ANALYSIS AND DESIGN OF MULTI-STOREY RESIDENTIAL BUILDING (G+4) BY USING STAAD.PRO & AUTOCAD

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ABSTRACT:

Structural design is the primary aspect of civil engineering. The foremost basic in structural engineering is the design of simple basic components and members of a building viz., Slabs, Beams, Columns and Footings. In order to design them, it is important to first obtain the plan for the particular building. Planning is done with AutoCAD; then, the structure is developed and examined with STAAD Pro. Depending on the suitability, the plan layout of beams and the position of columns are fixed. Thereafter, the vertical loads are calculated namely the dead load and live load. Once the loads are obtained, the component takes the load first i.e. the slabs can be designed. Designing of slabs depends upon whether it is a one-way or a two-way slab, the end conditions and the loading. From the slabs, the loads are transferred to the beam. The loads coming from the slabs onto the beam may be trapezoidal or triangular. Depending on this, the beam may be designed. Thereafter, the loads (mainly shear) from the beams are taken by the columns. After this, the designing of columns is taken up depending on end conditions, moments, eccentricity and if it is a short or slender column. Most of the columns designed in this project were considered to be axially loaded with bi-axial bending. Finally, the footings are designed based on the loading from the column and also the soil-bearing capacity value for that particular area. Most importantly, the sections must be checked for all four components with regard to strength and serviceability.

Keywords: *STAAD. Pro., Auto Cad, Gravity loads, Shear force, Bending moment.*

1.INTRODUCTION:

The construction industry has seen significant advancements in structural analysis and design methodologies with the development of computational tools. Among the various software's available, STAAD. Pro has emerged as a widely used program for analysing and designing multi-storey buildings due to its accuracy, efficiency and ability to handle complex structural systems.

Multi-storey buildings, such as G+4 structures, are commonly used in urban areas for residential, commercial, and institutional purposes. Designing these structures requires a comprehensive understanding of loads, material properties, structural behaviour to ensure safety, stability, and cost-effectiveness.

In traditional methods, structural analysis involved manual calculations and simplified assumptions, which often lead to conservative designs. However, with advanced tools like STAAD. Pro, engineers can accurately model structural elements, apply loads, and analyse responses under various conditions leading to optimized and reliable designs.

This study focuses on the analysis and design of a G+4 multi-storey residential building using STAAD. Pro, considering gravity loads (dead and live loads), and load combinations as per relevant design codes.

2. LITERATURE REVIEW

Deshmukh et.al (July 2016) The main objective of this project is to analysis and design a multistoried building G+19 (3-dimensional frame) using STAAD Pro software. The design involves analysing the whole structure by STAAD Pro. The design methods used in STAAD-Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. We conclude that STAAD-PRO is a very powerful tool which can save much time and is very accurate in designs. In this project, G+19 storied building is considered and applied various loads like wind load, static load, earthquake load and results are studied and compared by manual calculations.

Sasidhar et.al (April 2017) The project focuses on the structural analysis and design of a high-rise hospital building (G+10) using STAAD. Pro software. Structural analysis involves studying how a building responds to external loads and environmental factors throughout its service life. The project aims to predict forces, bending moments, stress, strain, and deflections for components like beams, columns, and slabs. STAAD. Pro is utilized to determine these factors, ensuring the building's structural components are economically and safely designed. The final goal is to identify the most cost-effective design for the building's structural elements.

Ibrahim et.al (April 2019) The study focusses after analysing the G+4 story residential building structure, conducted that the structure’s rate in loading like dead load, live load, wind load and seismic loads. Member dimension’s (Beam, column, slab) are assigned by calculating the load type and its quantity applied on it. Auto CAD gives detailed information at the structure member’s length, height, depth, size and numbers, etc. STAAD. Pro. has a capability to calculate the program contains number of parameters which are designed as per IS 456: 2000.

Rashmi Agashe et.al (April 2020) The project focuses on the structural planning and design of a G+4 story residential building using IS Code methods. It involves theoretical design and analysis, combining creativity, knowledge, and critical thinking. The entire structure is manually designed and verified using STAAD Pro software. Drafting and detailing are done using AutoCAD, which also serves as a base for transferring the structure to STAAD Pro for analysis. The design of elements like slabs, beams, columns, and staircases follows the "Limit State Method" as per IS: 456-2000. Load calculations are done according to IS: 875-1987 (Parts 1, 2, and 3). The project ensures that the building is planned in compliance with the National Building Code of India.

Monika Verma et.al (January 2023) The project focuses on the design and analysis of a multi-story high-rise building using AutoCAD for 2D and 3D drawings and STAAD Pro for structural analysis. With rapid urbanization and increasing population density, especially in metropolitan areas, high-rise buildings have become essential due to limited land availability. The structure is analyzed using the Limit State Design method, following Indian Standard Codes, and considering various loads such as dead load, live load, and wind load. STAAD Pro provides a fast, efficient, and accurate approach to structural planning and analysis, ensuring safety, cost-effectiveness, and timely completion. The objective is to assess the building's structural behaviour under all possible loading conditions and ensure it meets design standards while emphasizing the importance of modern software tools in the construction industry.

2.1 CRITICAL REVIEW

Timeline	Reference	Progress	Key Inference
2016	Deshmukh et al	Designed a G+19 building under various loads (wind, static, seismic) using Limit State Method as per Indian Standards.	STAAD. Pro. greatly reduces time and enhances accuracy in structural analysis compared to manual calculations.
2017	Sasidhar et al	Designed G+10 hospital building components like slabs, beams, and columns, focusing on stress and deflection.	STAAD.Pro ensures cost-effective, safe design for hospital buildings under dynamic loads.

2019	Ibrahim et al	G+4 residential structure analyzed using IS codes; results validated with AutoCAD dimensions.	STAAD Pro efficiently handles varying loads and provides precise detailing of structural elements.
2020	Rashmi Agashe et al	Designed G+4 building manually and with STAAD, ensured IS compliance in all elements.	Manual verification of STAAD Pro results boosts confidence in software-based design.
2023	Monika Verma et al	Used AutoCAD + STAAD Pro to design a high-rise under various loads as per Indian Codes.	High-rise design must adapt to urban challenges; STAAD Pro meets those efficiently.

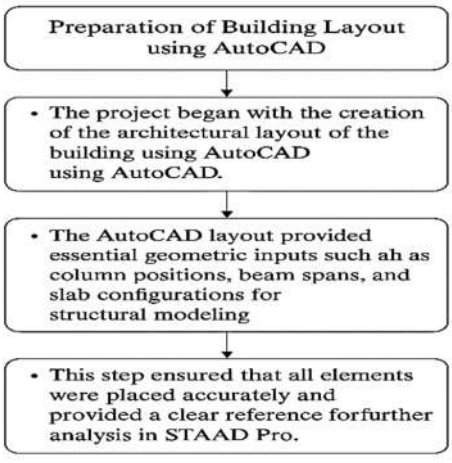
2.2 SUMMARY OF CRITICAL REVIEW

From the reviewed literature, the following key points are observed:

- STAAD. Pro enhances accuracy and efficiency in structural analysis compared to conventional methods.
- STAAD. Pro provides optimized reinforcement detailing, leading to material efficiency and cost-effectiveness.
- Indian Standard Codes (IS 456:2000, IS 875, IS 1893) are well-integrated into STAAD. Pro, ensuring compliance with safety norms.
- Comparative studies confirm that STAAD. Pro delivers faster and more reliable results than manual calculations.

3. METHODOLOGY

The methodology followed in the analysis and design of the multi- storeyed (G+4) residential building involved both conventional and software-based approaches. The process was divided into sequential phases to ensure the accurate modeling, analysis, and design of structural elements. The two major software tools used were AutoCAD and STAAD. Pro.



3.1 AUTOCAD

AutoCAD is a widely used computer-aided design software developed by Autodesk that enables users to create and edit 2D and 3D drawings, models, and sketches. It is a versatile tool used across various industries, including architecture, engineering, and interior design etc.

3.2 STAAD.PRO.

STAAD. Pro features a state-of-the-art user interface, visualization tools, and powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD. Pro is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

This project involves analysis and design of multi-storeyed (G+4) using a very popular designing software STAAD. Pro. The design software STAAD. Pro is chosen because of its following advantages:

- Easy to use interface
- Conformation with the Indian Standard Codes
- Versatile nature of solving any type of problem
- Accuracy of the solution

4 GEOMETRIC DETAILS

The Geometric details of the project is presented in the below table.

S. NO	PROJECT DESCRIPTION	REMARK
1	Type of structure	Residential
2	Total area	2372.63 sq. ft.
3	No of floors	G+4
4	No of flats	8
5	Beam size	230 x 450 mm
6	Column size	230 x 450 mm
7	Footing size	2.8 x 2.8 m
8	Grade of steel	415 N/mm^2
9	Grade of concrete	20 N/mm^2
10	SBC	150 kN/m^2

4.1 ARCHITECTURAL DRAWINGS

The architectural drawings from figures 1 to 5 shows building plan, slab layout, beam layout, column layout and footing layout

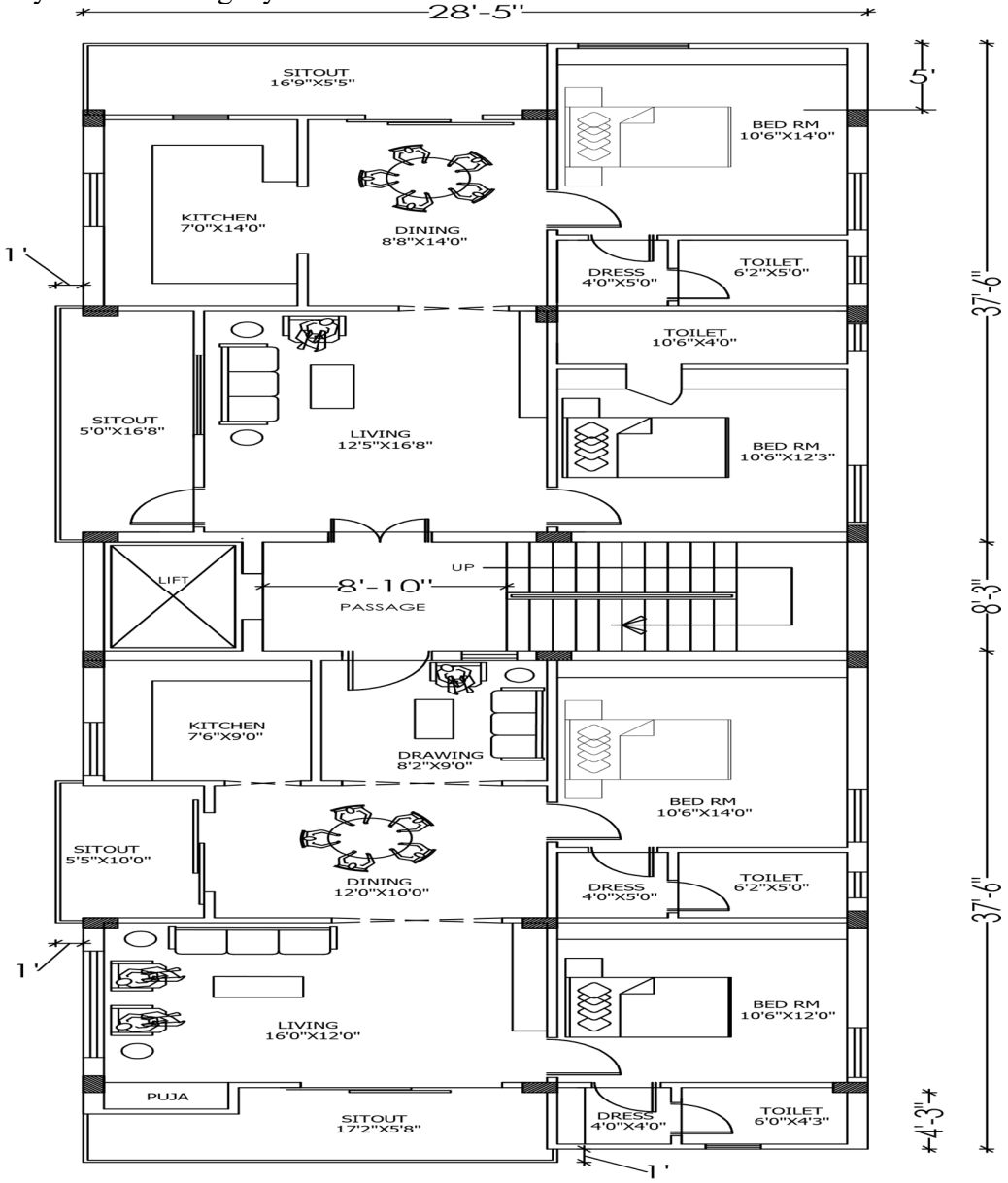


Figure 1 BUILDING PLAN

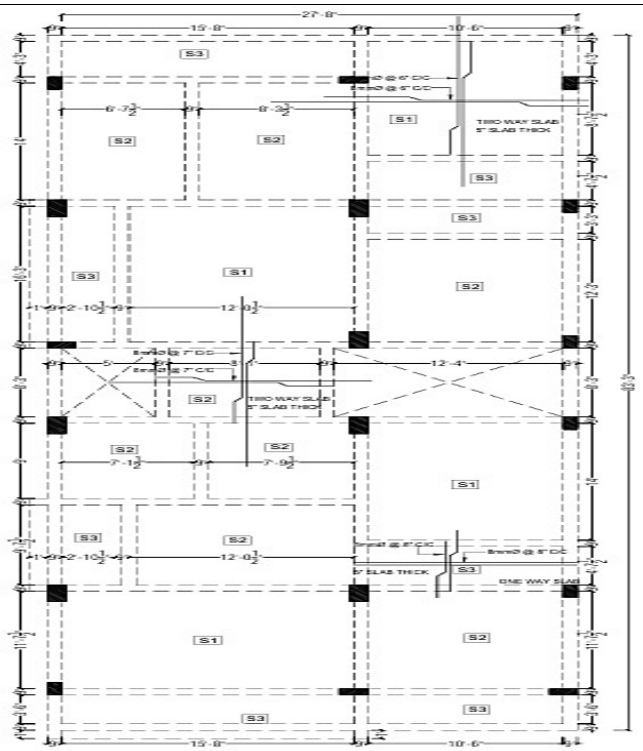


Figure 2 SLAB LAYOUT

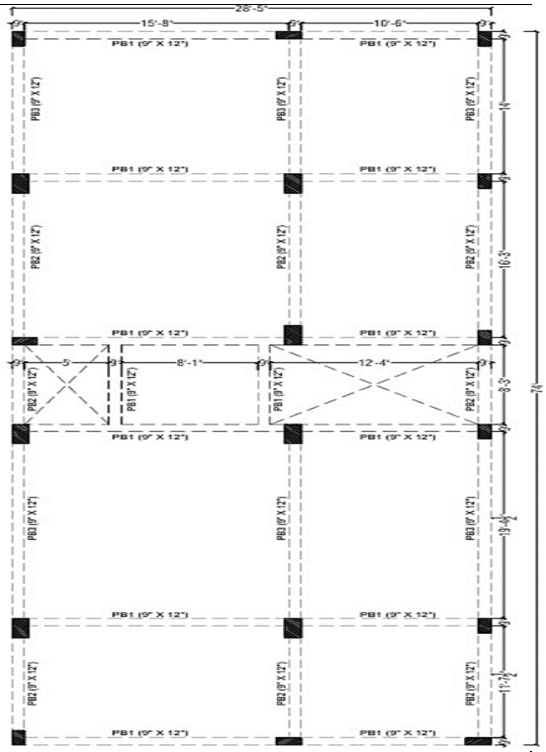


Figure 3 BEAM LAYOUT

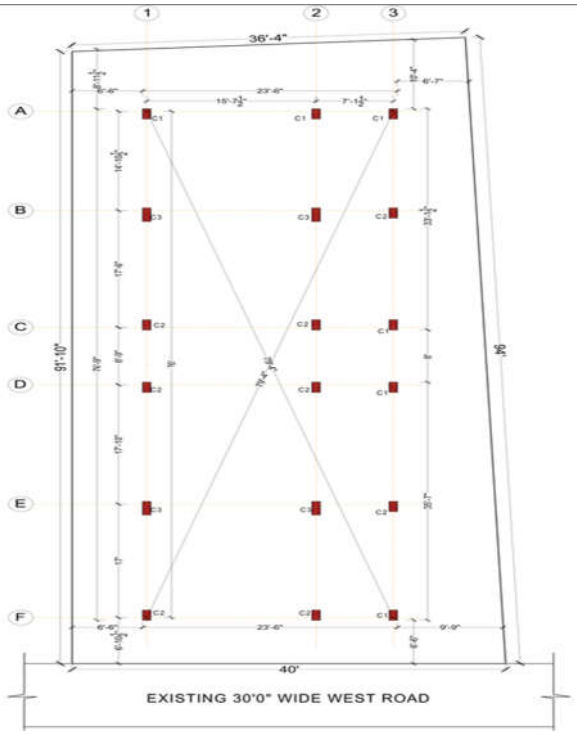


Figure 4 COLUMN LAYOUT

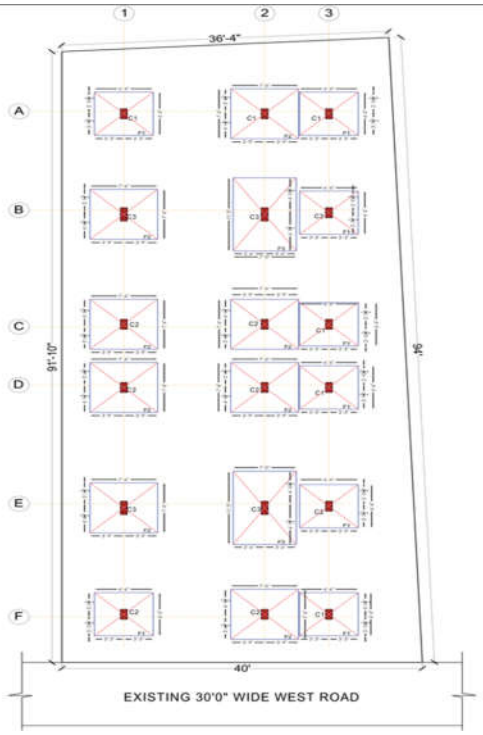


Figure 5 FOOTING LAYOUT

5.TYPES OF LOADS USED

- Dead Load
- Live Load

5.1 Dead Load

The first vertical load that is considered is 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 buildings. The dead load loads may be calculated from the dimensions of various members and their unit 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^2 and 25 kN/m^2 respectively.

5.2 Live Load

The second vertical load that is considered in design of a structure is imposed loads or live loads. Live loads are either movable or moving loads without any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. It is one of the major loads in the design. The minimum values of live loads to be assumed are given in IS 875 (part 2).

5.2.1 Wall Lad

Outer wall load = wall thickness X Height X density

= 0.23 X 3 X 20

Outer wall load = 13.8 kN/m

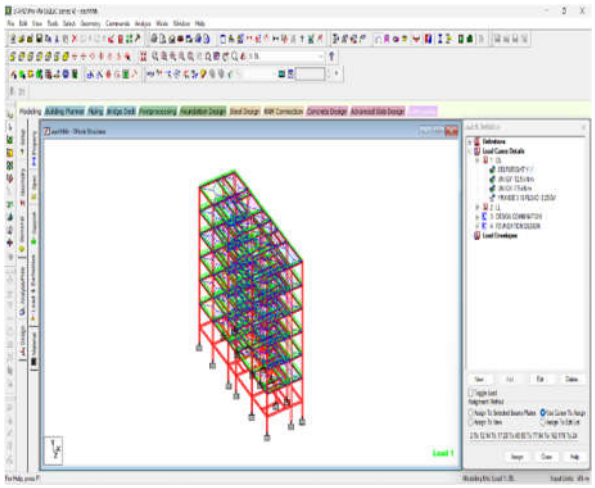


Figure 6 Self weight shown in red color

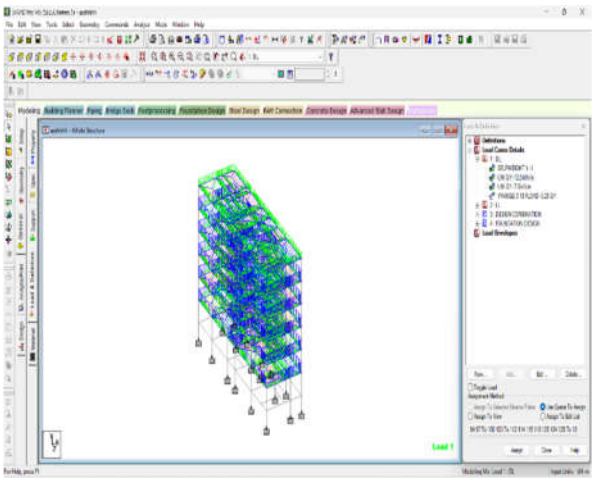


Figure 7 outer wall load

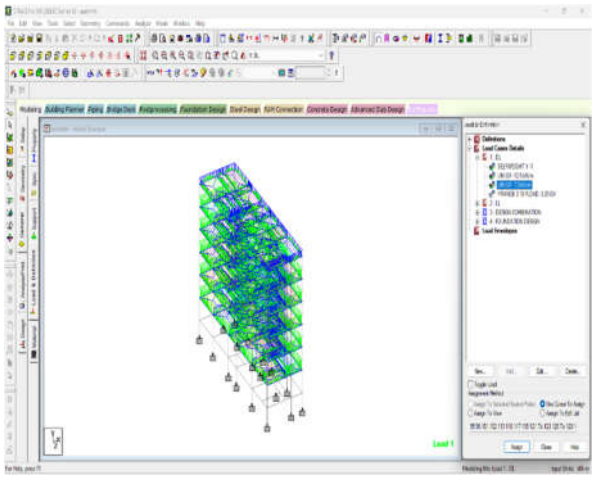


Figure 8 Internal Wall Load

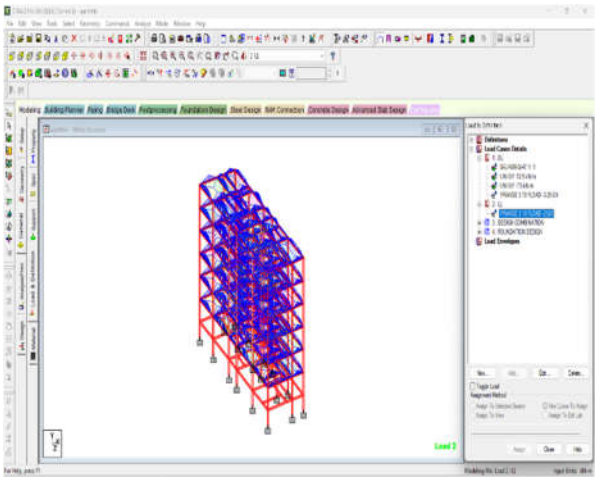


Figure 9 Live Load

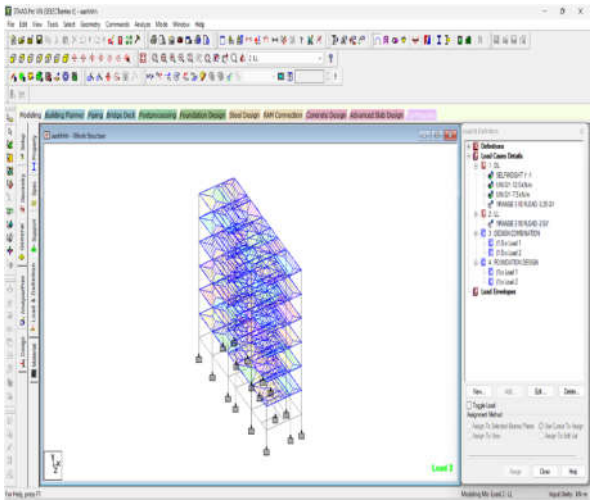


Figure 10 Floor Load

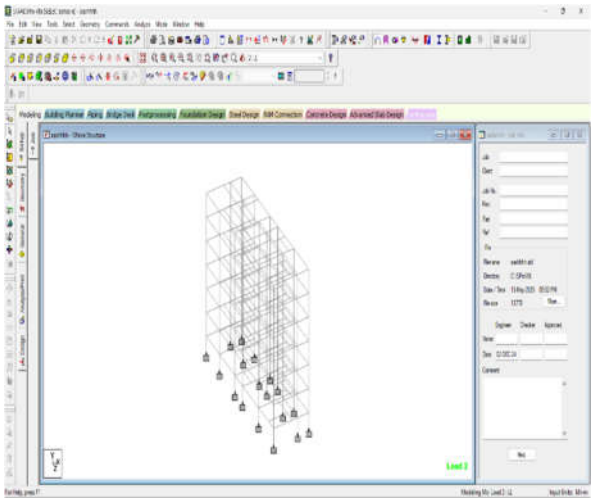


Figure 11 3-D View of the Model

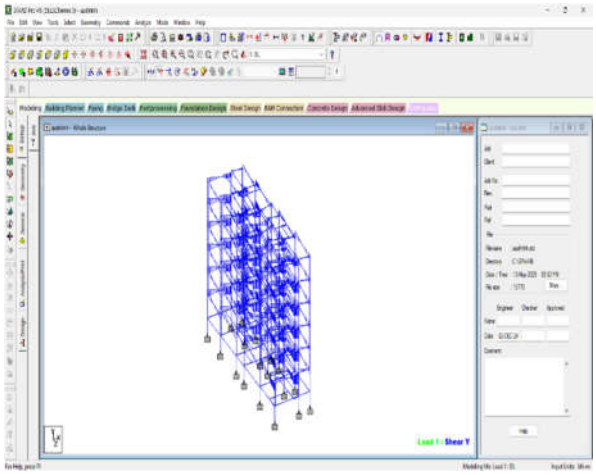


Figure 12 Showing Shear Forces of all the beams

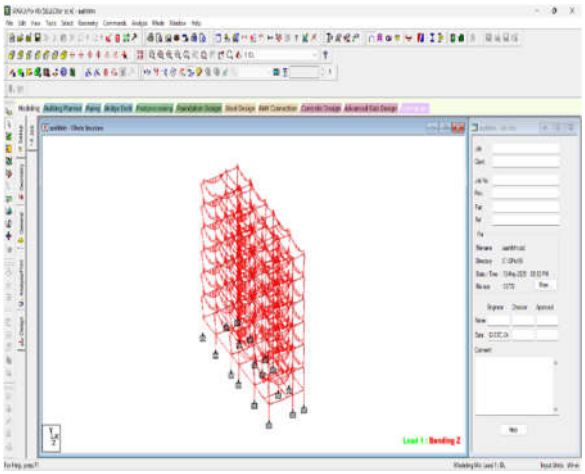


Figure 13 Showing Bending Moments of all the beams

6. STRUCTRE DESIGN

6.1 Beam design (Beam no.136)

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B E A M N O. 136 D E S I G N R E S U L T S

M20 Fe415 (Main) Fe415 (Sec.)

LENGTH: 4530.0 mm SIZE: 230.0 mm X 450.0 mm COVER: 25.0 mm

DESIGN LOAD SUMMARY (KN MET)

SECTION 0.0 mm 1132.5 mm 2265.0 mm 3397.5 mm 4530.0 mm

TOP 305.07 0.00 0.00 0.00 501.05

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

BOTTOM 0.00 197.86 197.86 197.86 0.00

REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 1132.5 mm 2265.0 mm 3397.5 mm 4530.0 mm

TOP 4-10í 3-10í 3-10í 3-10í 7-10í

REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 2 layer(s)

BOTTOM 3-10í 3-10í 3-10í 3-10í 3-10í

REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

SHEAR 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í

REINF. @ 145 mm c/c @ 145 mm c/c @ 145 mm c/c @ 145 mm c/c @ 145 mm c/c

SUMMARY OF PROVIDED REINF. AREA

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 645.0 mm AWAY FROM START SUPPORT

VY = 47.86 MX = 1.14 LD= 3

Provide 2 Legged 8í @ 145 mm c/c

SHEAR DESIGN RESULTS AT 712.9 mm AWAY FROM END SUPPORT

VY = -57.44 MX = 1.14 LD= 3

Provide 2 Legged 8í @ 145 mm c/c

6.2 Column design (Column no.60)

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C O L U M N N O. 60 D E S I G N R E S U L T S

M20 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3000.0 mm CROSS SECTION: 450.0 mm X 230.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 3 BRACED LONG(Z) /SHORT(Y)

DESIGN AXIAL FORCE (Pu) : 933.40

About Z About Y

INITIAL MOMENTS : 8.42 20.67

MOMENTS DUE TO MINIMUM ECC. : 18.67 19.60

SLENDERNESS RATIOS : 13.04 6.67

MOMENTS DUE TO SLENDERNESS EFFECT : 18.26 0.00

MOMENT REDUCTION FACTORS : 0.41 1.00

ADDITION MOMENTS (Maz and May) : 7.43 0.00

TOTAL DESIGN MOMENTS : 26.10 20.67

REQD. STEEL AREA : 1242.00 Sq.mm.

REQD. CONCRETE AREA: 102258.01 Sq.mm.

MAIN REINFORCEMENT : Provide 12 - 12 dia. (1.31%, 1357.17 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 1306.89 Muz1 : 28.61 Muy1 : 63.20

INTERACTION RATIO: 0.97 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 3

Puz : 1341.70 Muz : 30.64 Muy : 68.70 IR: 0.88

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6.Conclusion:

1.By Using STADD Pro, analysis and design of multistoried building is easier and quick process than manual process.
2.Proposed size of the beam and column can be safely used in the structure.
3.The structure is safe in shear, bending and deflection.
4.The structure taken is stable and structurally defined using various loads and combination.
5.By using STAAD. Pro, performed gravity loading analysis. So that, the results obtained in STAAD. Pro is more effective as compared to analysis and design performed by theoretical method.

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