e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

ANALYSIS AND DESIGN OF G+3 RCC BUILDING

Adarsh Krishna[*1], Ankit Kumar Tiwari[*2], A.K.L. Srivastava[*3]
[*1,2,3]Department Of Civil Engineering, NIT Jamshedpur, India.
DOI : https://www.doi.org/10.56726/IRJMETS37798

ABSTRACT

This paper presents the design and analysis of a G+3 RCC (Reinforced Cement Concrete) building using Staad Pro software. The primary objective of the study is to analyze the structural behavior of the building under gravity loads, such as dead and live loads, without considering seismic and wind loads.

The building plan has dimensions of 38.65m x 11.1 m with a height of 12m. The building is divided into four floors, including the ground floor, and has a total of 45 columns with a cross-sectional area of 230mm x 450mm. The beams have a cross-sectional area of 230mm x 450mm, and the slab thickness is 130mm.

Keywords: Analysis, Design, RCC, STAAD, RCDC.

I. INTRODUCTION

The design and analysis of multi-story buildings is a complex and challenging task that requires careful consideration of numerous factors, including structural integrity, stability, and safety. One of the most common types of multi-story buildings is the G+3 RCC building, which is widely used in both residential and commercial construction projects. The design and analysis of such a building require the use of advanced software tools and analytical methods to ensure its structural stability and safety.

In this journal, we present the design and analysis of a G+3 RCC building using the Staad Pro software. The building comprises beams, columns, slabs, and footings, which were designed and analyzed in Staad Pro, and detailed drawings and scheduling were created using AutoCAD. The journal is organized into several sections, starting with a brief overview of the project and its objectives. This is followed by a literature review, which provides an overview of the existing research on the design and analysis of G+3 RCC buildings. Next, we discuss the methodology used in our study, including the software tools and analytical methods employed. We then present the results of our analysis, including detailed structural designs and drawings, and discuss the implications of our findings for the construction industry.

II. METHODOLOGY

2.1 Developing the Building Layout

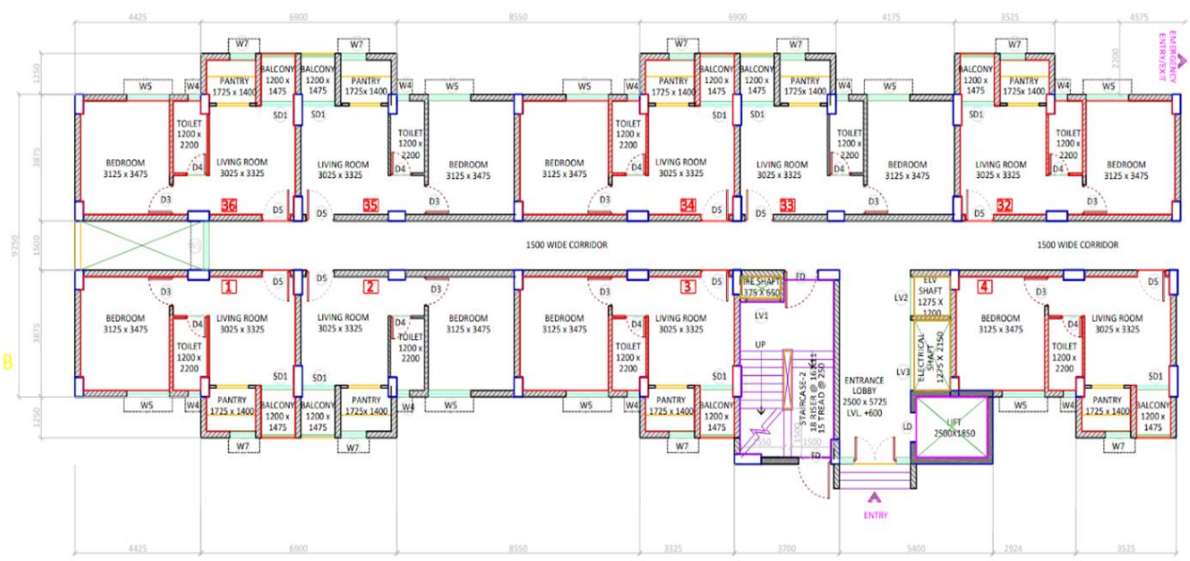


Fig. 1 Building Plan

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

2.2 Analysis of structure

In the analysis of an RCC building using STAAD Pro, the software is used to model the building's components, such as beams, columns, and slabs, and apply loads to simulate various operating conditions. The software can then perform a range of analyses, including linear and nonlinear static analysis, dynamic analysis, and seismic analysis, to determine the stresses, strains, and deflections in each component and evaluate its overall structural integrity.

2.2.1 Structure Modeling

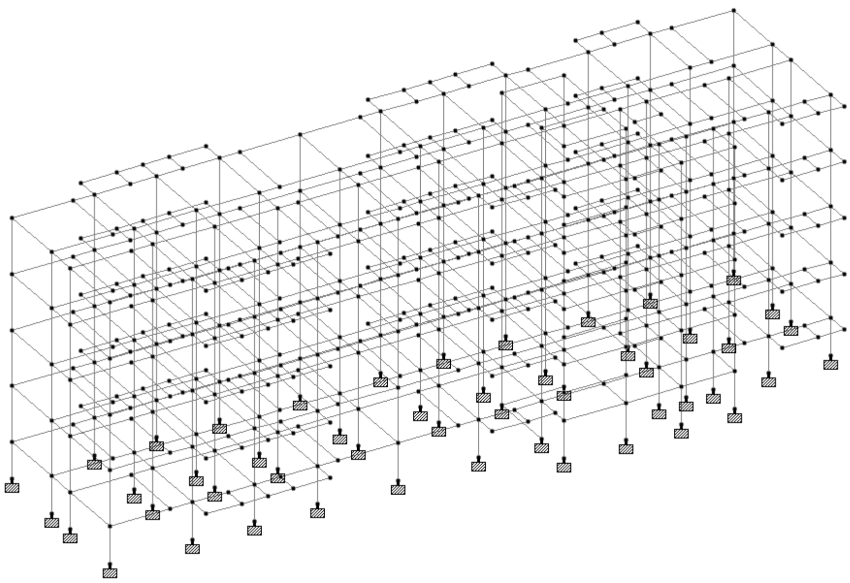


Fig. 2 Isometric view of model

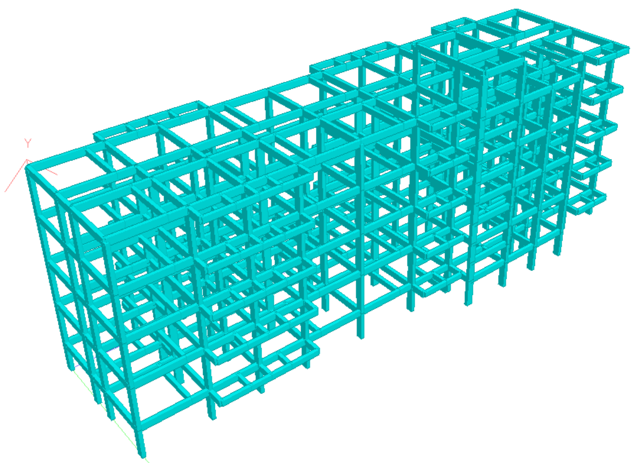


Fig. 3 Isometric view of model (3D Rendered)

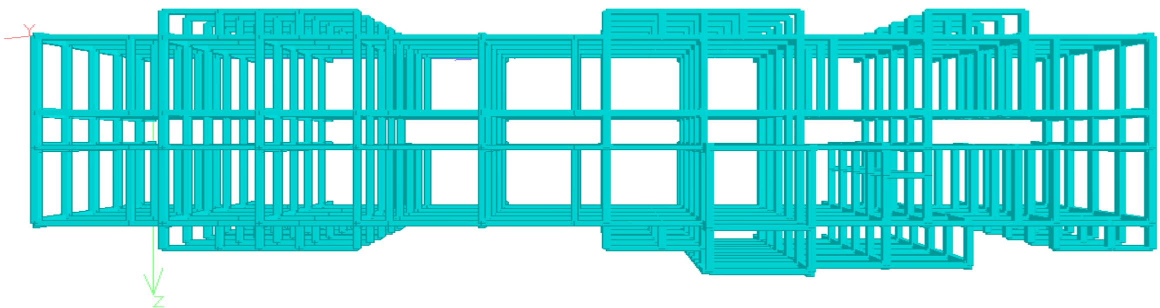


Fig. 4 Top View

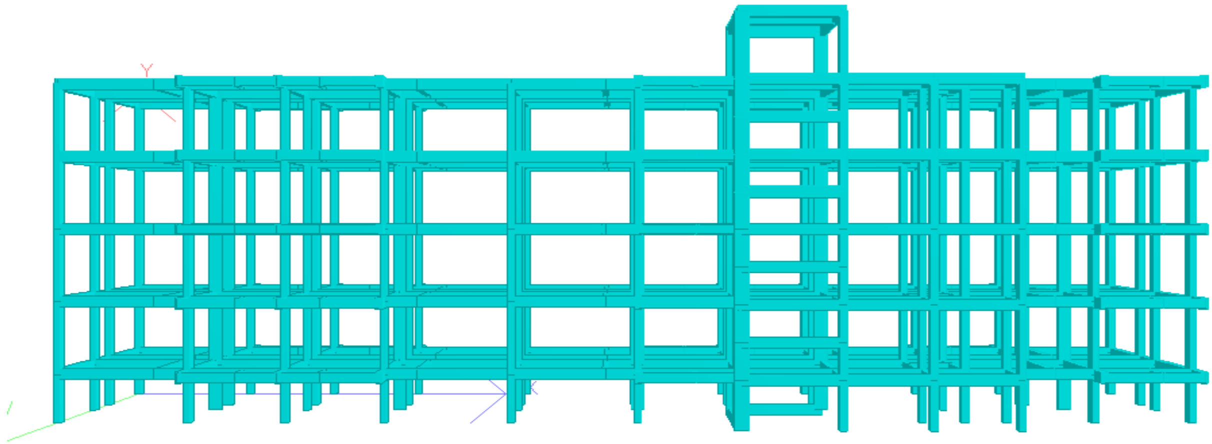
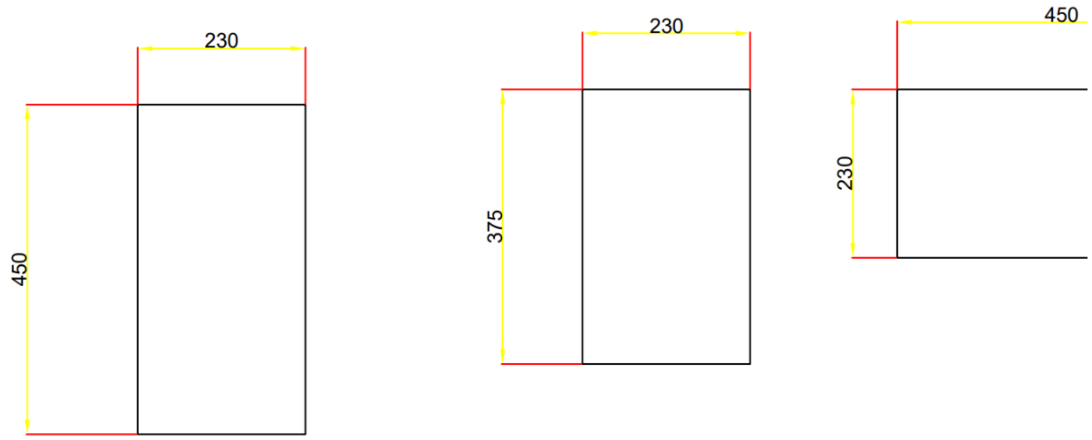
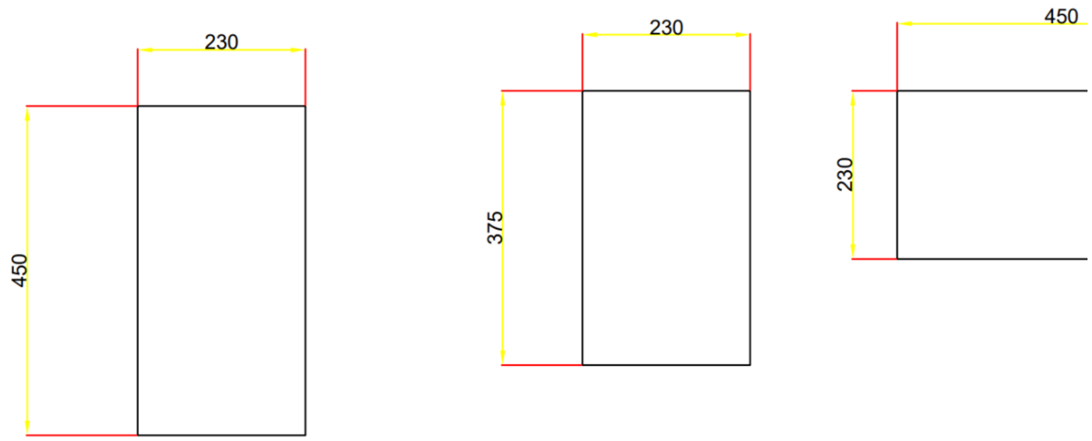
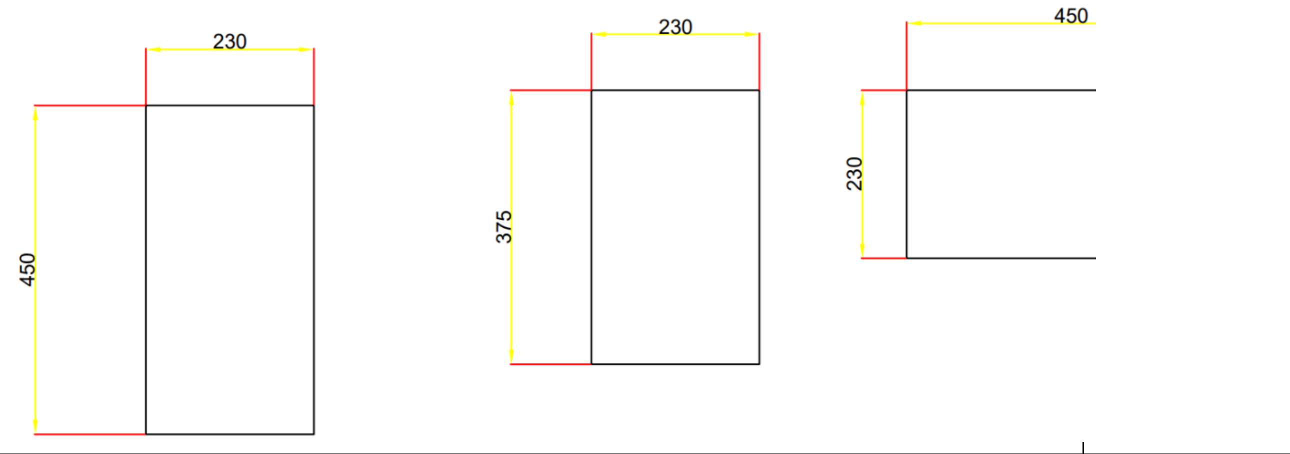


Fig. 6 Front view

2.2.2 Dimension of members

Table 1: Dimension of members

Section	Dimensions(mm)
Primary Beams (R2) 	230 x 450
Secondary Beams and Cantilever Beams (R3) 	230 x 375
Columns (R1)	230 x 450



Slab Thickness	130

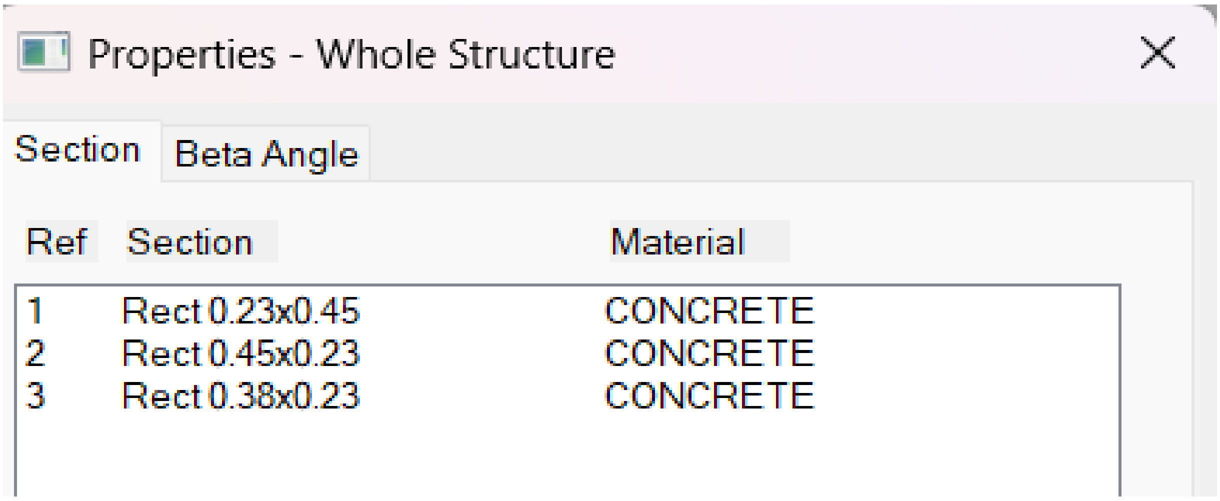


Fig .7 Section Properties

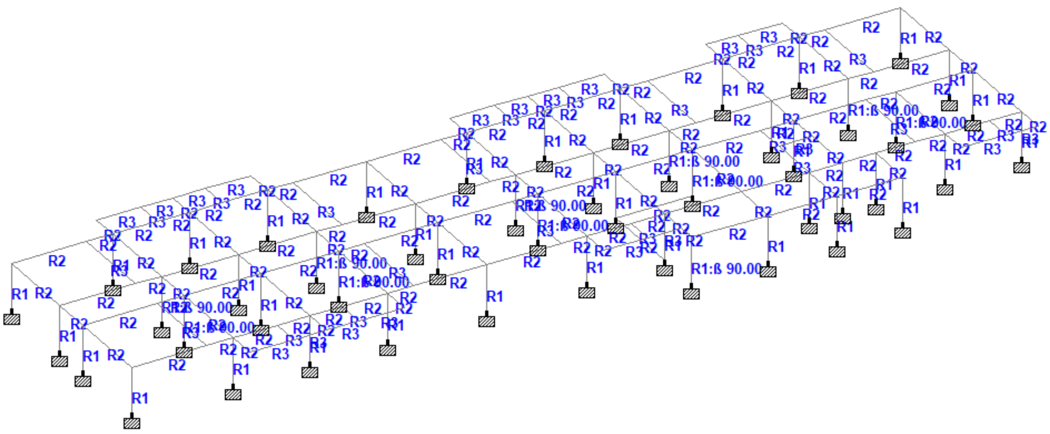


Fig. 8 Sections

2.2.3 Defining Loads and Load combinations

2.2.3.1 Dead Load

As per Indian Standard (IS) code, dead load refers to the weight of the structural components of a building, including walls, floors, roof, and any other fixed components. This weight remains constant and is always present, regardless of the occupancy or use of the building. IS code recommends that dead load calculations should be made based on the actual weight of materials used in construction. However, if the weight of the materials is not known, the code provides guidelines for estimating the dead load based on standard weights of materials.

Table 2: Dead Load of Building Components

Building Component	Dead Load (kN/m²)
Walls (including parapet walls)	0.20 to 1.50
Floors (including screed and finishes)	1.50 to 5.00
Roofs (including finishes)	0.75 to 2.00
Staircases (including landing)	3.00 to 5.00
Balconies	1.50 to 3.00

Table 3: Standard Weights of Building Materials

Building Material	Standard Weight (kN/m³)
Brickwork	19.2
Reinforced Cement Concrete (RCC)	25
Reinforcement Steel	78.5
Timber	5.0 to 10.0
Stone Masonry	25

Table 4: Additional Dead Load for Services

Services	Dead Load (kN/m²)
Electrical Fittings	0.5
Mechanical Services	1.5
Plumbing	0.75

2.2.3.2 Self Weight

Self-weight is a term used to describe the weight of a structure itself. In the design of buildings and other structures, it is important to account for the self-weight of the structure in order to ensure that it is able to withstand the stresses and forces that will be placed on it. The self-weight of a structure can be calculated based on a number of factors, including the type and thickness of materials used in construction, the shape and size of the structure, and other design parameters.

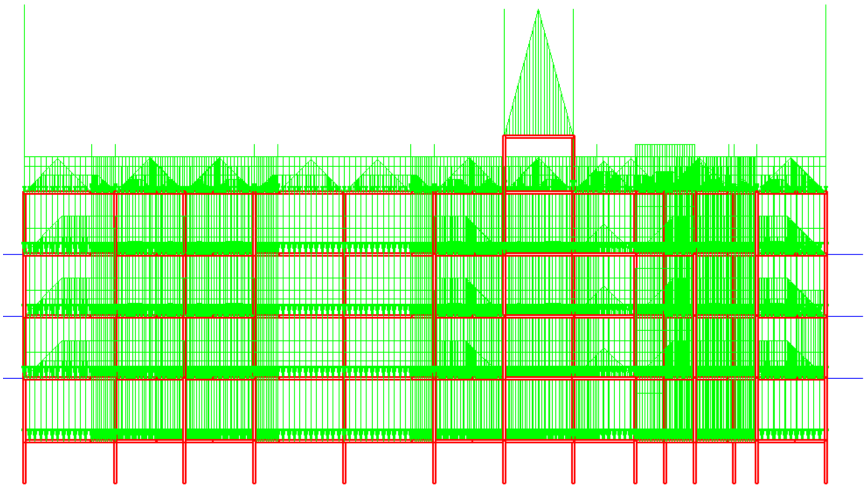


Fig. 9 Self weight Loading

2.2.3.3 Member Load

A member load refers to the load that is applied to a particular member of a structure, such as a beam or column. In the design of structures, it is important to accurately determine the loads that will be placed on each member in order to ensure that it is able to withstand the stresses and forces that will be applied to it. Member loads can come from a variety of sources, including the weight of the structure itself, as well as external forces such as wind, snow, or seismic activity.

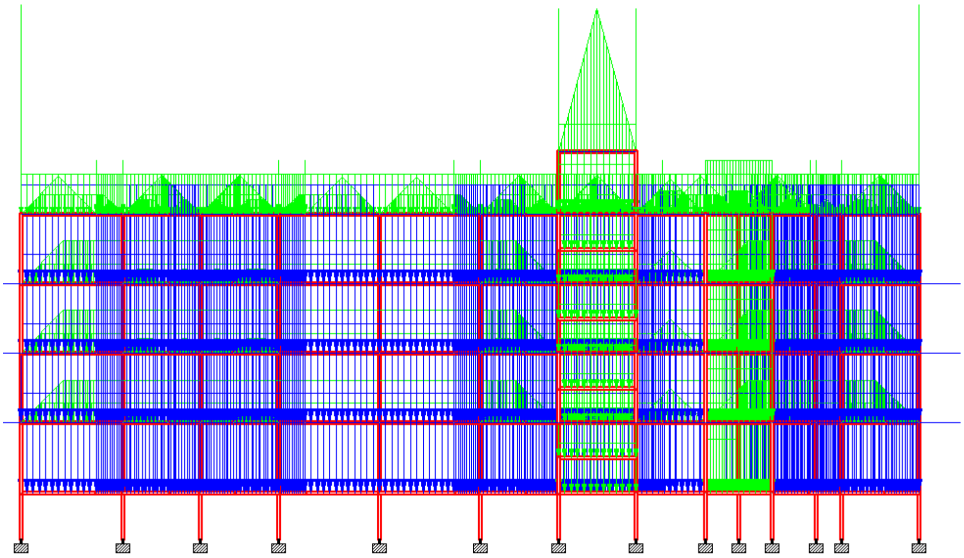


Fig.10 Wall Loading

2.2.3.4 Floor Load

A floor load refers to the weight or load that a floor of a building is designed to support. It is an important consideration in the design of buildings, particularly for spaces that will be used to hold heavy equipment or machinery, or for areas that will experience high foot traffic. The floor load for a building is typically calculated based on a number of factors, including the weight of the materials used in construction, the anticipated use of the space, and the weight of any equipment or furnishings that will be placed on the floor.

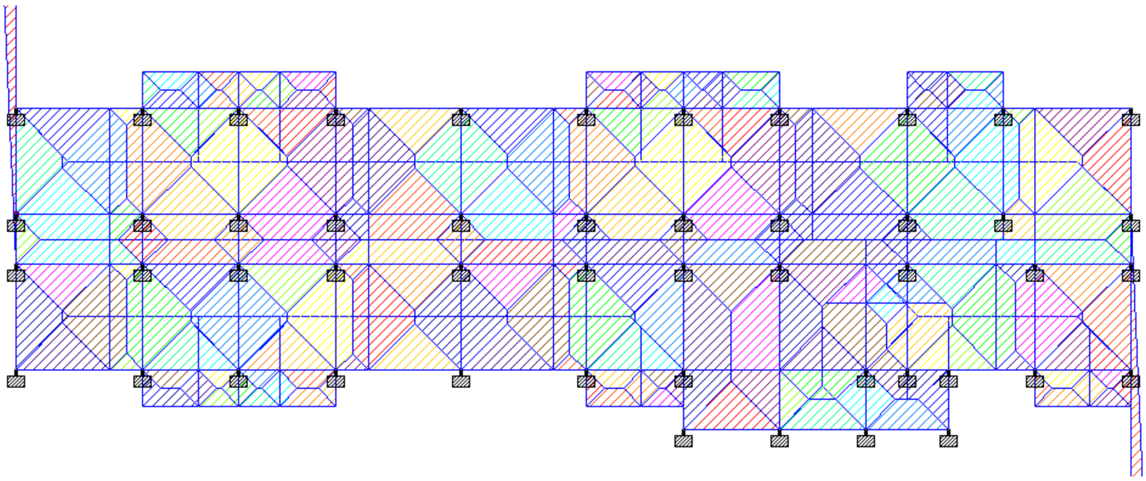


Fig.11 Floor Load

2.2.3.5 Live Load

Live load, also known as imposed load, is the weight of all the movable and temporary loads that a building or structure can be subjected to during its intended use. It includes the weight of people, furniture, equipment, and other temporary loads that are not considered part of the permanent structure.

IS code specifies the live load requirements for different types of structures, based on their intended use and occupancy. For example, the live load for residential buildings is lower than that for commercial or industrial buildings.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

Note: These values are minimum live loads and are subject to change based on the specific requirements of the building or structure. It is important to consider the type of occupancy, intended use, and other factors when determining the live load for a particular structure.

Table 5: Live Loads

Type of Structure	Intended Use	Live Load (kN/m^2)
Residential Buildings	Houses, apartments, and similar buildings	2
Office Buildings	Offices, banks, and similar buildings	3
Assembly Buildings	Theaters, auditoriums, churches, and similar buildings	4
Educational Buildings	Schools, colleges, and similar buildings	3
Hospital Buildings	Hospitals, clinics, and similar buildings	2.5
Hotel Buildings	Hotels and motels	3
Mercantile Buildings	Stores, shopping centers, and similar buildings	3
Industrial Buildings	Factories, warehouses, and similar buildings	5
Storage Buildings	Warehouses and similar buildings for storage of goods only	3

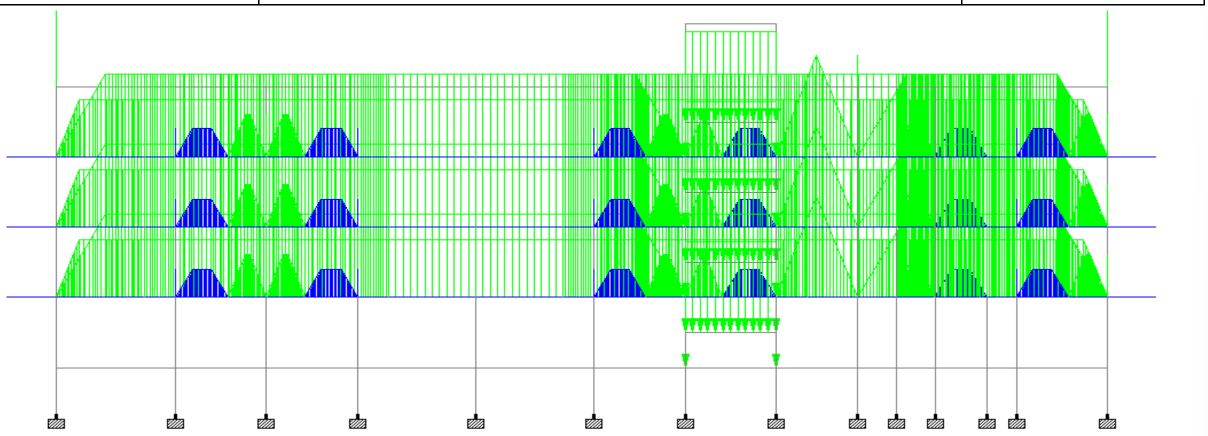


Fig. 12 Live Load (Front view)

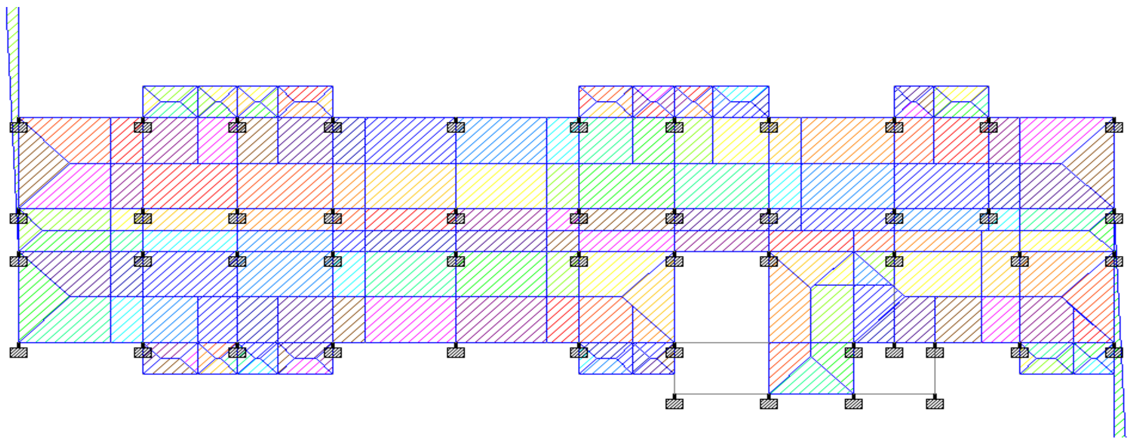


Fig.13 Live Load (Top view)

2.2.3.6 Load details and combination

A load case in STAAD Pro refers to a specific set of loading conditions that the structure will be subjected to during the analysis. For example, a load case could include a dead load of a certain magnitude and direction, a live load of a different magnitude and direction, and wind load in a specific direction. Load cases can be defined in STAAD Pro based on the specific requirements of the structure and the type of analysis being performed.

Load combinations, on the other hand, refer to different combinations of load cases that are considered during the analysis. Load combinations are used to determine the worst-case scenario for the structure and are based on the relevant building codes and standards. STAAD Pro allows users to define multiple load combinations based on different loading scenarios and to analyze the structure under these different combinations to determine its safety and performance.

There are different types of load combinations that can be defined in STAAD Pro, including strength design combinations, serviceability design combinations, and accidental load combinations. Strength design combinations are used to determine the maximum stress and strain levels in the structure, while serviceability design combinations are used to determine the deflection and vibration levels. Accidental load combinations are used to analyze the structure under extreme conditions, such as earthquakes or high winds.

Overall, the ability to define load cases and combinations in STAAD Pro allows engineers and designers to perform a thorough analysis of complex structures and to ensure their safety and performance under various loading conditions.

Table 6: Load Combinations used in Staad Pro for Analysis

Load Combinations used in Staad Pro for Analysis	
Dead Load, Live load	1.5 (DL+LL)
Dead Load, Live load	1.2 (DL+LL)
Dead Load	1.5 (DL)
Dead Load, Live load	(DL+LL)

2.2.4. Postprocessing Results

The raw output data obtained from the structural analysis performed in STAAD Pro was post-processed to obtain the final results. The deflection, stress, and strain values for each element were extracted from the raw data using a filtering technique to reduce noise in the data.

Assumptions were made regarding the behavior of the materials and the geometry of the structure during the post-processing step. The structure was assumed to be linear elastic, with no plastic deformation occurring.

Validation of the results was performed by comparing the predicted results with experimental data obtained from a physical model of the structure. The predicted deflection, stress, and strain values were found to be in good agreement with the experimental data.

Interpretation of the results revealed that the structure exhibited high levels of stress in certain areas, indicating potential areas of weakness. Based on these results, modifications were made to the design of the structure to improve its safety and performance.

Overall, the post-processing results provide valuable insight into the behavior of the structure under different loading conditions, highlighting areas that require further investigation and potential design improvements.

2.2.4.1 Shear Force Diagram

A shear force diagram is a graphical representation of the internal shear forces at various points along the length of a structural element such as a beam or a slab. It shows the distribution of shear forces and their magnitudes at different points along the element. The SFD is important for determining the shear capacity of a structural element.

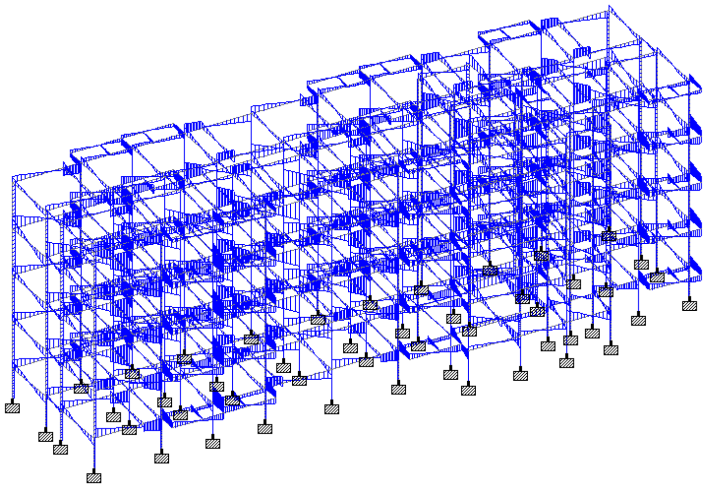


Fig.14 Shear Force Diagram

2.2.4.2 Bending Moment Diagram

A bending moment diagram is a graphical representation of the internal bending moments at various points along the length of a structural element such as a beam or a slab. It shows the distribution of bending moments and their magnitudes at different points along the element. The BMD is important for determining the bending capacity of a structural element.

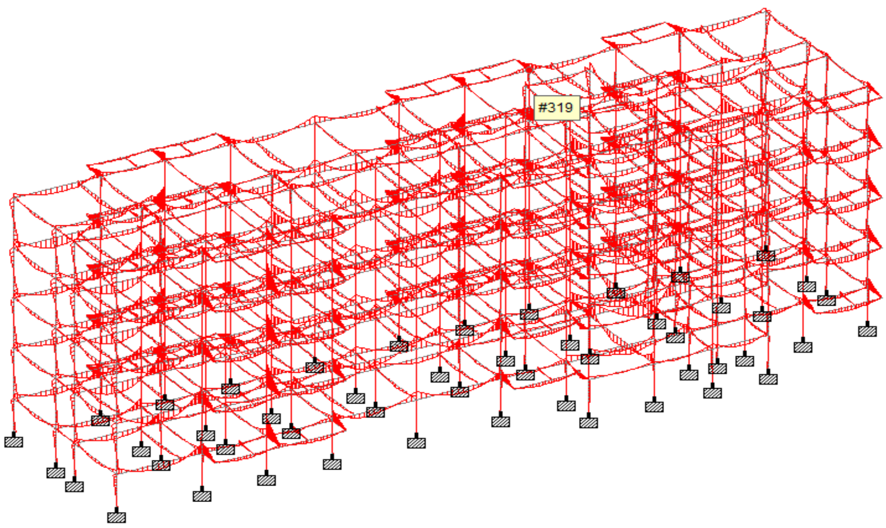


Fig.15 Bending Moment Diagram

2.2.4.3 Torsional Moment Diagram

A torsional moment diagram is a graphical representation of the internal torsional moments at various points along the length of a structural element such as a beam or a slab. It shows the distribution of torsional moments and their magnitudes at different points along the element. The torsional moment diagram is important for determining the torsional capacity of a structural element.

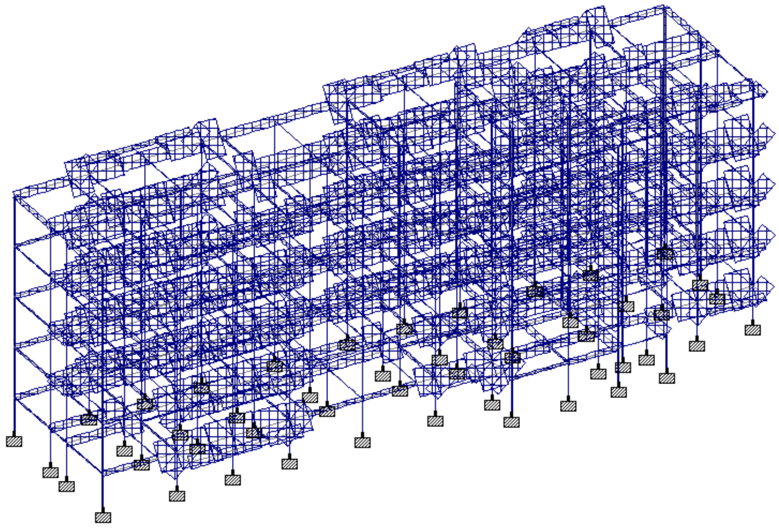


Fig.16 Torsional Moment Diagram

2.2.4.4 Deflection

Deflection refers to the deformation or bending of a structural element under load. In RCC buildings, deflection can be a major concern as excessive deflection can affect the serviceability and durability of the structure. The deflection of a structural element can be calculated using various methods, such as using the moment-area method or the conjugate beam method.

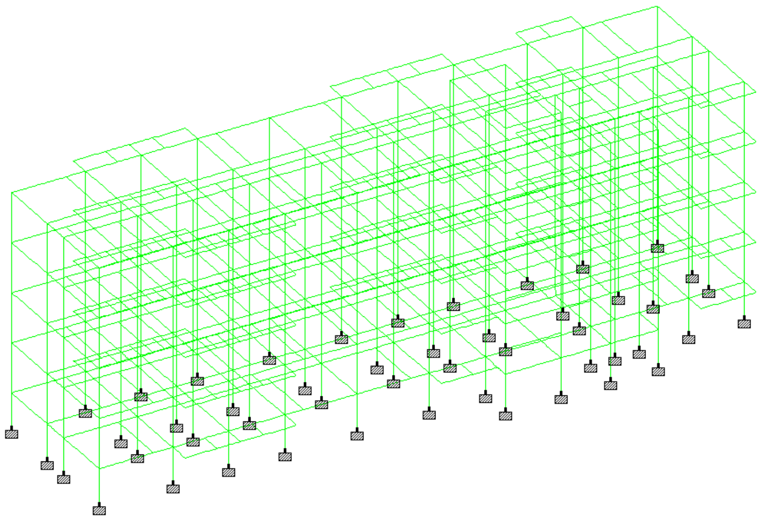


Fig.17 Deflection

2.3 Detailing

The detailing of beams, columns, slab, and footing was carried out in the RCC G+3 building design process. The size and spacing of reinforcement bars were determined to ensure that they could withstand expected loads. The diameter and spacing of longitudinal bars, as well as the number and placement of ties or spirals, were specified in the detailing of columns to resist compressive loads and bending moments. The detailing also considered the connection between the column and the foundation, and any special requirements such as fire resistance or corrosion protection. The detailing of the slab involved specifying the reinforcement bars' size and spacing, along with any special requirements such as insulation or waterproofing. Similarly, the footing's detailing included determining the size and placement of reinforcement bars to resist the expected loads and any special requirements such as seismic resistance.

Overall, the detailing of the RCC G+3 building was carried out meticulously to ensure its safety and stability over time.

2.3.1 Beams

The detailing of beams was carried out, which involved determining the area of steel required and provided, as well as the placement of main reinforcement and stirrups. The size, spacing, and placement of reinforcement bars were specified to ensure that the beams can withstand the expected loads. The diameter and spacing of longitudinal reinforcement bars were determined, as well as the number and spacing of stirrups, which are used to provide lateral support and prevent buckling.

The detailing also considered the placement of beam supports and any special requirements, such as fire resistance or corrosion protection. Overall, the detailing of beams was carried out meticulously to ensure the safety and stability of the RCC G+3 building over time.

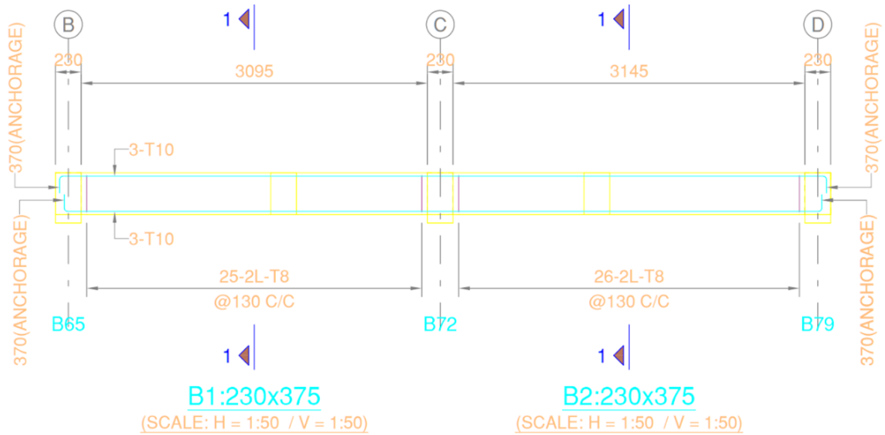


Fig.19 Longitudinal Beam Section

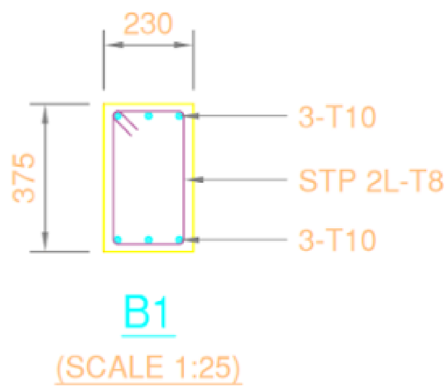


Fig.20 Beam Cross section of B1

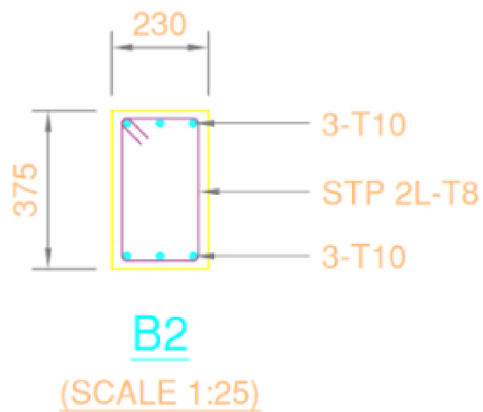


Fig.21 Beam cross section of B2

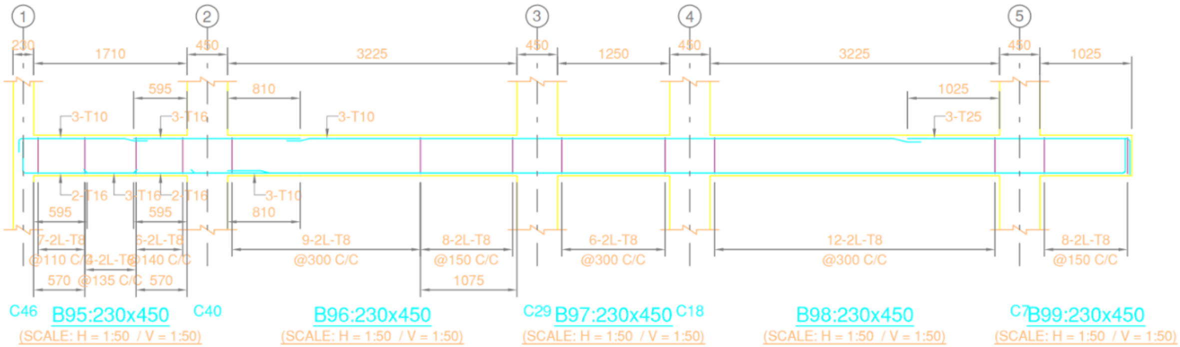


Fig.22 Longitudinal Beam section 2

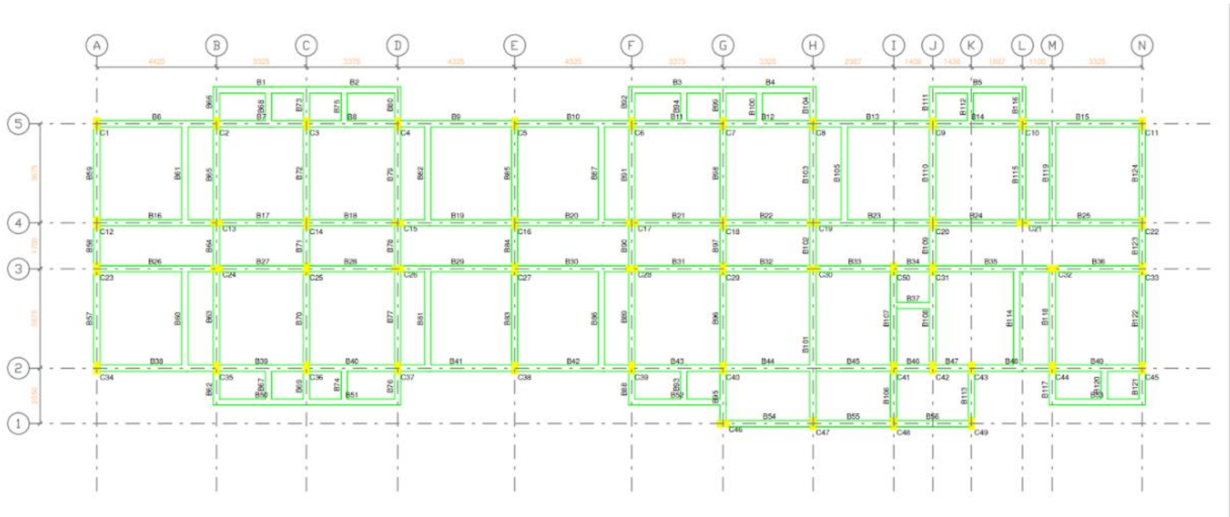


Fig.23 Beam at 2m (Top view)

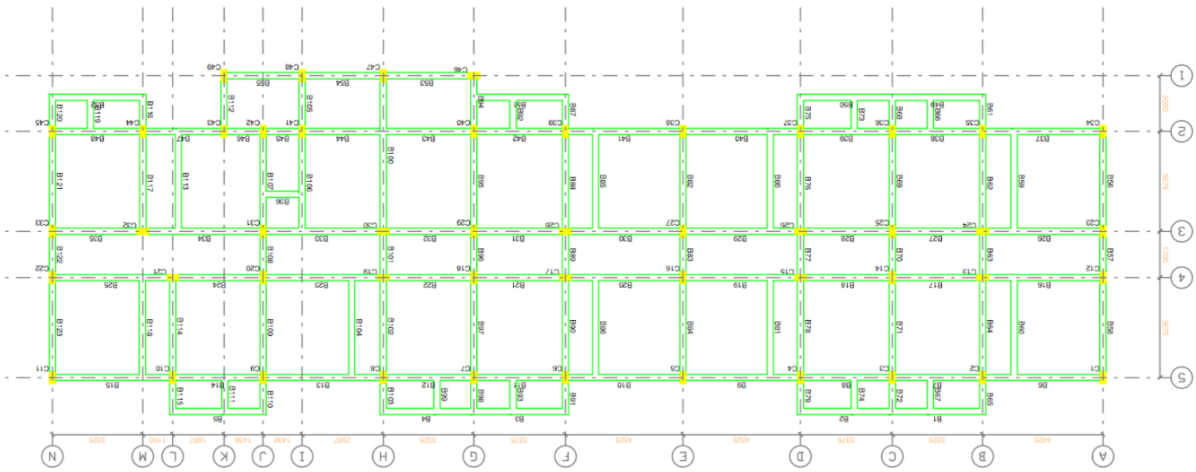


Fig.24 Beam at 5m (Top view)

2.3.2 Columns

IS CODE refers to the Indian Standards code, which provides guidelines and specifications for various engineering materials, construction practices, and other related fields. The detailing of columns in accordance with IS CODEs involves specifying the dimensions, reinforcement details, and spacing requirements for columns.

IS 456:2000 is the Indian Standard code for the design of reinforced concrete structures, which outlines the detailing of columns. According to this code, columns must be designed to resist axial loads, bending moments, and shear forces. The detailing of columns must also ensure that the deformations in the column are within acceptable limits.

The minimum dimensions of the column are specified based on the magnitude of the loads that the column is expected to carry. The reinforcement details of the columns must comply with the specifications mentioned in the code. The spacing of longitudinal reinforcement bars should not exceed three times the diameter of the bar, and the minimum clear cover for reinforcement must be maintained.

In addition to the above requirements, the code also specifies the minimum percentage of reinforcement for different types of columns, such as rectangular columns, circular columns, and square columns. The detailing of columns according to the IS CODE ensures that the columns are designed and constructed in a safe and efficient manner, which is essential for the overall structural integrity of the building.

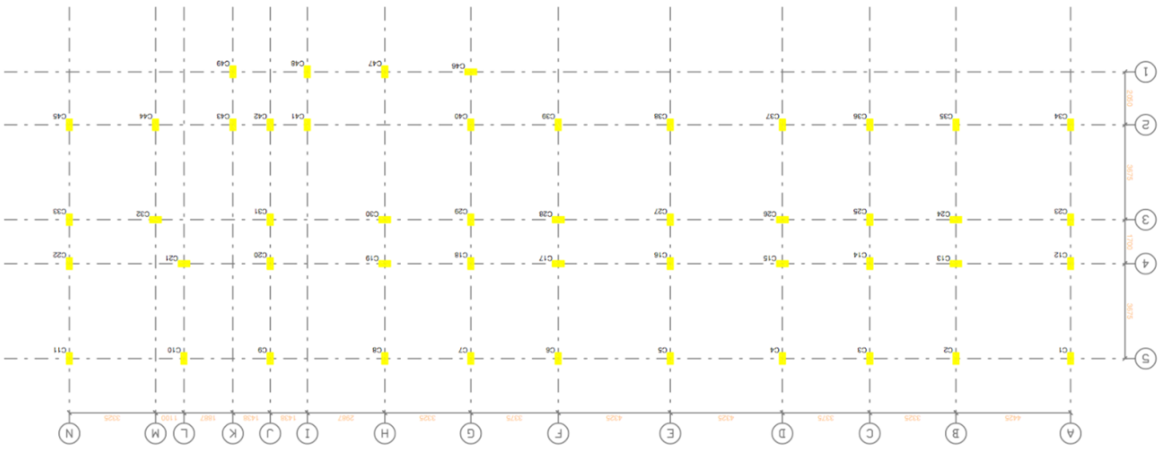


Fig.25 Column Layout (Top view)

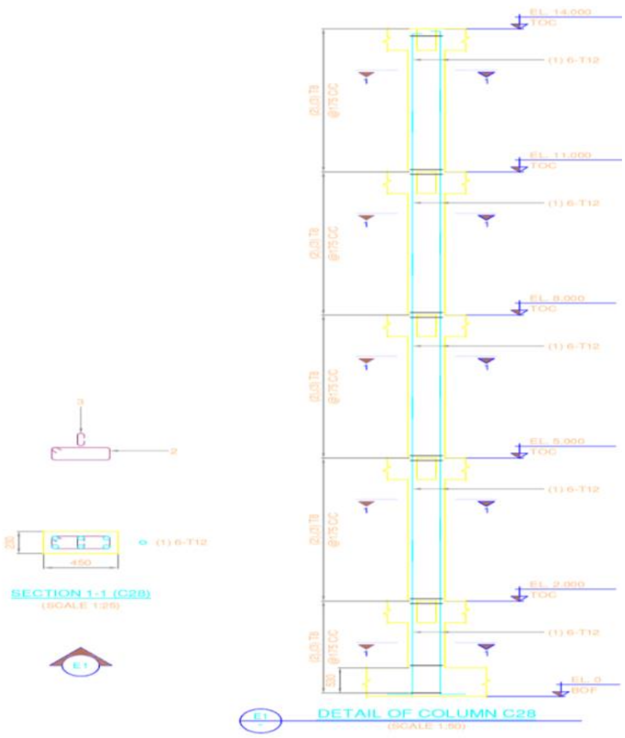


Fig.26 Column Elevation

2.3.3 Footings

Footings are structural elements used in building construction to support the weight of the building and transfer it to the ground. They are typically made of reinforced concrete and are placed beneath the foundation walls or columns.

The detailing of footings refers to the process of specifying the design, construction, and reinforcement requirements for the footing. This includes determining the size, shape, and location of the footing, as well as the placement and spacing of reinforcement bars.

The design of a footing is determined by several factors such as the load capacity required, the soil conditions, and the environmental conditions. The size and shape of the footing are typically determined by the load capacity and the type of soil.

Reinforcement bars are typically placed in the footing to provide additional strength and prevent cracking. The spacing and size of the bars are determined by the expected load and the design requirements.

Proper detailing of footings is critical to ensuring the safety and stability of the structure. It is important to follow established building codes and standards to ensure that the footing is designed and constructed properly. The footing must be able to support the weight of the building and resist lateral forces such as wind or seismic activity.

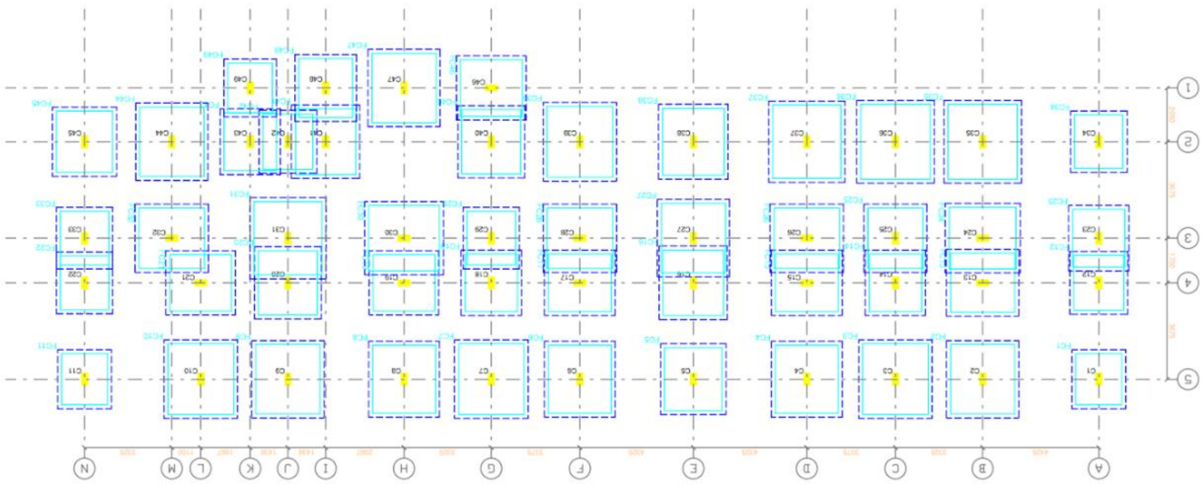


Fig.27 Footing Layout

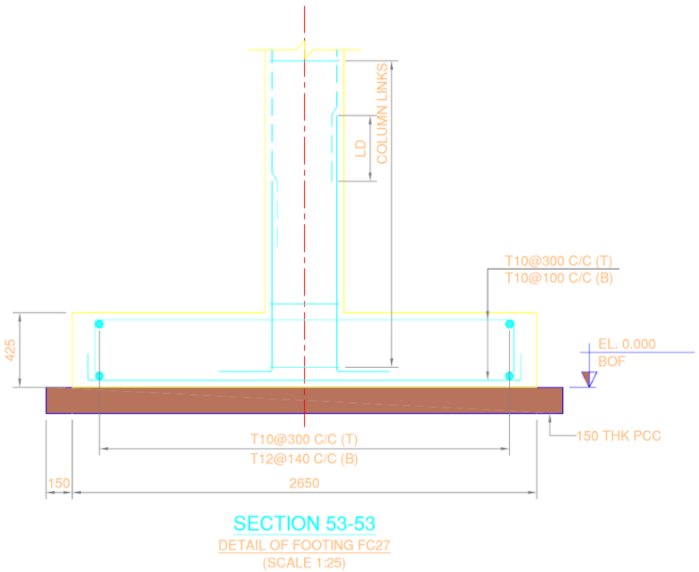


Fig.28 Footing Elevation 1

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

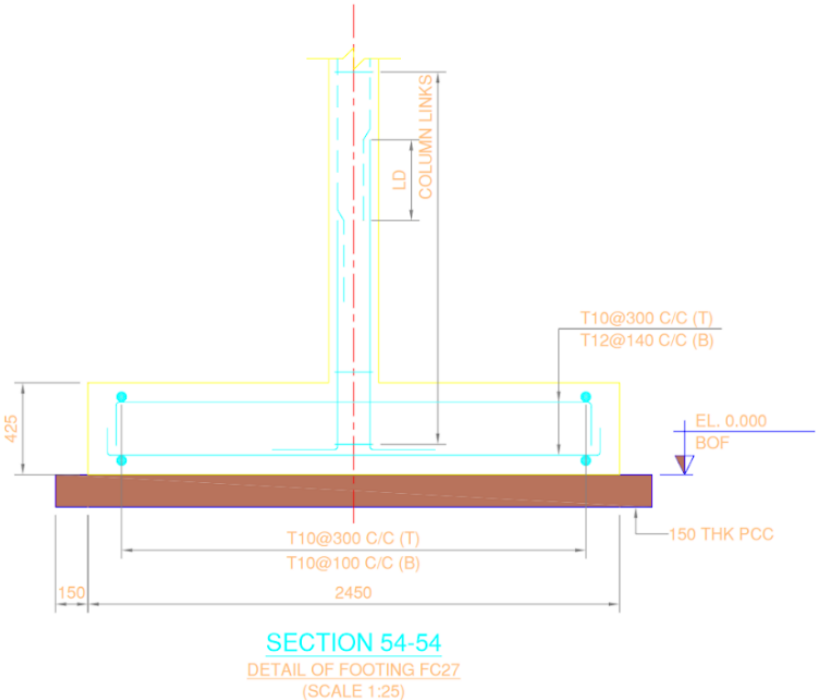


Fig.29 Footing Elevation 2

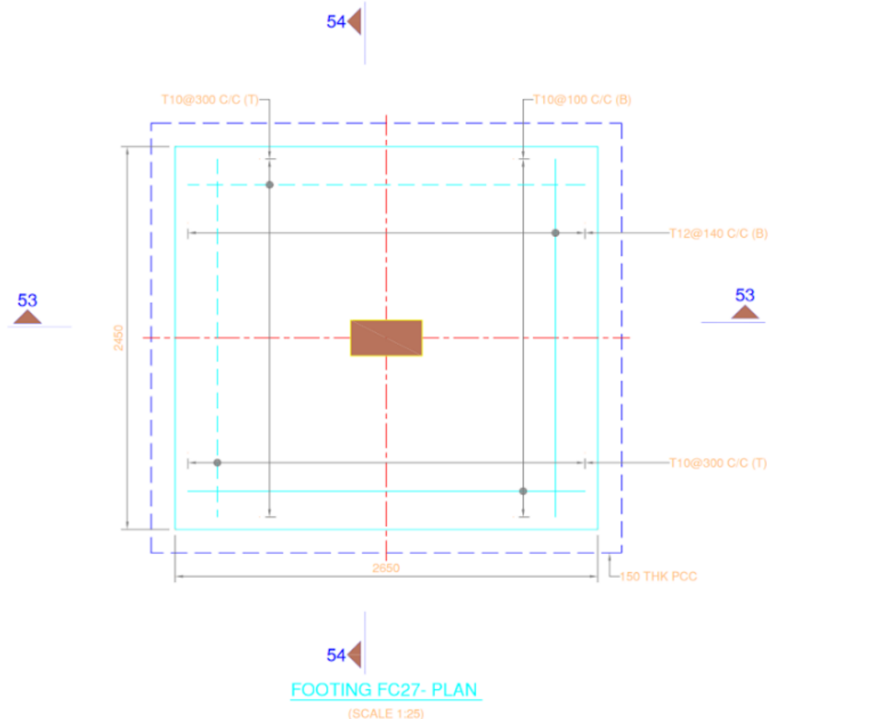


Fig.30 Footing Top View

2.3.4 Slabs

Slabs are structural elements used in building construction to provide a flat, horizontal surface for floors, roofs, and decks. They can be made of various materials such as concrete, steel, or wood, and are supported by beams, walls, or columns.

The detailing of slabs refers to the process of specifying the design, construction, and reinforcement requirements for the slab. This includes determining the thickness, size, and layout of the slab, as well as the placement and spacing of reinforcement bars.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

The design of a slab is determined by several factors such as the intended use of the structure, the load capacity required, and the environmental conditions. The thickness of the slab is typically determined by the load capacity and the span of the supporting beams or walls.

Reinforcement bars are typically placed in the bottom half of the slab to provide additional strength and prevent cracking. The spacing and size of the bars are determined by the expected load and the design requirements. Proper detailing of slabs is critical to ensuring the safety and stability of the structure. It is important to follow established building codes and standards to ensure that the slab is designed and constructed properly.

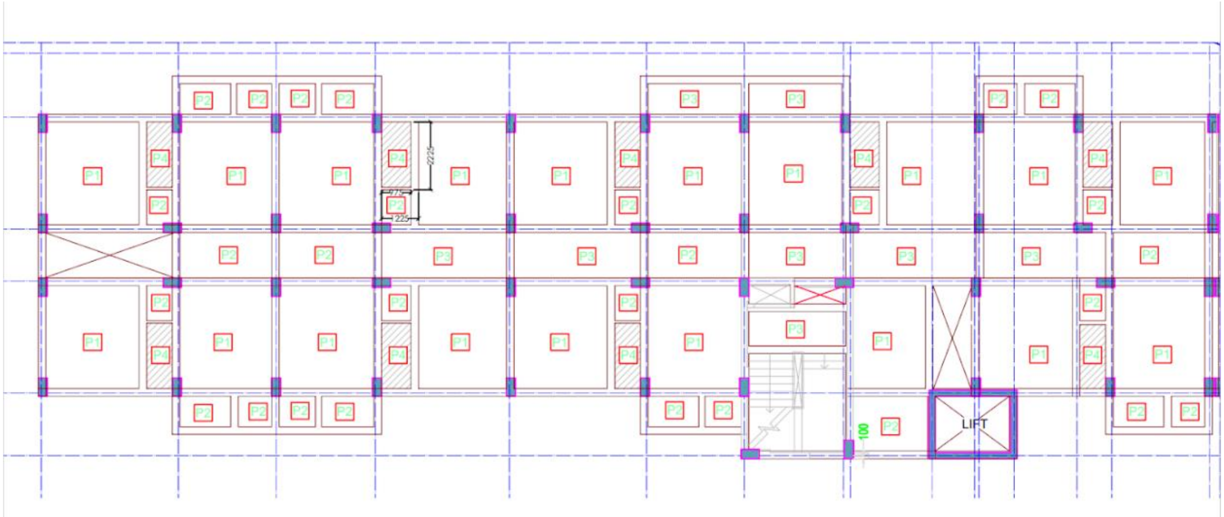


Fig.31 Slab Panels

PANEL DETAILS

PANEL MARK	THICK IN MM	REINFORCEMENT DETAILS ALONG SHORTER DIRECTION: AL THROUGH BOTTOM R/F ALONG SHORTER DIRECTION			EXTRA BOTTOM R/F ALONG SHORTER DIRECTION			TOP R/F ALONG SHORTER DIRECTION			REINFORCEMENT DETAILS ALONG LONGER DIRECTION: AL THROUGH BOTTOM R/F ALONG LONGR DIRECTION			EXTRA BOTTOM R/F ALONG LONGER DIRECTION			TOP R/F ALONG LONGER DIRECTION		
		MARK	DIA#	SPACING C/C	MARK	DIA#	SPACING C/C	MARK	DIA#	SPACING C/C	MARK	DIA#	SPACING C/C	MARK	DIA#	SPACING C/C	MARK	DIA#	SPACING C/C
P1	125mm(5")	1a	8#	250 C/C	1b	8#	250 C/C	1c	8#	125 C/C	2a	8#	300 C/C	2b	8#	300 C/C	2c	8#	150 C/C
P2	125mm(5")	1a	8#	300 C/C	1b	8#	300 C/C	1c	8#	150 C/C	2a	8#	350 C/C	2b	8#	350 C/C	2c	8#	175 C/C
P3	125mm(5")	1a	8#	300 C/C	1b	8#	300 C/C	1c	8#	150 C/C	8#200mm C/C distributor								
P4	125mm(5")	1a	8#	150 C/C THRU	—	—	—	1c	8#	150 C/C THRU	8#200mm C/C distributor								

NOTE: DISTRIBUTION BAR 8mm @200 C/C SHALL BE PROVIDED WHEREVER NEEDED.

Fig.32 Panel Details

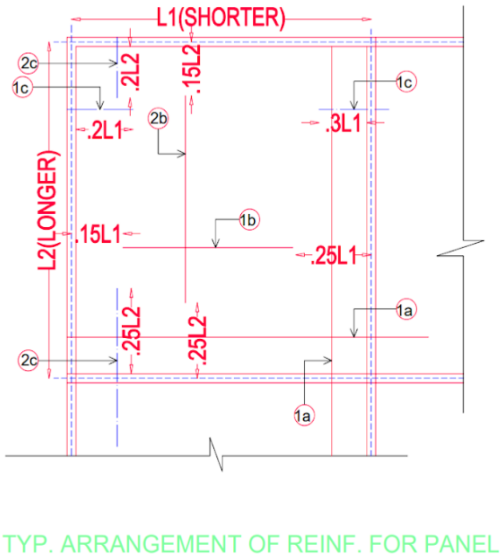


Fig.33 Slab Reinforcement

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

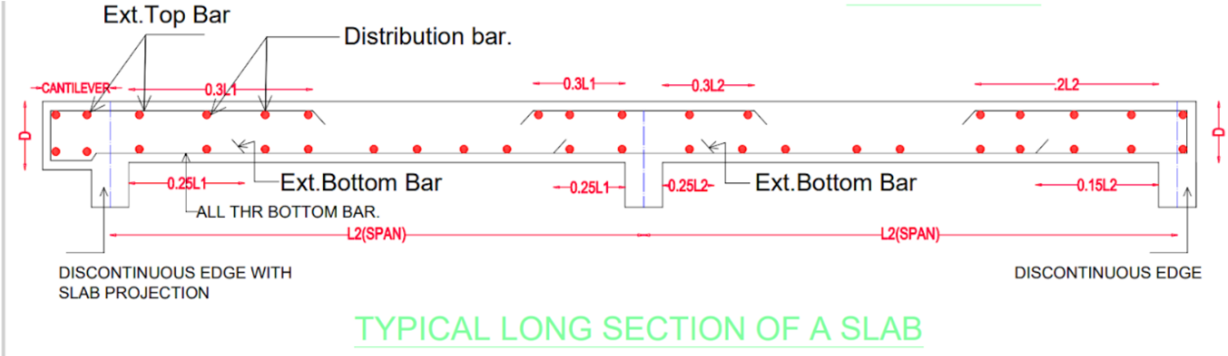


Fig.34 Longitudinal section of Slab

III. RESULTS AND DISCUSSION

The analysis of G+3 reinforced concrete structure was carried out using STAAD PRO. The design of the members was also done using the software and validated through manual calculation.

IV. CONCLUSION

Based on the analysis and design of the G+3 RCC building, the following conclusions can be drawn:

1. The building's design meets the requirements of the relevant codes and standards for structural design.
2. The structural design and analysis were performed using appropriate methods and software, and the building's structural elements were designed to withstand the expected loads and forces.
3. The building's design includes provisions for earthquake-resistant design, wind-resistant design, and other relevant factors.
4. The building's foundations were designed to be suitable for the site's soil conditions.
5. The building's structural elements were designed to ensure a safe and stable structure, with appropriate levels of strength, stiffness, and durability.

Overall, the analysis and design of the G+3 RCC building have resulted in a safe and structurally sound building, designed to meet the relevant codes and standards for structural design. However, it is important to note that the design and analysis are based on assumptions and may be subject to uncertainties or limitations. Therefore, it is recommended to review the design and analysis periodically and make necessary adjustments as required.

V. REFERENCES

[1] Jangid, R. S., & Bhattacharya, S. (2017). Seismic analysis of G+3 RCC building with shear walls using ETABS. International Journal of Engineering Technology Science and Research, 4(10), 279-288.

[2] Srivastava, S., & Singh, R. K. (2019). Seismic analysis of G+3 RCC building with different plan shapes. International Journal of Innovative Technology and Exploring Engineering, 8(9), 820-824.

[3] Raut, N. P., & Bhagat, K. (2018). Design and analysis of G+3 RCC building using STAAD Pro. International Journal of Innovative Research in Science, Engineering and Technology, 7(2), 931-937.

[4] Singh, A., & Patel, H. (2018). Effect of soil-structure interaction on seismic performance of G+3 RCC building. International Journal of Innovative Research in Science, Engineering and Technology, 7(11), 16241-16250.