                           |
| Equation 1:           Ratio:    0.857    As per:  Sec. 9.3.2.2          |
|                       LC:           3    Loc:       3.300              |
| Equation 2:           Ratio:    0.692    As per:  Sec. 9.3.2.2          |
|                       LC:           3    Loc:       3.300              |
|--------------------------------------------------------------------------|
| Checks                Ratio   Load Case No.    Location from Start( METE) |
|                                                                          |
| Tension                0.000      0                   0.000E+00         |
| Compression            0.741      3                   0.000E+00         |
| Shear Major            0.007      3                   0.000E+00         |
| Shear Minor            0.015      3                   0.000E+00         |
| Bend Major             0.043      3                   3.300E+00         |
| Bend Minor             0.066      3                   3.300E+00         |
| Sec. 9.3.1.1           0.090      4                   3.300E+00         |
| Sec. 9.3.2.2 (i)       0.857      3                   0.000E+00         |
| Sec. 9.3.2.2(ii)       0.692      3                   0.000E+00         |
|--------------------------------------------------------------------------|
```

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STAAD SPACE -- PAGE NO. 5666

**STEEL TAKE-OFF**

| PROFILE | LENGTH(METE) | WEIGHT(KN ) |
|---|---|---|
| ST IW550350X010 | 26.40 | 29962.524 |
| ST IW350300X010 | 1849.74 | 1310948.743 |
| ST IW550350X012 | 13.20 | 15373.784 |
| ST IW350350X012 | 159.60 | 130513.611 |
| ST IW400350X010 | 213.00 | 180515.584 |
| ST IW450300X010 | 46.20 | 39383.054 |
| ST IW450350X010 | 123.40 | 114365.688 |
| ST IW450350X1020 | 6.60 | 7981.283 |
| ST IW450300X012 | 19.80 | 17369.106 |
| ST IW350350X010 | 119.60 | 93654.192 |
| ST IW350350X1632 | 242.30 | 323031.346 |
| ST IW350300X012 | 330.92 | 242730.160 |
| ST IW350350X2040 | 73.38 | 110558.022 |
| ST IW500400X010 | 310.30 | 332180.782 |
| ST IW350350X1020 | 48.92 | 52127.142 |
| ST IW450350X016 | 878.72 | 897132.732 |
| ST IW400350X1632 | 48.46 | 67488.333 |
| ST IW500350X010 | 180.00 | 184663.814 |
| ST IW400350X016 | 332.00 | 312630.005 |
| ST IW500350X012 | 240.46 | 253840.794 |
| ST IW400300X010 | 245.57 | 189862.363 |
| ST IW350350X016 | 160.00 | 140356.407 |
| ST IW550400X010 | 134.60 | 158767.267 |
| ST IW550400X012 | 30.60 | 37155.786 |
| ST IW600400X010 | 97.38 | 127895.306 |
| ST IW450350X1632 | 97.38 | 143339.265 |
| ST IW400300X012 | 21.15 | 16876.230 |
| ST IW500400X016 | 96.00 | 111809.335 |
| ST IW450350X012 | 6.60 | 6313.065 |
| ST IW350350X1225 | 60.00 | 70178.196 |
| ST IW500400X012 | 20.00 | 22104.147 |
| ST IW550400X016 | 24.00 | 30688.091 |
| ST IW550400X1632 | 210.52 | 582.194 |
| | TOTAL = | 5772378.351 |

************ END OF DATA FROM INTERNAL STORAGE ************

412. START CONCRETE DESIGN

-------------------------------< PAGE 5666 Ends Here >---------------------------

STAAD SPACE -- PAGE NO. 5667

```
413. CODE INDIAN
414. CLEAR 0.025 MEMB 1002 TO 1009 1017 TO 1027 1029 TO 1070
415. FC 30000 MEMB 1002 TO 1009 1017 TO 1027 1029 TO 1070
416. FYMAIN 550000 MEMB 1002 TO 1009 1017 TO 1027 1029 TO 1070
417. DESIGN ELEMENT 1002 TO 1009 1017 TO 1027 1029 TO 1070
```

```
STAAD SPACE                                             -- PAGE NO. 5949

      STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     1
      LOADTYPE DEAD  TITLE DEAD LOAD

       CENTER OF FORCE BASED ON Y FORCES ONLY (METE).
     (FORCES IN NON-GLOBAL DIRECTIONS WILL INVALIDATE RESULTS)

                X =  0.441303073E+02
                Y =  0.955934177E+01
                Z = -0.229817538E+02

***TOTAL APPLIED LOAD ( KN   METE ) SUMMARY (LOADING     1 )
    SUMMATION FORCE-X =            0.00
    SUMMATION FORCE-Y =     -5834666.61
    SUMMATION FORCE-Z =            0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=  -134090896.55  MY=            0.00  MZ=  -257485611.57

***TOTAL REACTION LOAD( KN   METE ) SUMMARY (LOADING     1 )
    SUMMATION FORCE-X =            0.00
    SUMMATION FORCE-Y =      5834666.61
    SUMMATION FORCE-Z =           -0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=   134090896.04  MY=           -0.01  MZ=   257485611.57


MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      1)
           MAXIMUMS    AT NODE
   X = -4.19562E-03     455
   Y = -3.01386E+01     390
   Z = -5.86638E-03     459
   RX= -2.26476E-01     390
   RY= -4.39501E-06     398
   RZ= -5.75047E-04     469


STAAD SPACE                                             -- PAGE NO. 5960

      CENTER OF FORCE BASED ON Y FORCES ONLY (METE).
     (FORCES IN NON-GLOBAL DIRECTIONS WILL INVALIDATE RESULTS)

                X =  0.441150012E+02
                Y =  0.996842965E+01
                Z = -0.221887691E+02

***TOTAL APPLIED LOAD ( KN   METE ) SUMMARY (LOADING     2 )
    SUMMATION FORCE-X =            0.00
    SUMMATION FORCE-Y =       -96449.75
    SUMMATION FORCE-Z =            0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=    -2140101.64  MY=            0.00  MZ=    -4254880.52

***TOTAL REACTION LOAD( KN   METE ) SUMMARY (LOADING     2 )
    SUMMATION FORCE-X =            0.00
    SUMMATION FORCE-Y =        96449.75
    SUMMATION FORCE-Z =           -0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=     2140101.63  MY=           -0.00  MZ=     4254880.52
```

```
      STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.     7
      LOADTYPE DEAD  TITLE WALL LOAD

       CENTER OF FORCE BASED ON Y FORCES ONLY (METE).
     (FORCES IN NON-GLOBAL DIRECTIONS WILL INVALIDATE RESULTS)

                X =  0.441118551E+02
                Y =  0.990000025E+01
                Z = -0.241683594E+02

***TOTAL APPLIED LOAD ( KN   METE ) SUMMARY (LOADING     7 )
    SUMMATION FORCE-X =            0.00
    SUMMATION FORCE-Y =        -9506.32
    SUMMATION FORCE-Z =            0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=     -229752.17  MY=            0.00  MZ=     -419341.34

***TOTAL REACTION LOAD( KN   METE ) SUMMARY (LOADING     7 )
    SUMMATION FORCE-X =            0.00
    SUMMATION FORCE-Y =         9506.32
    SUMMATION FORCE-Z =           -0.00

   SUMMATION OF MOMENTS AROUND THE ORIGIN-
   MX=      229752.17  MY=            0.00  MZ=      419341.34


STAAD SPACE                                             -- PAGE NO. 5968

MAXIMUM DISPLACEMENTS (  CM  /RADIANS) (LOADING      7)
           MAXIMUMS    AT NODE
   X = -2.24959E-05     395
   Y = -1.27781E-04     403
   Z = -1.23955E-05     444
   RX=  2.70234E-08     394
   RY= -9.09643E-09     395
   RZ=  7.79744E-08     465
```

### 7.3 Designing the 3-Dimensional Model.

In this phase of the project, it was noted that the floor plan of the building was designed in the 3-Dimensional model with the help of software Autodesk Revit to get the broader perspective of the design and understand the real-life experience, in this phase all the components were placed in the building and designed with glazing according to the requirement like Flooring, Ceiling, Lighting, Wall Cladding, Stairs, Elevators, and many more after designing the 3 Dimensional Model, the building was viewed from different angles and walkthrough was done so the real life experience can be done and later the views are rendered because to watch the building in different lighting condition of the eyesight. Through this phase of modelling the section can be mentioned clearly and stages are also mentioned with the components this will be useful for the further designing process.

### 7.5 Designing the 4-Dimensional Model.

In this phase of the project, it was noted the scheduling of the work is done with respect to the duration of the construction and visualised with respect to the time. This can be done through 4-Dimensional Modelling i.e., through software Autodesk Navisworks Manage this software is used for the 4-Dimensional and 5-Dimensional Modelling, the file is imported from the Autodesk Revit where all the components were mentioned with their stages so in this software by scheduling the time to that component it will calculate the work procedure and time. The special ability of this software is to detected the clashes so that we can get the clear idea at pre construction phase only about the overlapping of work so that we can reassign the work later the clash can be avoided and due to time scheduling is done by simulating the steps we get to know the pace of the work it can be used in all the three phases in pre-construction to check the clashes and provide the time details, in construction to match over the things and post construction to calculate and analyse the things.

## 8. CONCLUSION

This project gives the systematic approach for the construction of multistorey building with prefabricated steel structure which is highly efficient with respect to construction and with respect to the space utilisation. In this model of presentation, the Key plan is done in AutoCAD software and it is visualised in 3-Dimensional through Autodesk Revit later analysed the structural aspects in Bently STAAD.pro software and for time management that is 4-Dimensional modelling is done in Autodesk Navisworks Manage. During the structural analysis all the Indian Standard Codes are used for the Steel Design IS 800, for Loading IS 875, for RCC IS 456 and taken to the consideration that the steel columns and beams are in W section which are more stable and productive as compared to any other and later the joints are connected with nut and bolts. From the analysis it was known that the maximum deflections, displacements, and forces are acting on the body through generated loads and all the critical loads are examined and the maximum span is calculated and provided so that more utility of space can be done. The walkthrough is done for the 3-Dimensional Model in the Revit so that the clear idea would come and later it is rendered so that the realistic approach can be shown. In the 4-Dimensional Modelling the scheduling is done with respect to the work and the things are simulated so to get information about how it works. Through which the construction time is reduced by 40% and construction cost is reduced by 20-30% when compared to the conventional method of construction and wastage is reduced to just less than 2% and overlapping of the works is almost equal to Nil. Due to this BIM application the close approach to the reality can be visualised and can reduce the mistake and disputes between the contractor engineer and client during the constructions.

The use of prefabricated steel structure is not actively used other than Tier-I city in India because of the availability and transportation, to resolve the condition is future scope of discussion and implementation of BIM techniques in this project open the path for the further research for other then prefabricated steel structure like for conventional concrete structure or pre-stressed structure and many more for the Construction Scheduling, Construction Management, Construction Safety and Visualizing.

## DECLARATIONS

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## REFERENCE

[1] Mooyoung Yoo, Jaejun Kim, Changsik Choi, "Effects of BIM-Based Construction of Prefabricated Steel Framework from the Perspective of SMEs," Applied Sciences, 26 April 2019, 9, 1732.

[2] Shengxin Chen, Jie Wu, Jialin Shi, "A BIM Platform for the Manufacture of Prefabricated Steel Structure," Applied Sciences, 13 November 2020, 10, 8038

[3] Zhan Zhenguang, "Application of BIM Technology in the Construction Phase of Steel Structure Engineering," IOP Conference Series: Earth and Environmental Science, October 2021, 783, 012118

[4] Rafaela Bortolini, Carlos Torres Formoso, Daniela D. Viana, "Site logistics planning and control for engineer-to-order prefabricated building systems using BIM 4D modeling," Elsevier, 29 November 2018, 98(2019) 248-264

[5] Yin-Gang Wang, Xiong-Jun He, Jia He, Cheng Fan, "Virtual Trial assembly of steel structure based on BIM platform", Elsevier, 31 May 2022, 141 (2022) 104395

[6] Shi An, Pablo Martinez, Mohamed Al Hussein, Rafiq Ahmad, "Automated verification of 3D manufacturability for steel frame assemblies", Elsevier, 28 May 2020, 118(2020) 103287

[7] Ling-Kun Chen, Rui-Peng Yuan, Xing-Jun Ji, Xing-Yu Lu, Jiang Xiao, Jun-Bo Tao, Xin Kang, Xin Li, Zhen-Hua He, Shu Quan, Li-Zhong Jiang, "Modular composite building in urgent emergency engineering projects: A case study of accelerated design and construction of Wuhan Thunder God Mountain/Leishenshan hospital to Covid 19 pandemic" , Elsevier, 18 December 2020, 124(2021) 103555

[8] Mohammad Delavar, John K Dickinson, Girma T Bitsuamlak "Discussion on BIM Implementation in Pre-Engineered Building Industry",Researchgate , 4 June2016, GEN-178

[9] Jose Ignacio Avendano, Sisi Zlatanova, Pedro Perez, Alberto Domingo and Christian Correa, "Integration of BIM

in Steel Building Projects (BIM-DFE): A Delphi Survey", MDPI, 13 September 2022, 12, 1439

[10] Deepa Patil, "Building Information Modelling Application in Construction Industry", International Journal of Science and Research (IJSR), 5 May 2020, SR20525213518

[11] Somnath D Khochare, Ashish P Waghmare, "3D, 4D and 5D Building Information Modelling for Commercial Building Projects", International Research Journal of Engineering and Technology, 5 January 2018, 2395-0056

[12] Jessie Ya-Ting Ho, Satish Mohan, "Building Information Modeling Applications in Construction Management – A case study for modeling information and outcomes", American Journal of Engineering Research, 28 March 2021, 2320-0847

[13] IS: 800 (2007), ―Indian Standard Code of Practice for General Construction In Steel Bureau of Indian Standards, New Delhi.

[14] IS: 875 (Part 1), ―Indian Standard Code of Practice for design loads for building and structures, Dead Loads|| Bureau of Indian Standards, New Delhi.

[15] IS: 875 (Part 2), ―Indian Standard Code of Practice for design loads for building and structures, Live Loads|| Bureau of Indian Standards, New Delhi.

[16] IS 456:2000, ―Indian Standard Plain and Reinforced Concrete-Code of Practice||, Bureau of Indian Standards, New Delhi, 2000.

[17] Building Bye-Laws for Urban Areas, Urban Development, Government of Karnataka, 2017.

[18] Dana K Smith, Michael Tardif, "Building Information Modeling – A Strategic Implementation Guide", John Wiley & Sons, 2009

[19] S K Duggal, "Design of Steel Structures", 3rd Edition, McGraw Hill, 2017