

# Analysis and Design of Villa

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## Abstract:

This paper discusses the use of software programs like ETabs and Sketchup for modelling, analysing, and designing multi-story structures. Sketchup is a user-friendly 3D modelling software with an extensive database of user-created models for various projects, including furniture building and architecture. It is used for interior design, landscaping, video game design, 3D printing, and interior design. Sketchup 3D Warehouse is the world's largest 3D model library, hosting over 4.8 million searchable and pre-made models and products. ETABS is a leading software for analysing and designing reinforced cement concrete buildings, and many design companies use it for their projects. The paper focuses on analysis of the G+1 building using ETABS, following IS 456-2000 guidelines. Dead and live loads are considered for structure analysis.

**Keywords:** AutoCAD, Sketchup and ETabs

## 1. INTRODUCTION

In the realm of architectural design and structural engineering, the integration of advanced software tools has become imperative for creating efficient, aesthetically pleasing, and structurally sound buildings. This project delves into the synergistic utilization of SketchUp, Escape, and ETABS for the holistic modeling, design, and analysis of a residential structure. By harnessing the combined power of SketchUp, Escape, and ETABS, this project endeavors to demonstrate a holistic approach to a villa modeling, design, and analysis. From the inception of design concepts to the validation of structural integrity, each stage of the process benefits from the synergistic interplay of these software tools. Ultimately, the integration of SketchUp, Escape, and ETABS not only enhances the efficiency and accuracy of the design process but also fosters a deeper understanding of the intricate relationship between form, function, and structural performance in architectural design.

## 2. LITERATURE REVIEW

Following are the research works conducted on analysis and design of a building by using different software's.

Tal (2013) Master the art of rendering in SketchUp, seamlessly transitioning from initial modeling to stunning presentations. Tailored for architects, landscape architects, and interior designers, this guide unlocks the full potential of SketchUp's rendering capabilities. Elevate your designs with lifelike visuals, bringing your architectural visions to life with precision and style.

Varalakshmi et al (2014) Discover the design process of a G+5 residential building using ETABS. Gain insights from the International Conference on Advances in Engineering and Technology. Explore innovative approaches to structural engineering in high-rise construction.

Abhay Guleria (2014) Dive into the structural analysis of multi-Storey buildings with ETABS. Explore varied plan configurations in the International Journal of Engineering Research & Technology. Gain insights into efficient structural design and optimization strategies.

Schreyer (2015) SketchUp empowers architects with robust 3D modeling capabilities, extensive extensions for enhanced functionality, and seamless integration with BIM workflows. and customizable scripting, it facilitates the entire architectural design process, from conceptualization to execution.

Kucinskiene and Kucinskas (2015) Explore landscape design visualization possibilities in the Experience Areas feature. Delve into the Journal of Sustainable Architecture and Civil Engineering for insights. Discover innovative approaches to sustainable landscape architecture.

Chandrashekar and Rajasekhar (2015) Explore the analysis and design process of multi-storied buildings with ETABS software. Gain valuable insights from the International Journal of Scientific and Research. Delve into innovative approaches to structural engineering and optimization.

Gupta (2015) This study investigates the impact of shear wall locations on the seismic performance of RCC framed buildings. Through comprehensive analysis, it evaluates structural stability and resilience under seismic forces. Gain insights into optimizing shear wall placement for enhanced building safety in seismic-prone regions.

Balaji and Selvarasan (2016) Explore the design and analysis of multi-storeyed buildings in ETABS under static and dynamic loading conditions. Gain insights from the International Journal of Technical Research and Applications. Delve into advanced structural engineering techniques for optimized building performance.

Geethu et al. (2016) Dive into a comparative study of multi-storied building design and analysis using STAAD.Pro and

ETABS software. Gain insights into the strengths and limitations of each platform. Explore advanced structural engineering techniques for optimal building performance.

Mohith (2017) Gain expertise in commercial building analysis and design utilizing ETABS software. Master structural engineering principles for robust and efficient designs. Generate detailed output and optimize building performance with ETABS proficiency.

Huang et al. (2018) The use of virtual reality (VR) in architecture and construction, discussing its benefits, applications, and challenges. It highlights case studies, discusses challenges like cost barriers, and speculates on future directions and opportunities. The survey also explores potential advancements and research areas for further development and improvement in VR applications.

Holley (2018) "Beyond Flat Space: Representing Architecture in Virtual Reality," focusing on works that explore virtual reality (VR) in architecture and spatial representation. Here are some key references.

Brock (2018) This guide provides a comprehensive overview of utilizing SketchUp for creating 3D building models tailored for builders. It offers step-by-step instructions, tips, and techniques to efficiently leverage SketchUp's tools and features in architectural design. From conceptualization to detailed modeling, this resource equips builders with the skills to produce accurate and visually appealing 3D representations of their projects.

Ali et al. (2020) This highlights the computer-aided design, analysis, and drafting process for a multi-Storey RCC building using ETABS software. It emphasizes the integration of advanced modeling techniques, structural analysis, and drafting functionalities to ensure robustness and efficiency in the design process. Through this approach, engineers can streamline the design workflow and enhance the accuracy and reliability of structural designs for multi-Storey RCC buildings.

Dhomne (2021) This study focuses on the analysis and design of a multistorey residential building utilizing the ETABS software. It explores structural integrity, load distribution, and design optimization to ensure safety and efficiency in high-rise construction. Through comprehensive analysis and simulation,

this research aims to provide valuable insights for engineers and architects in the construction industry.

Thakur et al. (2021) This study conducts a design and comparative analysis of a G+6 residential building using STAAD.Pro and ETABS. It explores the structural integrity and performance of the building under various loading conditions. Gain insights into the strengths and weaknesses of both software platforms for structural engineering.

Setyaningfebry et al. (2022) These references should provide insights into the development of web-based rendering systems, with a focus on user experience, scalability, performance optimization, and emerging technologies such as virtual reality and augmented reality.

Bruckner et al. (2022) It may explore the integration of various disciplines such as architecture, engineering, and landscape architecture within BIM workflows, highlighting challenges, benefits, and best practices identified in relevant literature. The study may offer insights into optimizing collaboration and efficiency in contemporary building projects through BIM-oriented approaches.

Cline (2023) SketchUp offers seamless 3D visualization and space planning, ideal for interior design projects. From concept to execution, it enables designers to efficiently create, modify, and present their designs with precision and creativity.

Ardhan et al. (2023) SketchUp 3D modeling techniques, and perhaps case studies or best practices in designing dual-function buildings. It may delve into topics such as space optimization, functionality, aesthetic considerations, and practical applications within the context of PT. Daffa Ekspresindo Logistics' specific requirements and constraints.

### 3.0 PLANNING AND MODELLING

For the drafting and design of any construction, AutoCAD is quite beneficial. The fields of architecture and construction also employ this software. The software's several built-in capabilities enable complex drafting. In addition to 2D, 3D and other dimensions, AutoCAD is also appropriate for perspective design, which refers to a way of perceiving objects.

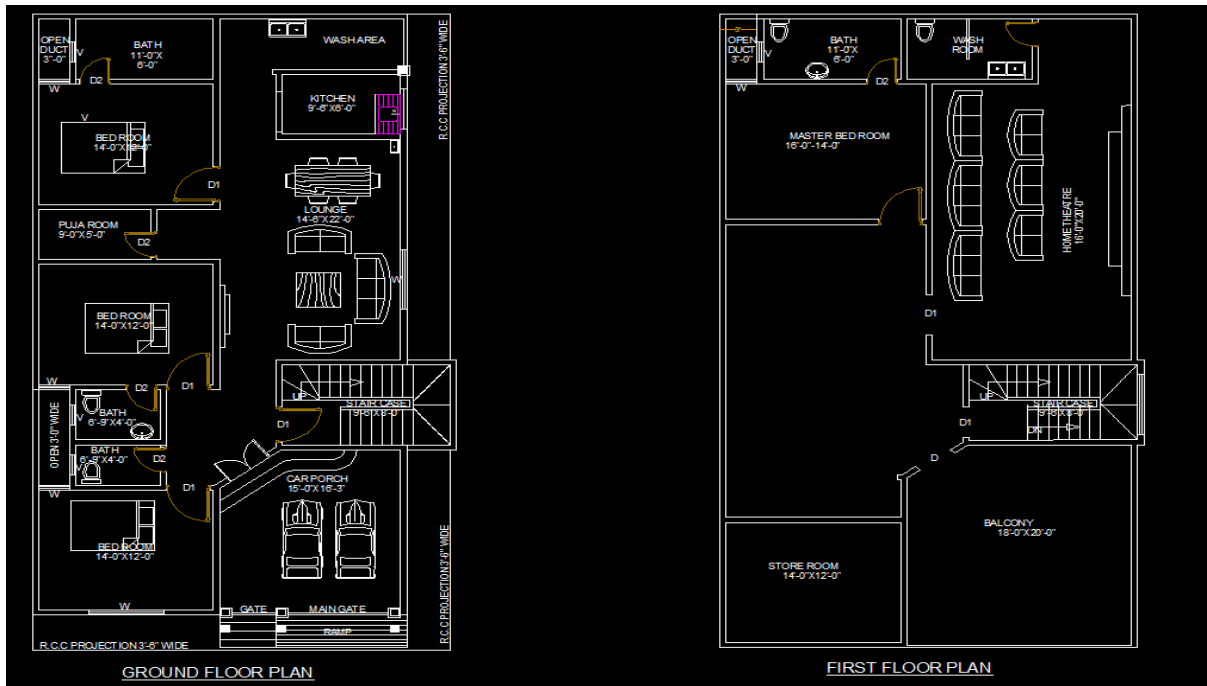


Fig 1: Auto CAD Plan

BED ROOMS = 14'X12'  
LIVING AREA = 14'6"X22'  
POOJA ROOM = 9'X5'  
KITCHEN = 9'6"X6'

MASTER BEDROOM=16'X14'  
HOME THEATER=16'X20'  
STORE ROOM=14'X12'  
BALCONY=18'X20'

### 3.1 Importing a CAD file into SketchUp

After you've checked and prepared your CAD file, you're ready to import it into SketchUp. The following steps walk you through the import process for your operating system:

1. In SketchUp, open the SketchUp model into which you want to import your .dwg or .dxf file.
2. Select File > Import. An Import dialog box appears.
3. Navigate the place your hard drive where your CAD file is saved.
4. From the Files of Type drop-down list, select AutoCAD Files (\*.dwg, \*.dxf).
5. Select the file you want to import.
6. Click the Options button. The Import AutoCAD DWG/DXF Options dialog box appears, as shown in the following figure.
7. (Optional) In the Geometry area, select your preferences for the following options:
  - select Merge Coplanar Faces to tell SketchUp to automatically remove triangulated lines from planes.
  - Selecting the Orient Faces Consistently box tells SketchUp to analyse the direction of imported faces and orient the faces so that their direction is uniform.
8. (Optional) Select the Preserve Drawing Origin checkbox to place the imported geometry at the origin defined in the .dwg or .dxf file. Leave the checkbox deselected if you want to place the imported geometry near the SketchUp origin.
9. (Optional) To import geometry at the correct scale, select the unit used in your CAD file from

the Units drop-down list. Your options are Model Units, Inches, Feet, Yards, Miles, Millimetres, Centimetres, Meters and Kilometres.

- Click OK in the Import AutoCAD DWG/DXF Options dialog box.

- Back in the Import dialog box, click the Import button, SketchUp Pro begins importing your CAD file.

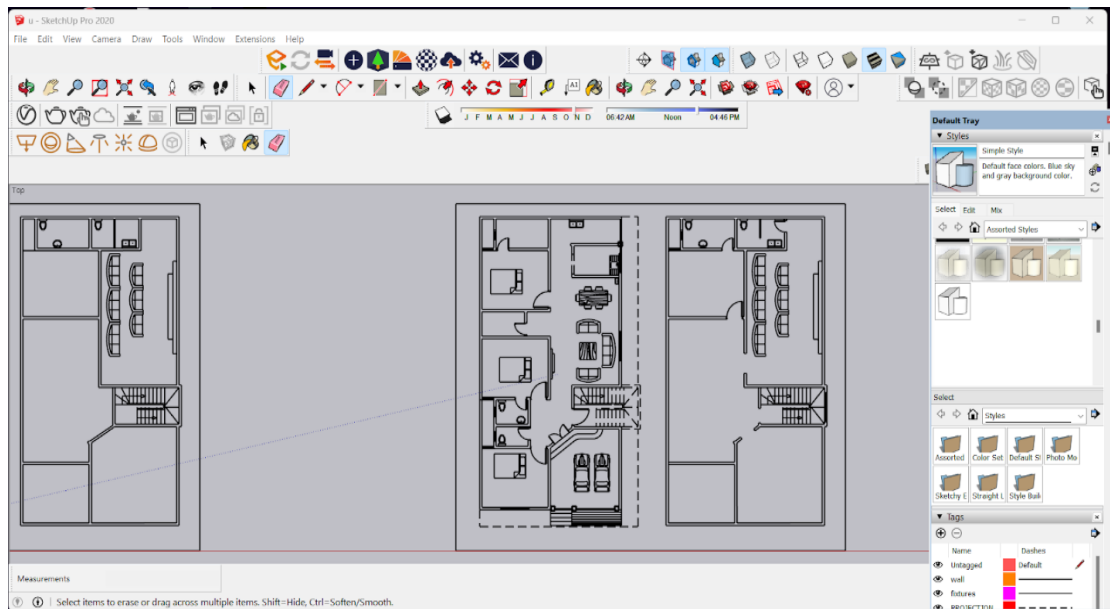


Fig 2: Importing a CAD file into SketchUp

### 3.2 Exporting a SketchUp Model as a 3D CAD file

When you export a SketchUp model as a 3D CAD file, you can select what entities are exported. To export your model, follow these steps:

In SketchUp, select File > Export > 3D Model. The Export Model dialog box appears.

- Navigate to the location where you want to save your exported file.
- (Optional) Change the file name if you like. By default, the exported file uses the same name as your SketchUp file name.

- Select either .dwg or .dxf as the file format for your exported file. In Microsoft Windows, select your file type from the Save As Type drop-down list. In Mac OS X, use the Format drop-down list.
- Click the Options button to open the Export Options dialog box, shown in the following figure. From the AutoCAD Version drop-down list, select the version of AutoCAD you'd like to use to open the exported file. In the Export area, select the checkbox for each type of entity that you want to include in the exported file. Click OK when you're done. Back in the Export Model dialog box, click Export, and your file appears in the location where you chose to save it.

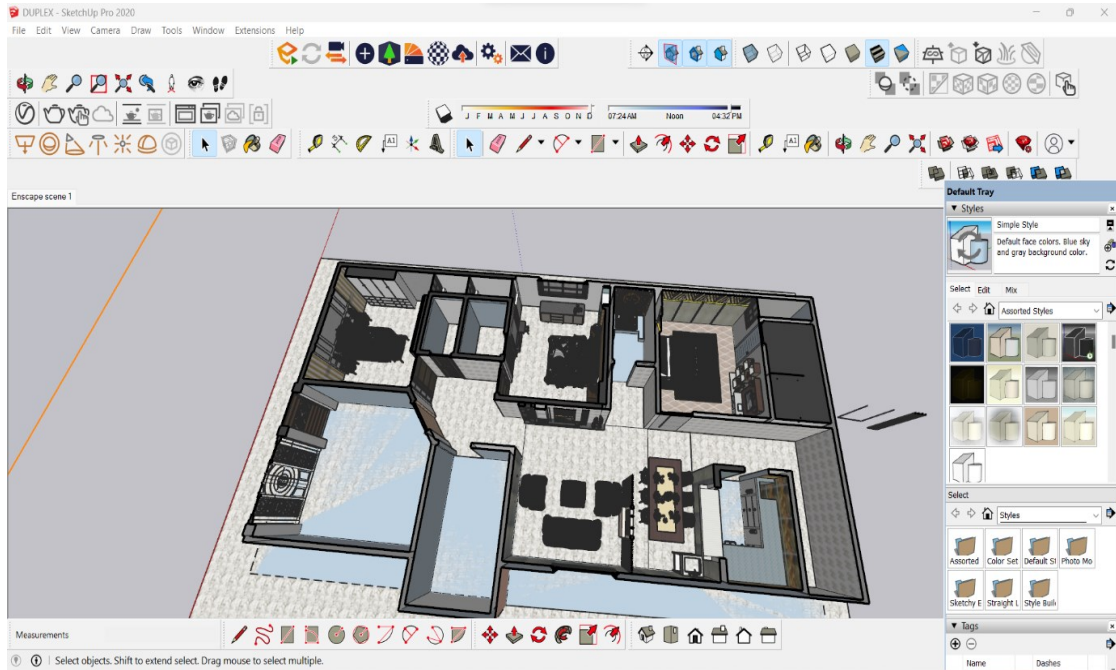


Fig 3: Exporting a SketchUp Model as a 3D CAD file



Fig 4: Bed room



Fig 5: Hall



Fig 6: Elevation without rendering



Fig 7: Elevation with rendering

#### 4. ANALYSIS AND DESIGN

##### 4.1 IMPORTING AUTOCAD PLAN TO ETABS

ETABS is an engineering software product designed for multi-story building analysis and design. It offers modelling tools, load prescriptions, and analysis methods that coordinate with the unique grid-like geometry of these structures. ETABS can evaluate basic or advanced systems under static or dynamic conditions, and can capture material nonlinearity under monotonic or hysteretic behaviour. Its intuitive features make it practical for applications of any complexity. ETABS integrates every aspect of the engineering design process, from design conception to schematic drawing production. It includes

features for steel and concrete frames, composite beams, columns, steel joists, and concrete and masonry shear walls. The software also supports nonlinear modelling techniques and provides comprehensive and customizable reports for analysis and design output. ETABS is an invaluable suite of tools for structural engineers designing buildings, from one-story industrial structures to tall commercial high-rises.

Import the AutoCAD Plan:

- In ETABS, navigate to the "File" menu.
- Select "Import" and then choose "AutoCAD Drawing (\*.DWG)" from the dropdown menu.
- Browse to the location where you saved your AutoCAD drawing file and select it.
- Click "Open" to import the AutoCAD plan into your ETABS model

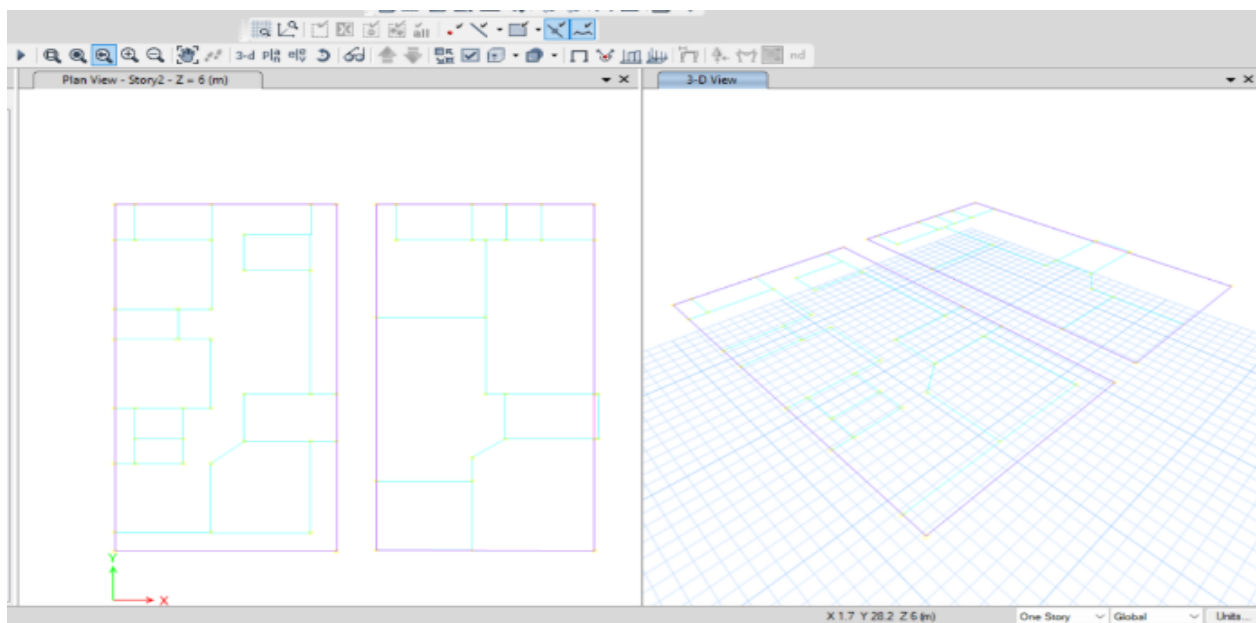


Fig 8: Centre line diagram

## 4.2 PLAN OF THE VILLA

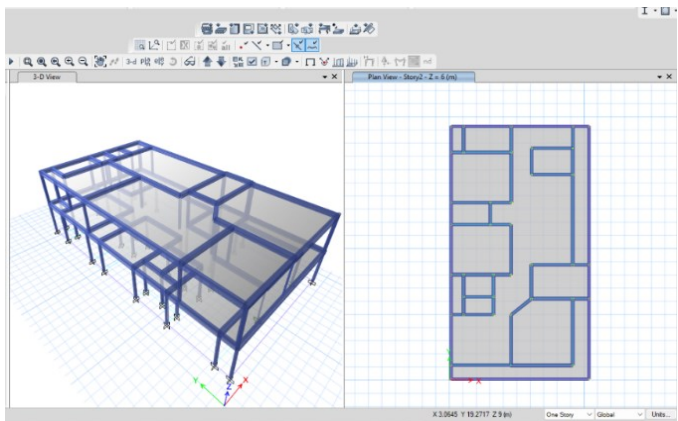


Fig 9: Ground Floor

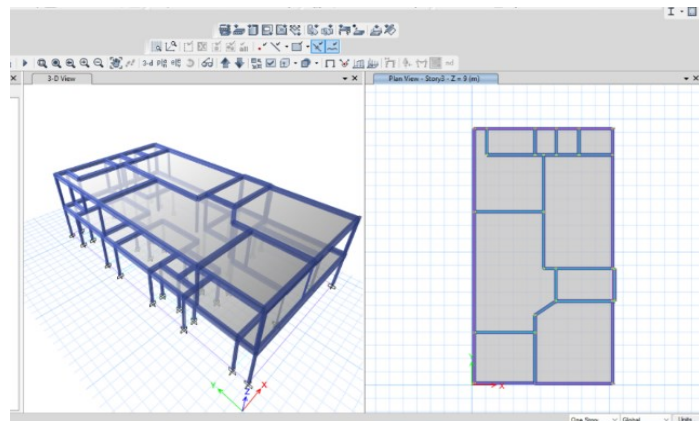


Fig 10: First Floor

## 4.3 Loads Considered:

### 4.3.1 Dead Load:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the

other permanent constructions in the weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m<sup>3</sup> and 25 kN/m<sup>3</sup> respectively.

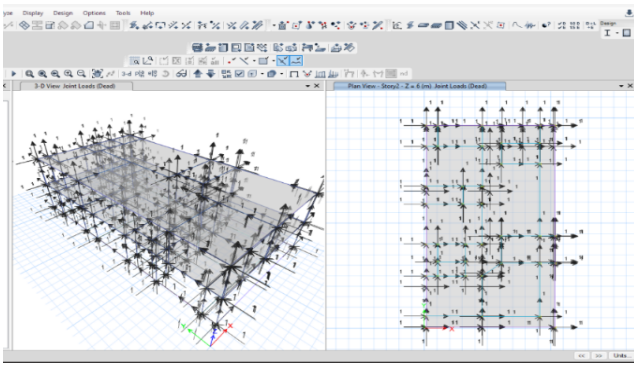


Fig 11: Dead load for ground floor

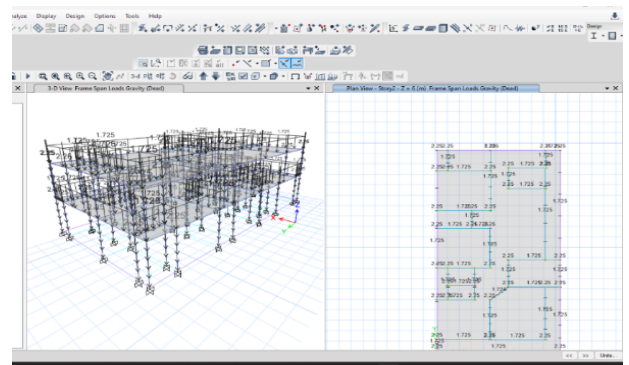


Fig 12: Dead load for first floor

4.3.2 Imposed Load or live load:

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads

due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

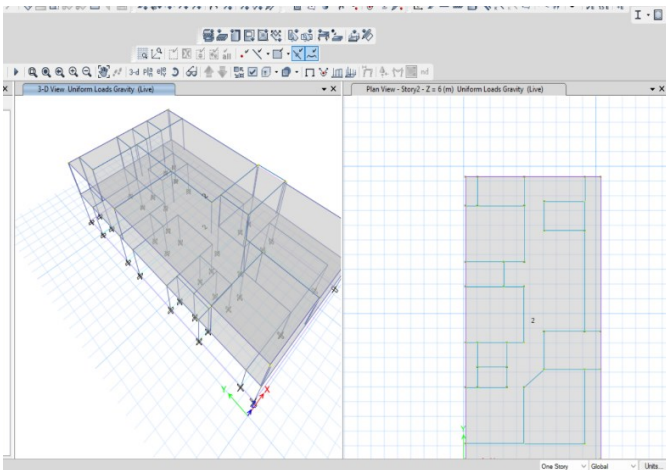


Fig 13: Live load for ground floor

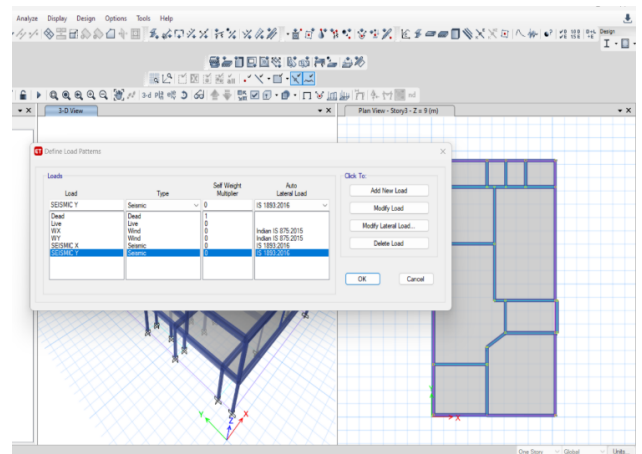


Fig 14: Live load for first floor

4.3.3 Wind Load:

Air mass moving at a certain velocity has a kinetic energy equal to  $\frac{1}{2}mv^2$ , where m and v are the mass and velocity of air in motion. When an obstacle like a building is encountered, a part of the kinetic energy is converted to potential energy of pressure. The intensity of wind pressure depends on factors like the angle of incidence, roughness of the surrounding area, and the structure's lateral resistance.

The maximum design wind pressure depends on the duration of gusts and the probability of exceptional wind pressure. Most buildings have wind pressure specified in Indian Standards, IS code 875 -3 (1964), but tall and slender buildings may develop aerodynamic instability due to constant gusts and vibration during wind storms. If the building's energy absorbs more than it can dissipate, the vibration amplitude increases until failure occurs. Wind tunnel experiments are often necessary for detailed study.



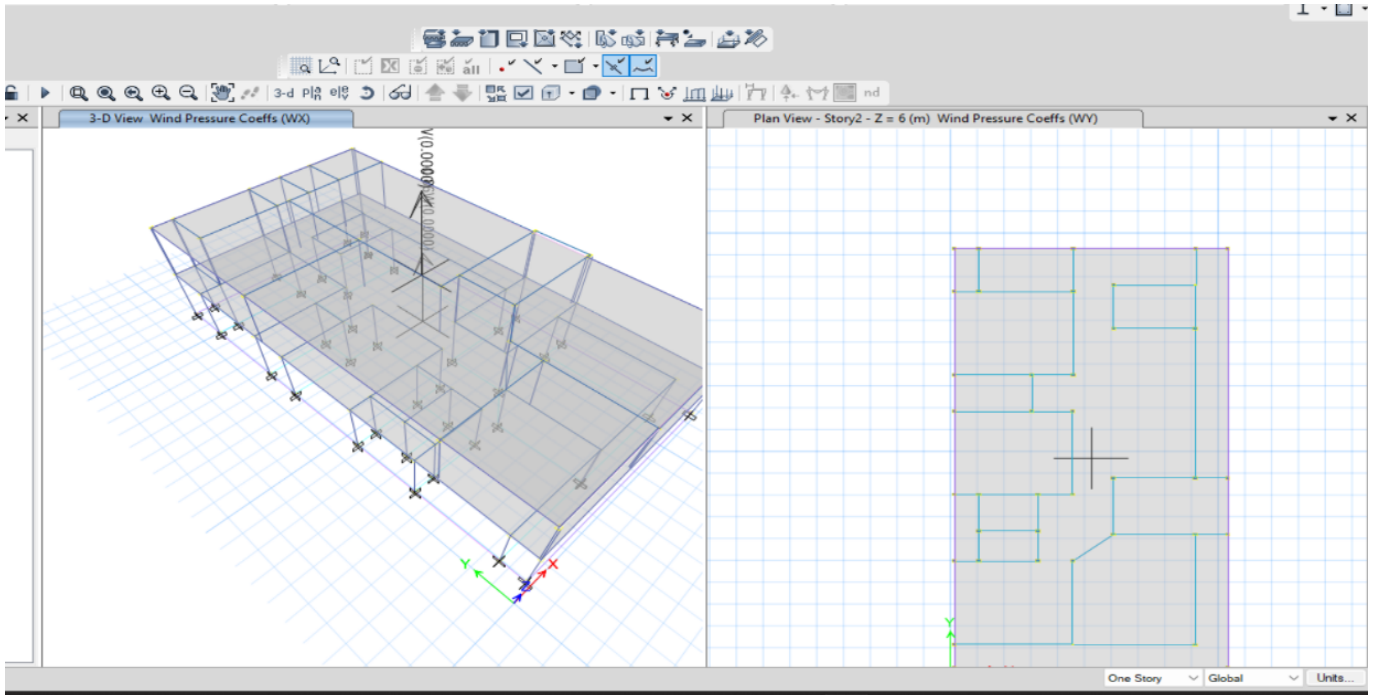


Fig 15: Wind load

#### 4.4 SHEAR FORCE

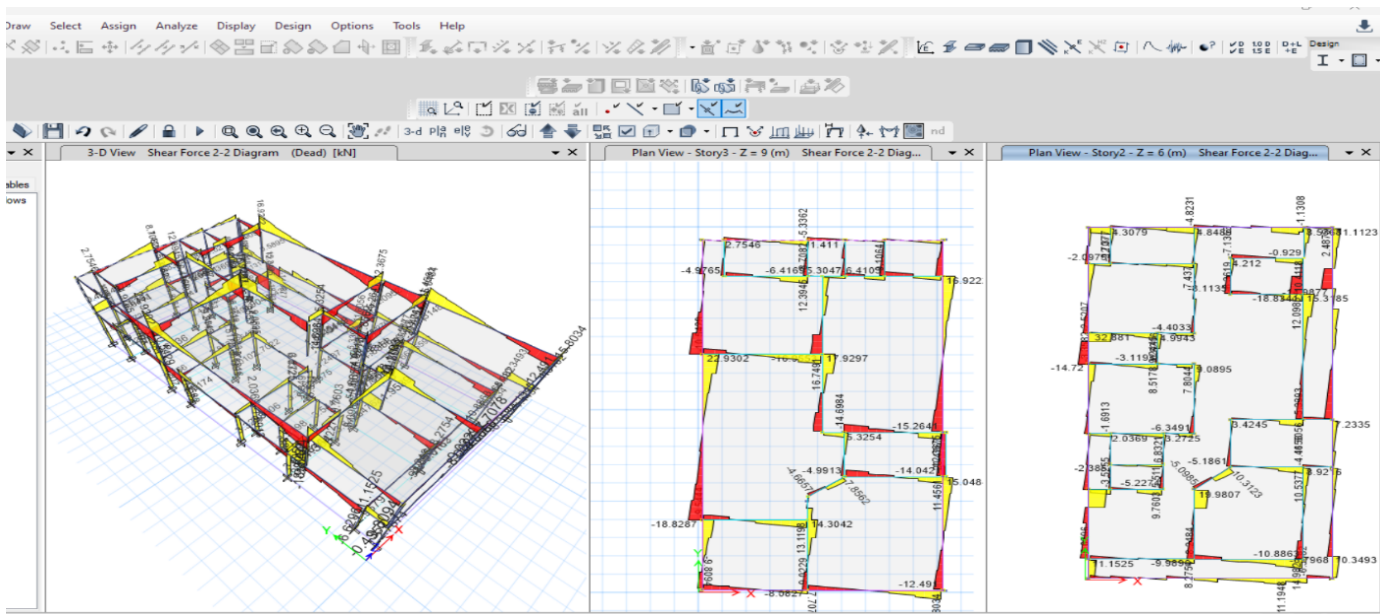


Fig 16: Shear Force variation

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### 4.5 BENDING MOMENT

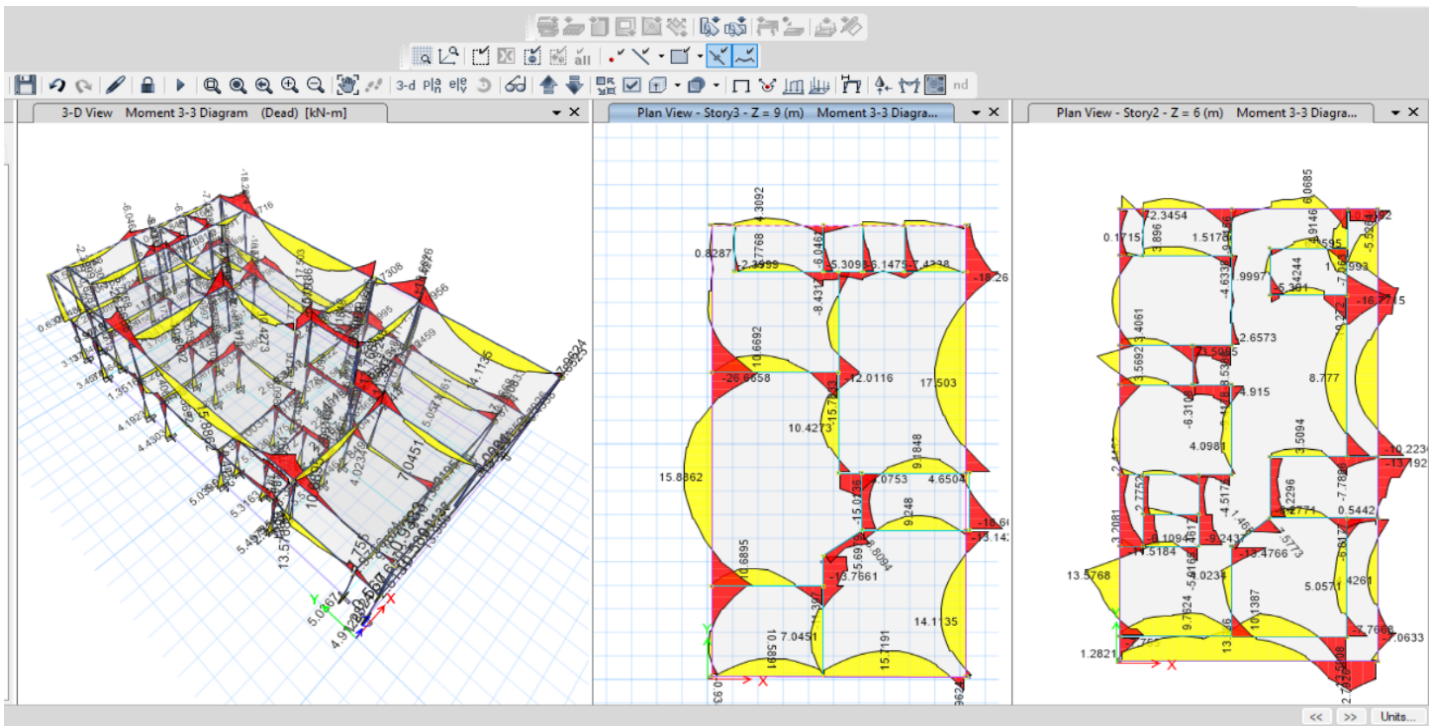


Fig 17: Bending Moment variation

### 4.6 REINFORCEMENT VALUES

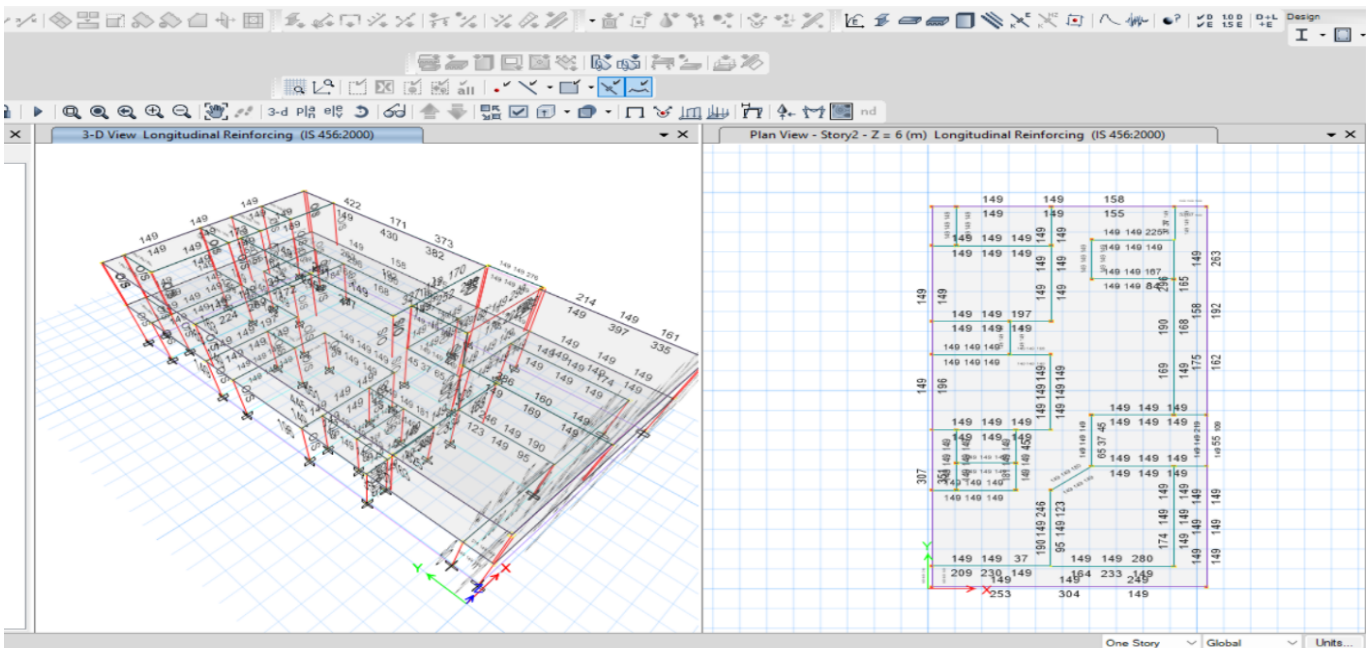


Fig 18: Ground Floor

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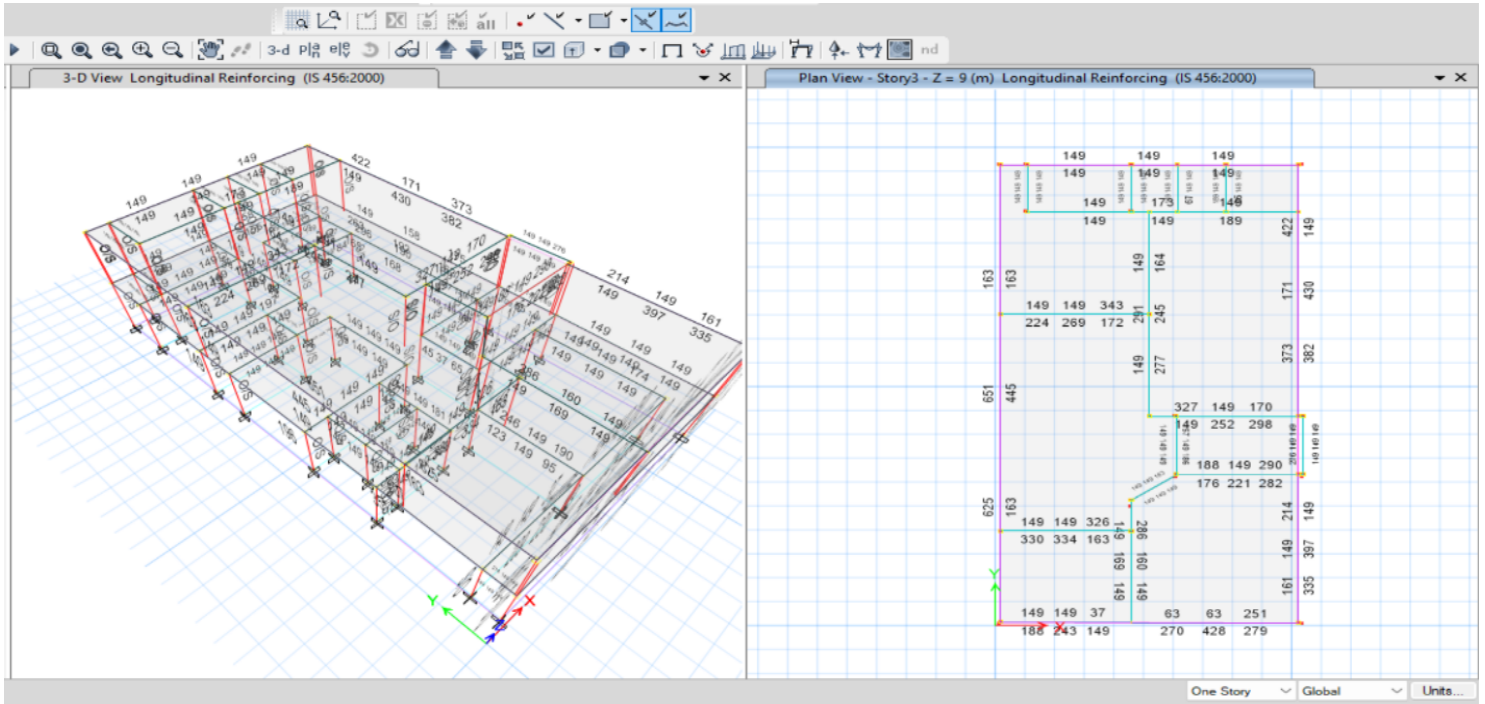


Fig 19: First Floor

4.7 BEAM REINFORCEMENT DETAILS

Table 1: Beam reinforcement details

BEAM NO'S	DIMENSIONS (m)	REINFORCEMENT
B <sub>1</sub>	4.54 X 0.3 X 0.3	6#12@270
B <sub>2</sub>	5.27 X 0.3 X 0.3	
B <sub>3</sub>	0.96 X 0.3 X 0.3	
B <sub>4</sub>	4.54 X 0.3 X 0.3	
B <sub>5</sub>	4.31 X 0.3 X 0.3	
B <sub>6</sub>	3.93 X 0.3 X 0.3	
B <sub>7</sub>	3.93 X 0.3 X 0.3	
B <sub>8</sub>	4.91 X 0.3 X 0.3	
B <sub>9</sub>	5.87 X 0.3 X 0.3	
B <sub>10</sub>	0.65 X 0.3 X 0.3	
B <sub>11</sub>	1.88 X 0.3 X 0.3	
B <sub>12</sub>	1.81 X 0.3 X 0.3	
B <sub>13</sub>	1.51 X 0.3 X 0.3	
B <sub>14</sub>	1.28 X 0.3 X 0.3	
B <sub>15</sub>	0.96 X 0.3 X 0.3	
B <sub>16</sub>	1.49 X 0.3 X 0.3	
B <sub>17</sub>	1.49 X 0.3 X 0.3	
B <sub>18</sub>	1.49 X 0.3 X 0.3	
B <sub>19</sub>	1.71 X 0.3 X 0.3	
B <sub>20</sub>	2.71 X 0.3 X 0.3	

<b>B21</b>	<b>2.71 X 0.3 X 0.3</b>	<b>6#12@270</b>
<b>B22</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B23</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B24</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B25</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B26</b>	<b>0.99 X 0.3 X 0.3</b>	
<b>B27</b>	<b>3.44 X 0.3 X 0.3</b>	
<b>B28</b>	<b>3.44 X 0.3 X 0.3</b>	
<b>B29</b>	<b>0.65 X 0.3 X 0.3</b>	
<b>B30</b>	<b>0.99 X 0.3 X 0.3</b>	
<b>B31</b>	<b>3.44 X 0.3 X 0.3</b>	
<b>B32</b>	<b>3.44 X 0.3 X 0.3</b>	
<b>B33</b>	<b>0.65 X 0.3 X 0.3</b>	
<b>B34</b>	<b>1.88 X 0.3 X 0.3</b>	
<b>B35</b>	<b>1.99 X 0.3 X 0.3</b>	
<b>B36</b>	<b>6.97 X 0.3 X 0.3</b>	
<b>B37</b>	<b>9.08 X 0.3 X 0.3</b>	
<b>B38</b>	<b>3.31 X 0.3 X 0.3</b>	
<b>B39</b>	<b>1.21 X 0.3 X 0.3</b>	
<b>B40</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B41</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B42</b>	<b>4.53 X 0.3 X 0.3</b>	
<b>B43</b>	<b>3.93 X 0.3 X 0.3</b>	
<b>B44</b>	<b>3.93 X 0.3 X 0.3</b>	
<b>B45</b>	<b>2.78 X 0.3 X 0.3</b>	
<b>B46</b>	<b>2.10 X 0.3 X 0.3</b>	
<b>B47</b>	<b>2.10 X 0.3 X 0.3</b>	
<b>B48</b>	<b>0.65 X 0.3 X 0.3</b>	
<b>B49</b>	<b>3.87 X 0.3 X 0.3</b>	
<b>B50</b>	<b>2.10 X 0.3 X 0.3</b>	
<b>B51</b>	<b>2.16 X 0.3 X 0.3</b>	
<b>B52</b>	<b>2.16 X 0.3 X 0.3</b>	
<b>B53</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B54</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B55</b>	<b>0.65 X 0.3 X 0.3</b>	
<b>B56</b>	<b>3.87 X 0.3 X 0.3</b>	
<b>B57</b>	<b>4.32 X 0.3 X 0.3</b>	
<b>B58</b>	<b>0.96 X 0.3 X 0.3</b>	
<b>B59</b>	<b>4.5 X 0.3 X 0.3</b>	
<b>B60</b>	<b>5.27 X 0.3 X 0.3</b>	
<b>B61</b>	<b>0.96 X 0.3 X 0.3</b>	
<b>B62</b>	<b>4.54 X 0.3 X 0.3</b>	
<b>B63</b>	<b>4.31 X 0.3 X 0.3</b>	
<b>B64</b>	<b>5.87 X 0.3 X 0.3</b>	
<b>B65</b>	<b>3.93 X 0.3 X 0.3</b>	
<b>B66</b>	<b>4.54 X 0.3 X 0.3</b>	
<b>B67</b>	<b>4.31 X 0.3 X 0.3</b>	
<b>B68</b>	<b>3.93 X 0.3 X 0.3</b>	

<b>B69</b>	<b>3.93 X 0.3 X 0.3</b>	
<b>B70</b>	<b>4.91 X 0.3 X 0.3</b>	
<b>B71</b>	<b>0.65 X 0.3 X 0.3</b>	
<b>B72</b>	<b>1.88 X 0.3 X 0.3</b>	
<b>B73</b>	<b>1.81 X 0.3 X 0.3</b>	
<b>B74</b>	<b>1.50 X 0.3 X 0.3</b>	
<b>B75</b>	<b>0.96 X 0.3 X 0.3</b>	
<b>B76</b>	<b>1.49 X 0.3 X 0.3</b>	
<b>B77</b>	<b>1.49 X 0.3 X 0.3</b>	
<b>B78</b>	<b>1.49 X 0.3 X 0.3</b>	
<b>B79</b>	<b>1.71 X 0.3 X 0.3</b>	
<b>B80</b>	<b>2.71 X 0.3 X 0.3</b>	
<b>B81</b>	<b>2.71 X 0.3 X 0.3</b>	
<b>B82</b>	<b>0.65 X 0.3 X 0.3</b>	
<b>B83</b>	<b>1.88 X 0.3 X 0.3</b>	
<b>B84</b>	<b>1.99 X 0.3 X 0.3</b>	
<b>B85</b>	<b>2.78 X 0.3 X 0.3</b>	
<b>B86</b>	<b>0.96 X 0.3 X 0.3</b>	
<b>B87</b>	<b>3.44 X 0.3 X 0.3</b>	
<b>B88</b>	<b>3.44 X 0.3 X 0.3</b>	
<b>B89</b>	<b>6.97 X 0.3 X 0.3</b>	
<b>B90</b>	<b>9.08 X 0.3 X 0.3</b>	
<b>B91</b>	<b>3.31 X 0.3 X 0.3</b>	
<b>B92</b>	<b>1.21 X 0.3 X 0.3</b>	
<b>B93</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B94</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B95</b>	<b>4.53 X 0.3 X 0.3</b>	
<b>B96</b>	<b>3.93 X 0.3 X 0.3</b>	
<b>B97</b>	<b>3.93 X 0.3 X 0.3</b>	
<b>B98</b>	<b>2.78 X 0.3 X 0.3</b>	
<b>B99</b>	<b>0.65 X 0.3 X 0.3</b>	
<b>B100</b>	<b>3.85 X 0.3 X 0.3</b>	
<b>B111</b>	<b>2.10 X 0.3 X 0.3</b>	
<b>B112</b>	<b>2.10 X 0.3 X 0.3</b>	
<b>B113</b>	<b>2.78 X 0.3 X 0.3</b>	
<b>B114</b>	<b>3.87 X 0.3 X 0.3</b>	
<b>B115</b>	<b>2.10 X 0.3 X 0.3</b>	
<b>B116</b>	<b>2.10 X 0.3 X 0.3</b>	
<b>B117</b>	<b>1.79 X 0.3 X 0.3</b>	
<b>B121</b>	<b>3.87 X 0.3 X 0.3</b>	
<b>B121</b>	<b>4.32 X 0.3 X 0.3</b>	

6#12@270

#### 4.8 COLUMN REINFORCEMENT DETAILS

As per the design, it is observed that all columns are having same dimensions and reinforcement.

Table 2: Column reinforcement details

DIMENSION (m)	REINFORCEMENT
3 X 0.3 X 0.3	4#16

#### 5. CONCLUSION

The paper discusses the use of ETABS for structural design, highlighting its benefits in strength, serviceability and durability. It suggests that altering beam and column dimensions and producing reinforcement detailing can improve the design process. The study also highlights the

effectiveness of Google SketchUp in building interior design, with its virtual reality capabilities providing valuable insights into spatial relationships. Combining SketchUp and Enscape with ETABS streamlines project workflows, resulting in high-quality, aesthetically pleasing, and structurally sound architectural designs.

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