



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 6, June 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Analysis and Design of Multi-Storey (G+10) Residential Building Using STAAD Pro

Sharath B^[1], Hemadri Reddy V^[2], Akash^[3], Ashwini R^[4], Mamatha M^[5]

^[1]Assistant Professor, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India

^[2]U.G. Student, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India

^[3]U.G. Student, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India

^[4]U.G. Student, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India

^[5]U.G. Student, Department of Civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, India

ABSTRACT: Structural planning is an art and science that combines creativity and technical knowledge to design structures that are cost-effective, functional, and able to withstand the intended loads and environmental conditions. In today's competitive world, the use of software has become increasingly prevalent in the field of structural planning. Software tools like STAAD Pro, AutoCAD, and others offer advanced capabilities for analyzing and designing structures. The project involves the analysis and design of a multi-storey (G+10) residential building using STAAD Pro software while considering seismic loads, in accordance with IS Codal provisions. The objective is to create an economical, serviceable, and durable structure. The structure is analyzed using STAAD Pro software to gain insights into its behaviour and response. Manual calculations are used to design the building's structural elements like columns, beams, slabs, staircase, and shear walls incorporating necessary outputs from STAAD Pro. STAAD Foundation software is employed for foundation design. AutoCAD is utilized for drafting and detailing. Loads acting on the members are considered according to IS 875: 1987 (Part 1, Part 2), while seismic loads are applied as per IS 1893: 2016.

KEYWORDS: Analysis, Design, STAAD Pro, Seismic Loads, Residential Building and Multistoried.

I. INTRODUCTION

Civil engineering plays a crucial role in constructing structures that are efficient and fulfill their intended purpose. This project focuses on the analysis and design of a G+10 residential building with four 2 BHK flats on each floor and a floor-to-floor distance of 3m. To accomplish this, the software tool chosen is STAAD Pro, renowned for its user-friendly interface, adherence to Indian Standard Codes, versatility in problem-solving, and accuracy of solutions. Seismic analysis is a vital aspect of the project to ensure the building can withstand earthquakes without failure. This involves following proper procedures and considering factors such as structural loads, geometry, support conditions, and material properties. By conducting a thorough analysis using STAAD Pro, structural engineers can optimize the design and ensure the building's safety and stability. The primary objective of this project is to perform a comprehensive analysis of the multi-storey building, considering all possible load combinations and designing all structural elements to fulfill their intended function. Through the utilization of STAAD Pro and adherence to seismic analysis principles, the project aims to achieve a structurally sound building in seismic zone 5, prioritizing the structural integrity and safety of the residents.

II. LITERATURE SURVEY

The project on analyzing and designing a multistoried (G+10) residential building using STAAD Pro software is supported by relevant literature from various research papers in India.

The papers mentioned can be grouped based on their focus and findings. The first group includes papers by Rashmi Agashe [1], Mahesh Pawar [2], and Sreeshna K.S [4]. These papers primarily center around the analysis and design of buildings using the STAAD Pro software. They highlight the efficiency and advantages of using STAAD Pro in various aspects of the analysis and design process, such as structural analysis, determining deflection limits, calculating required reinforcement, and preparing structural layouts. The second group consists of papers by B Ramakrishna [3] and Abhishek K. Patil [5]. These papers specifically address seismic analysis and

design considerations. B Ramakrishna examines variations in shear force, bending moment, and deflection values across different seismic zones, noting progressive increases from Zone II to Zone V. Abhishek K. Patil compares the structural response of a building with and without seismic loads, revealing similarities in bending moment and shear force, but differences in axial force and displacement.

These studies emphasize the importance of utilizing STAAD Pro for efficient analysis and design of multistoried residential building. The research supports the significance and necessity of the project in developing a safe and reliable structure.

III. METHODOLOGY

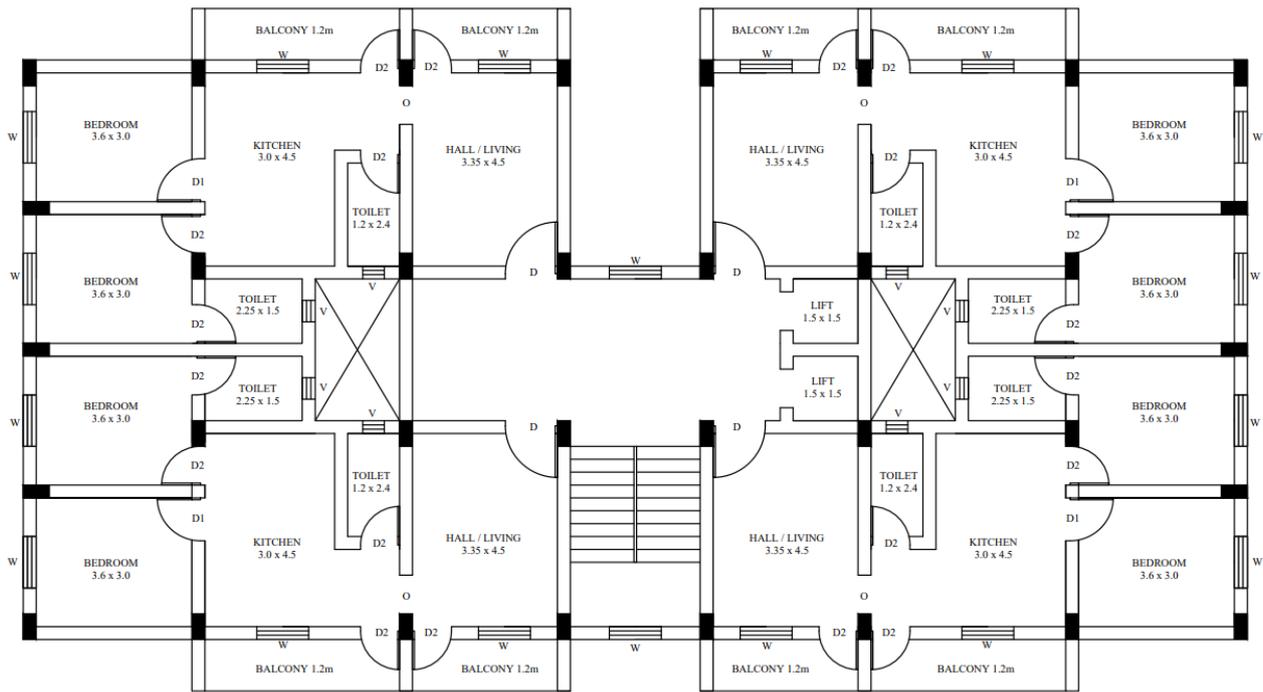
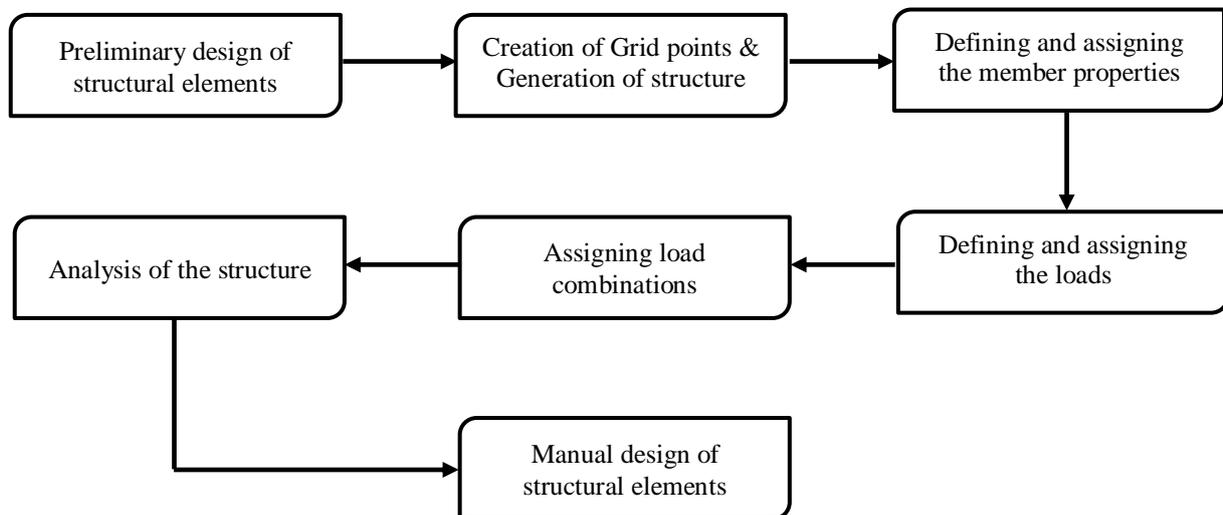


Fig 1: Project Plan

The process of analyzing and designing a structure using STAAD Pro can be divided into several steps:



IV. MODELLING AND ANALYSIS

1. Project Details

The project involves the construction of a residential building with the following specifications. It is an RCC framed structure with walls made of cement concrete blocks, having a thickness of 300 mm. The building is designed to accommodate 2 BHK (bedroom, hall, kitchen) apartments. The plot size for the construction is 28.3 meters in length and 15.9 meters in width. The building consists of 11 storeys, including the ground floor, making it a G+10 structure. There is one doglegged staircase provided for vertical circulation. The shear walls in the building have a thickness of 300 mm. The floor-to-floor height is set at 3 meters. The concrete used for construction is of grade M25, while the steel reinforcement is of grade Fe-500. These specifications serve as the foundation for the design and construction of the residential building, ensuring its structural integrity and durability.

2. Generation of Structure

The structure's nodes are meticulously positioned at the designated center-to-center distances between columns as per the building plan. These nodes are then interconnected using beams, establishing a skeletal framework. To create the slabs, the plate command is utilized, allowing for the formation of horizontal floor elements. Additionally, the shear wall surfaces are drawn using the surface command, ensuring the presence of adequate structural elements to resist lateral forces. By accurately defining the nodes, beams, slabs, and shear walls, the structural model is prepared for further analysis and design considerations.

3. Defining and assigning the member properties

In the analysis and design process of the multistorey residential building using STAAD Pro, member properties are a crucial aspect. Based on preliminary calculations, the following member properties have been assigned to the structural elements:

- ✓ Column = 450 mm × 750 mm
- ✓ Beam = 450 mm × 450 mm
- ✓ Slab thickness = 150 mm
- ✓ Shear wall thickness = 300 mm

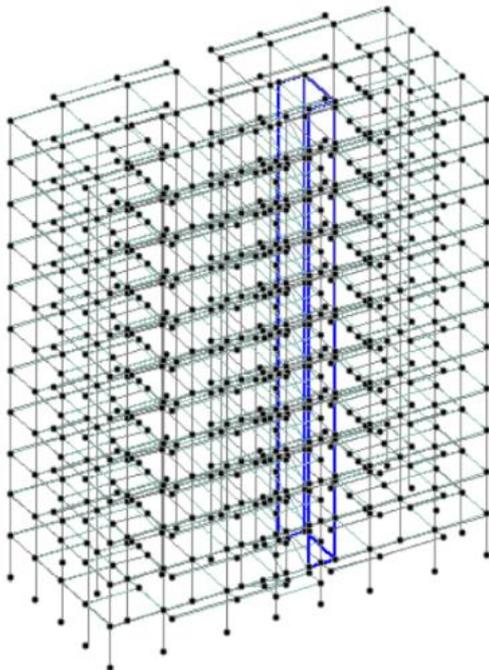


Fig 2: Skeletal Diagram of the Structure

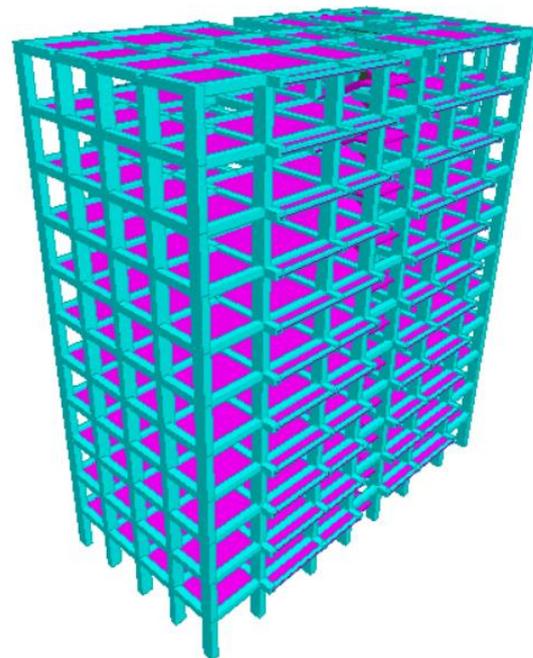


Fig 3: 3D Rendered view of the Structure

Assigning Supports

To provide stability and proper load distribution, the base supports of the structure were assigned as fixed. The support generation process was facilitated using the support generator feature within the STAAD Pro software.

4. Assigning Loads

i) Dead Loads

a. Self-weight

The self-weight of the structure was automatically generated by STAAD Pro using the self-weight command within the load case column. This accounted for the weight of the entire structure itself.

b. Wall load

The wall load was manually calculated, taking into account the density of concrete block walls as 20 kN/m³, as per IS 875 (Part 1) [7]. A wall load of 15.3 kN/m was assigned to the structure.

c. Floor finish load

A floor finish load of 2 kN/m² was assigned to account for the additional weight of the finishing materials applied to the floors.

ii) Live Loads

The live loads on the structure were assigned based on the guidelines provided by IS 875 (Part 2) [8]. The following loads were applied for different occupancies in a residential building:

- ✓ All rooms and kitchens = 2 kN/m²
- ✓ Staircase and corridors = 3 kN/m²
- ✓ Toilet and bathrooms = 2 kN/m²
- ✓ Balconies = 3 kN/m²

ii) Seismic Loads

The seismic load for the structure is determined based on the provisions of IS 1893-2016 code [9]. STAAD Pro software provides a seismic load generator that follows the specified IS code requirements. When assigning seismic loads, the following parameters need to be considered:

- ✓ Seismic zone: Zone 5
- ✓ Response reduction factor: 5
- ✓ Zone factor: 0.36
- ✓ Importance factor: 1

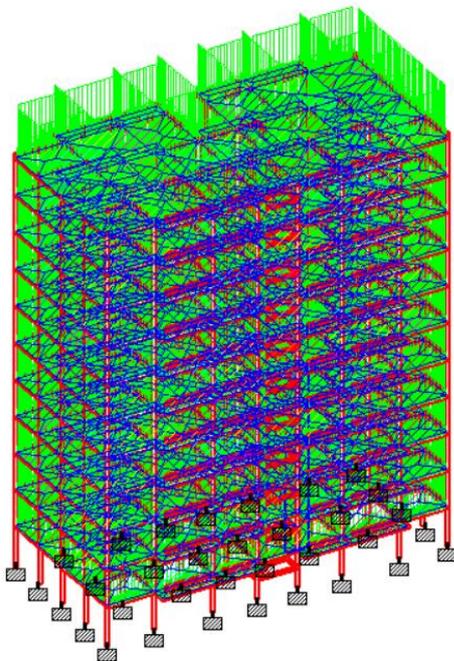


Fig 4: Structure under Dead Load

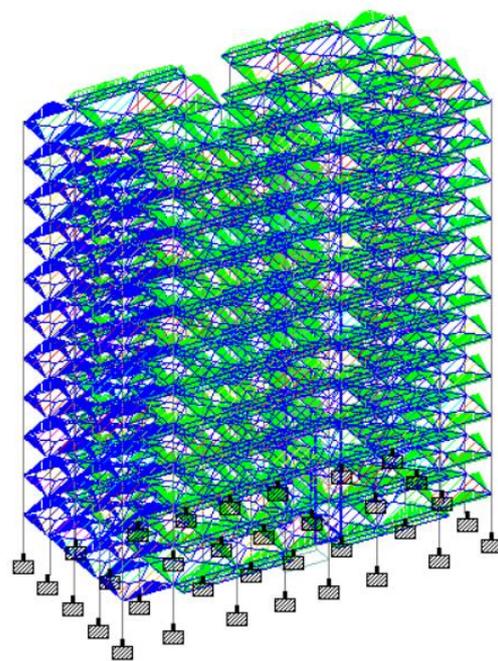


Fig 5: Structure under Live Load

5. Load Combinations

The load combinations for the structure are determined as per the guidelines provided in IS 456:2000. When considering both wind and seismic loads, the maximum of the two is considered since wind and seismic loads typically do not act on the structure simultaneously, as per the IS code. In the case of a structure designed in seismic zone 5, the seismic loads are expected to be the governing loads compared to wind loads. Therefore, only seismic loads are



considered for the analysis of the structure. The structure is analyzed by considering the following load combinations to ensure its strength and stability under different loading scenarios:

- | | |
|------------------------|------------------------|
| 1. 1.5 (DL + LL) | 8. 1.2 (DL + LL + EQz) |
| 2. 1.5 (DL + EQx) | 9. 1.2 (DL + LL - EQz) |
| 3. 1.5 (DL - EQx) | 10. 0.9DL + 1.5EQx |
| 4. 1.5 (DL + EQz) | 11. 0.9DL - 1.5EQx |
| 5. 1.5 (DL - EQz) | 12. 0.9DL + 1.5EQz |
| 6. 1.2 (DL + LL + EQx) | 13. 0.9DL - 1.5EQz |
| 7. 1.2 (DL + LL - EQx) | |

6. Analysis and Design

After assigning all the material properties and loads, the structure is subjected to analysis to ensure its integrity and stability. During the analysis process, any errors or warnings are checked to ensure the accuracy of the model. In this case, no errors or warnings were encountered, indicating that the structure was properly modelled and considered safe in all aspects. To proceed with the design process, the structure is designed for concrete based on the guidelines provided in the IS 456 code [6] and SP 16 [11]. Parameters such as clear cover, yield strength (f_y), characteristic compressive strength (f_{ck}), minimum diameter of main reinforcement for columns, and maximum diameter of bars used for design are specified. Furthermore, it is essential to specify which members are to be designed as beams and which members are to be designed as columns. This step helps in accurately designing the structural elements based on their intended function and load-bearing capacity.

7. Design Results

The design data obtained from the output file generated by STAAD Pro is used to design all the structural elements of the building, including columns, beams, slabs, and other components. This data contains crucial information such as member sizes, reinforcement details, bending moments, and shear forces. It is carefully analyzed and utilized to ensure that each element meets the necessary design criteria and requirements, considering factors such as material strengths and safety factors. This step is vital to ensure the structural integrity and stability of the building structure.

8. Design of structural elements

Due to the poor structural detailing capabilities of STAAD Pro, the detailing of all the structural elements is done manually. The reinforcement area provided by STAAD Pro is compared with manual design calculations, and it is observed that both are nearly the same. Hence, the reinforcement area from STAAD Pro is considered, and the detailing of columns and beams is carried out manually using AutoCAD software. This manual detailing process ensures accurate and precise reinforcement placement in the structural elements. An example of this manual detailing process is shown below.

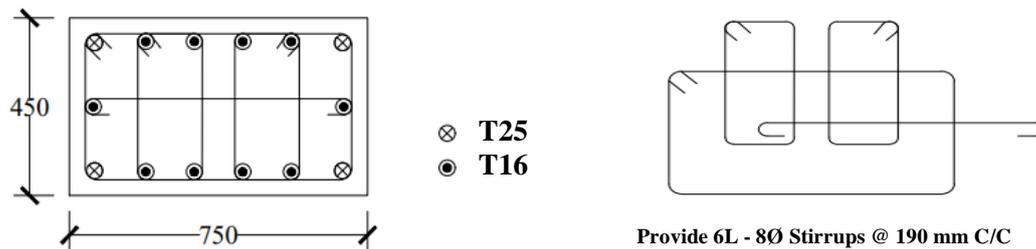


Fig 6: Column Detailing

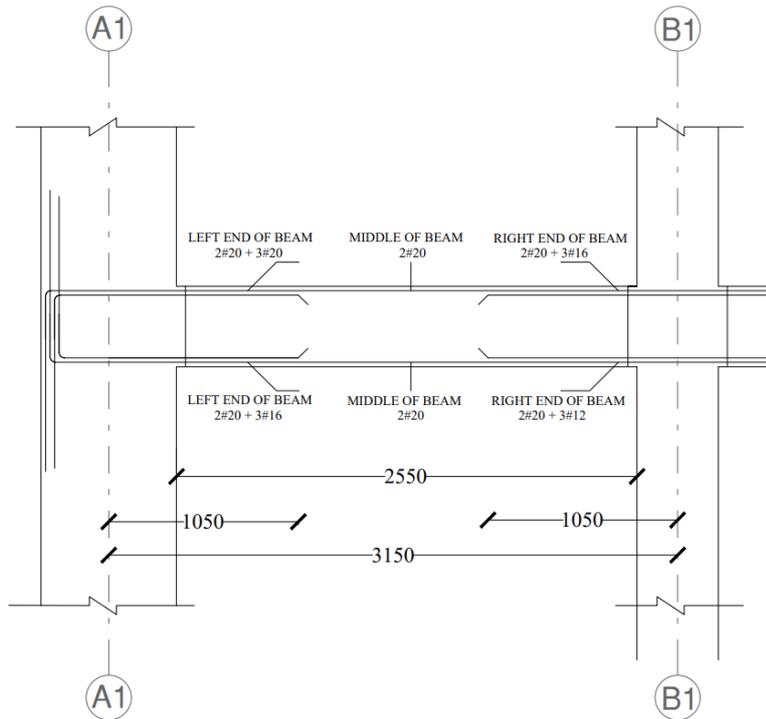


Fig 7: Beam Detailing

The slabs and staircase of the structure were designed manually using the IS 456 method. The shear wall was also designed manually by considering the bending moments and shear forces obtained from STAAD Pro, following the IS 13920 - 2016 code provisions [10]. For the footings, isolated footings were designed initially. In cases where there was an overlap of isolated footings due to heavy loads, combined footings were designed. The design of the footings was carried out using Staad Foundation Software. The footing plan is shown below.

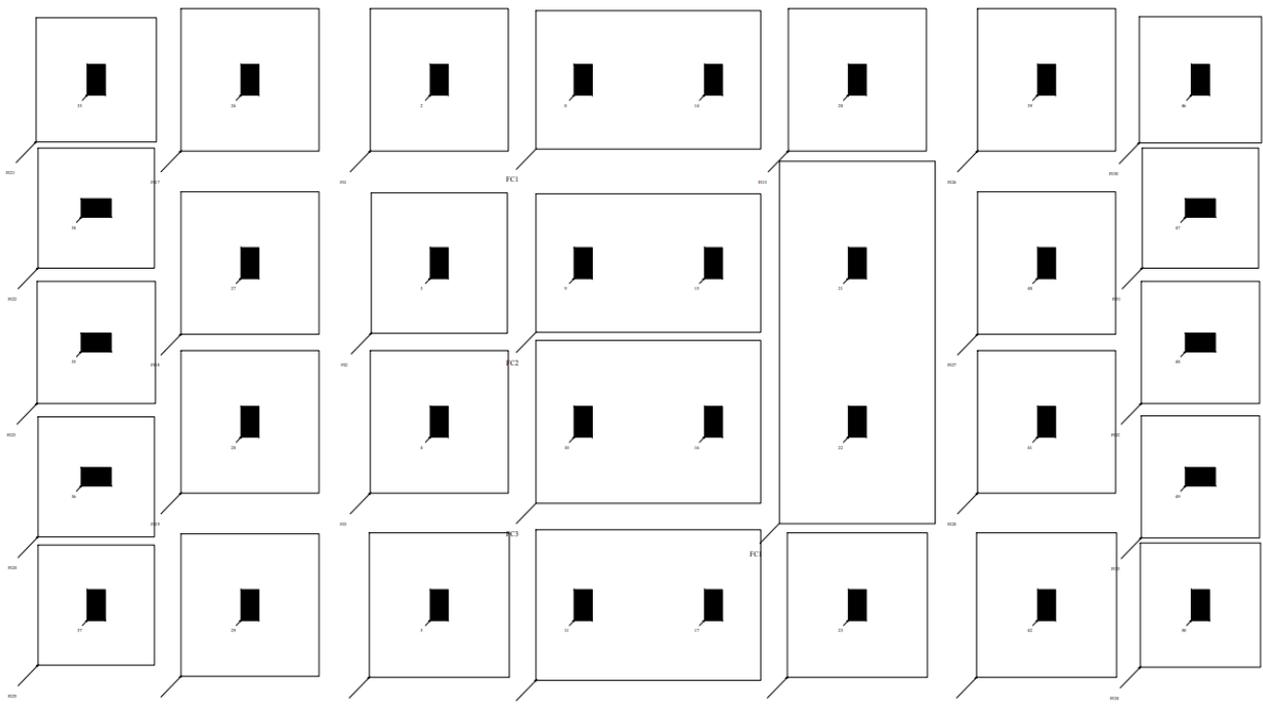


Fig 8: Footing Plan

V. CONCLUSION

After a comprehensive analysis and design process for a G+10 storey residential building, the following are the conclusions reached:

1. The structural analysis performed using STAAD Pro software verified the structural integrity of the building's components, confirming their safety against shear and flexure. This ensures that the design meets the necessary safety requirements.
2. Manual detailing of columns and beams was found to offer more precise and worker-friendly designs for on-site construction, highlighting the importance of human expertise in the design process.
3. The proposed sizes of the structural elements were deemed appropriate for the building's requirements.
4. Additionally, the G+10 storey residential building demonstrated its capacity to withstand all anticipated loads, ensuring structural stability and safety.
5. The calculation of a total concrete volume requirement of 907 cubic meters provides valuable information for the construction planning and material procurement processes.
6. The same procedure can be followed to analyze the structure in different seismic zones, and the results can be compared.

Overall, the comprehensive analysis and design process confirm the structural integrity and safety of the G+10 storey residential building. The chosen dimensions and design elements effectively support the intended loads, while manual detailing enhances the construction process. The structure demonstrates its capacity to withstand loads and provides useful information for construction planning and material procurement. Additionally, the procedure used can be replicated for structures in different seismic zones for comparison purposes.

REFERENCES

- [1] Agashe, R., Baghele, M., Deshmukh, V., Khomane, S., Patle, G. and Yadav, K., 2020. To Study Analysis and Design of Multi-Storey building using STAAD-pro. and Comparing with Manual Calculations. *International Research Journal of Engineering and Technology (IRJET) Volume, 7*.
- [2] Pawar, M., Janorkar, V., Patel, R., Khedkar, H. and Chambulwar, S., Analysis and design of g+ 7 residential building using STAADPRO software.
- [3] Ramakrishna, B., Swetha, G., Shazia, S.A., Sai, K.K. and Dinesh, S.D.V., 2022, March. Analysis of Multi-Storied Building in Different Seismic Zones using STAAD Pro. In *IOP Conference Series: Earth and Environmental Science* (Vol. 982, No. 1, p. 012074). IOP Publishing.
- [4] Sreeshna, K.S., 2016. Analysis and Design of an Apartment building. *IJISSET-International Journal of Innovative Science, Engineering & Technology*, 3(3), pp.456-479.
- [5] Patil, A.K., Solanke, A.P., Dabhekar, K.R., Khedikar, I.P., Agrawal, R., Rajput, P.P. and Chavan, P.V., 2021, November. Comparative Analysis of Structure with and without Seismic Load. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1197, No. 1, p. 012028). IOP Publishing.
- [6] IS456, I.S.C., 2000. Plain and reinforced concrete—code of practice (fourth revision). *Bureau of Indian Standards, Manak Bhavan, 9*.
- [7] Bureau of Indian Standards (BIS), 1987. Code of practice for design loads (other than earthquake) for buildings and structures. *IS 875 (Part 1)*.
- [8] BIS, I., 1987. 875 (Part 2) Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.
- [9] IS 1893 (Part 1). (2016). IS 1893 (Criteria for Earthquake resistant design of structures, Part 1: General Provisions and buildings). Bureau of Indian Standards, New Delhi, 1893(December), 1–44.
- [10] BIS, I., 2016. 13920 (2016) Ductile design and detailing of reinforced concrete structures subjected to seismic forces—code of practice. *Bureau of Indian Standards, New Delhi*.
- [11] SP 16: 1980, Design Aids for Reinforced Concrete to IS: 456-1978, New Delhi, Bureau of Indian Standards.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.423



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

9940 572 462 6381 907 438 ijirset@gmail.com



www.ijirset.com

Scan to save the contact details