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Analysis and Design of Earthquake Resistant Building with Shear Walls using ETABS

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ABSTRACT: The increasing frequency and intensity of earthquakes in recent years underscore the need for robust structural systems to ensure the safety and stability of residential buildings, particularly multi-story flats. In earthquake-prone regions, the integration of shear walls has emerged as a crucial strategy for enhancing seismic resistance. This study focuses on the analysis and design of earthquake-resistant flats incorporating shear walls, utilizing ETABS software for comprehensive modelling and simulation. The research investigates the impact of shear walls on seismic performance, with particular emphasis on optimizing wall placement, thickness, reinforcement detailing, and material properties. Dynamic analyses, including response spectrum and time-history analysis, are conducted to assess the structural behaviour under seismic loading. The findings reveal that the inclusion of shear walls significantly enhances lateral stiffness, reduces inter-story drift, and minimizes overall structural deformation, thereby improving seismic resilience and ensuring compliance with safety codes.

KEYWORDS: Shear walls, Earthquake resistance, Structural analysis, ETABS, Seismic performance.

I. INTRODUCTION

The rise in seismic activity in recent years has highlighted the critical need for resilient structural systems to safeguard multi-story residential buildings, especially in earthquake-prone regions. Traditional reinforced concrete (RC) frame structures often lack adequate lateral load resistance, making them vulnerable to damage during seismic events. Shear walls, when strategically integrated, enhance the lateral stiffness and strength of buildings, effectively mitigating seismic forces and reducing structural deformations.

This study aims to analyze and design earthquake-resistant flats incorporating shear walls, employing ETABS software to conduct comprehensive simulations and optimize key design parameters such as wall placement, thickness, reinforcement detailing, and material properties. The research undergoes the seismic performance of flats with shear walls, emphasizing their contribution to structural safety and resilience.

II. LITERATURE SURVEY

The significance of shear walls and composite walling systems in enhancing the seismic performance and overall structural integrity of high rise buildings is collectively emphasized by Hargunani et al. [1]. The findings contribute valuable insights into optimizing design approaches for safer and more resilient structures in seismic prone regions. The behaviour of RC structures incorporating either shear walls or steel bracings for seismic resistance by Pujari et al. [2]. Comparison of the effectiveness of these systems in an asymmetrical plus-shaped G+7 RC frame structure is evaluated. The analysis employed the Response Spectrum Method (RSM) and conducted using ETABS software. The shear walls and bracings placed at various locations within the model. Parameters like base shear, displacement, story drift, time period, and story acceleration to assess the relative stiffness and strength provided by each system were compared. Mahadik [3] carried out to study using finite element analysis of shear wall model and compared the behavior of normal concrete shear wall and steel fiber reinforced concrete shear wall (SFRC) with and without opening using ETABS software to know improvement in behavior when subjected to lateral load by adding steel fibers in concrete. Researches [4] uses different shapes of shear walls in high rise symmetrical buildings. Z, U and T shaped flanged shear walls in 15, 20, 30 storey building is analyzed using response spectrum analysis in ETABS software. Earthquake zone III (Ahmedabad) & zone V (Bhuj) with soil condition I (Hard soil) & soil III (Loose soil) are consider to compare the

results in terms of time period, storey drift, storey shear, storey displacement. For dynamic earthquakes, IS 1893-2002 & IS 13920-1993 are used respectively in ETABS V16 software.

III. METHODOLOGY

The building plan was prepared based on the requirements and guidelines provided by National Building Code [5] and the drafting was done using AutoCAD. Analysis and Design was carried out using ETABS. The manual design was carried out based on IS 456-2000 [6].

IV. DESIGN CONSIDERATIONS AND MODELING OF BUILDING STATEMENT OF THE PROJECT

In the present study, analysis of G+ 10 stories building in Zone III seismic zones is carried out in ETABS. Basic parameters considered for the analysis are:

1. Utility of building: Residential building
2. No. of stories: G+3 (4 stories)
3. Type of construction: RCC structure
4. Ground floor height: 3m
5. Other floor height: 3m
6. Grade of concrete: M30
7. Grade of reinforcing steel: HYSD Fe500
8. Dimension of beam: 300mmx450mm
9. Dimension of column: 300mmx300mm
10. Thickness of slab: 150mm
11. Loads considered in buildings: DL, LL, EQL & WL
12. Density on concrete: 25 KN/m²
13. Seismic zones: Zone III
14. Site type: II
15. Importance factor: 1
16. Response reduction factor: 5
17. Seismic coefficient factor: 0.16
18. Basic wind speed: 50 m/s
19. Wind design code: IS 875:2016
20. RCC design code: IS 456:2000
21. Earthquake design code: IS 1893:2002 (Part-I)

PLAN DETAILS

1. Ground floor plinth area = 585.5 m²
2. Total plinth area of structure = 585.5 x 4 = 2342 m²
3. Ground floor area = 536 m²
4. Total floor area of structure = 536 x 4 = 2144 m²

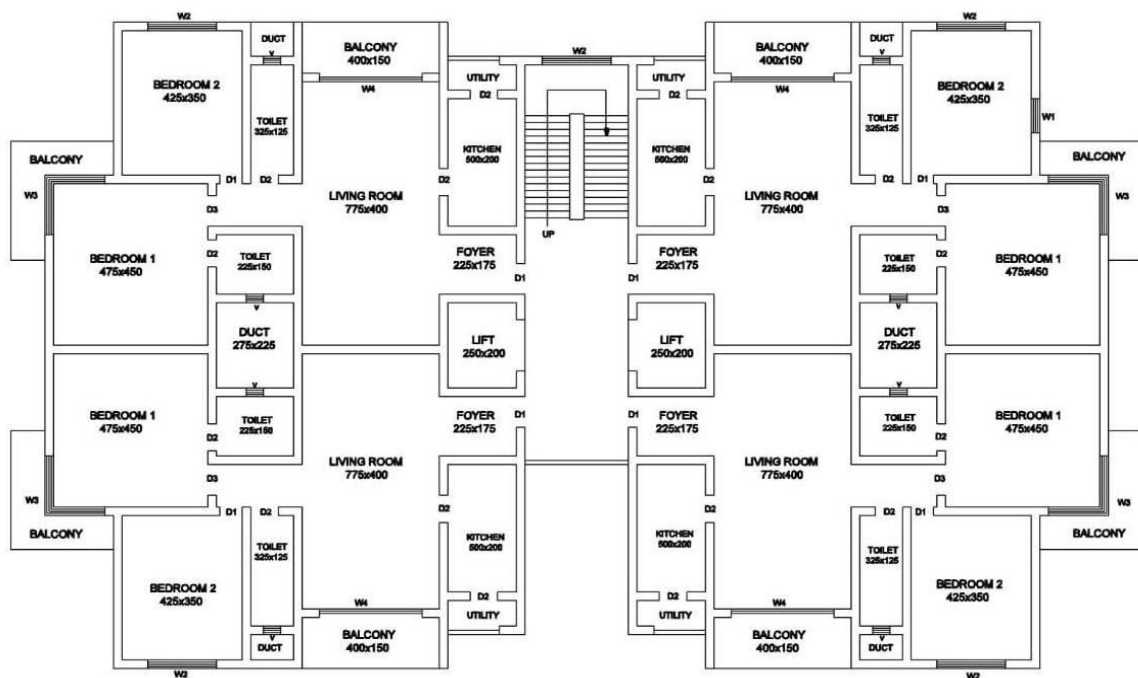
MODELING IN ETABS

Steps involved:

1. Selection of a grid pattern.
2. Defining beams, columns, deck slabs.
3. Modelling.
4. Defining loads and load combinations
5. Assigning loads.

DIMENSIONS			
TYPES	DESCRIPTION	SIZE	NOS
D1	WOODEN DOOR	90x210	8
D2	WOODEN DOOR	80x210	16
D3	WOODEN DOOR	90x210	4
W1	WOODEN WINDOW	100x120	1
W2	WOODEN WINDOW	200x120	5
W3	GLAZED WINDOW	350x210	4
W4	GLAZED WINDOW	300x210	4
V	WOODEN VENTILATION	50x50	8

Table 1. Details of Joineries



TYPICAL FLOOR PLAN

Fig 1. Typical floor plan

V. DESIGN CONSIDERATIONS AND MODELING OF BUILDING STATEMENT OF THE PROJECT

1. DESIGN RESULT

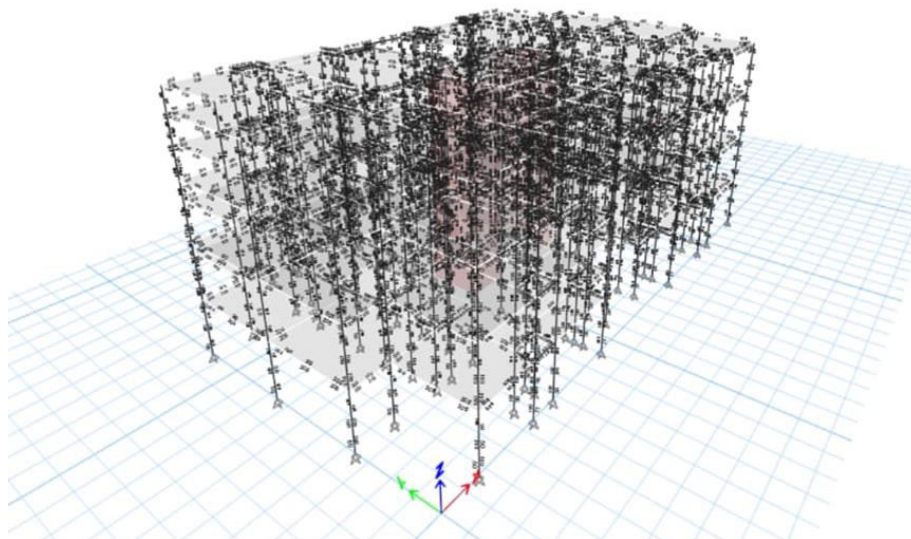


Fig 2. 3D View of the model

- Overall design value of model is obtained.
- Designed value of Beams and Columns are obtained.
- The figure shows the longitudinal reinforcing of model.

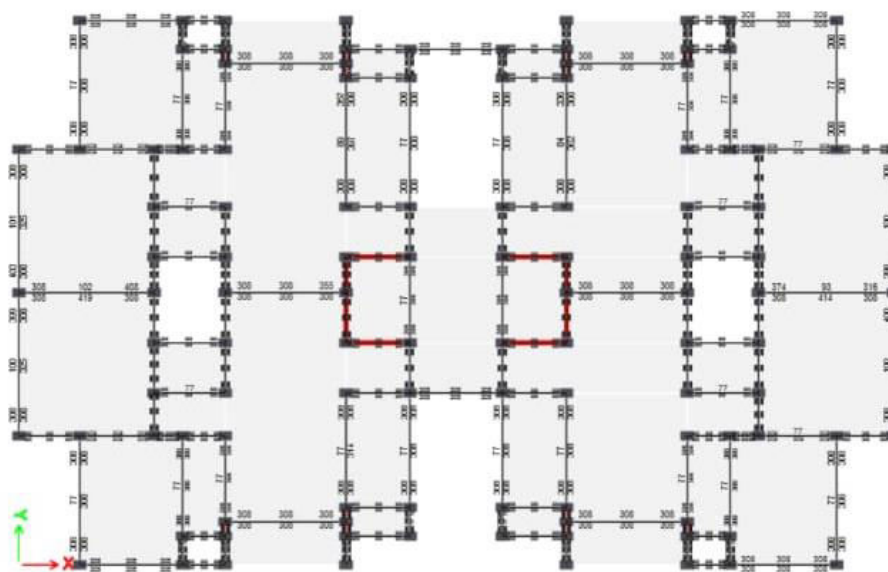


Fig 3. Plan view of the model

2. BENDING MOMENT DIAGRAM AND SHEAR FORCE DIAGRAM

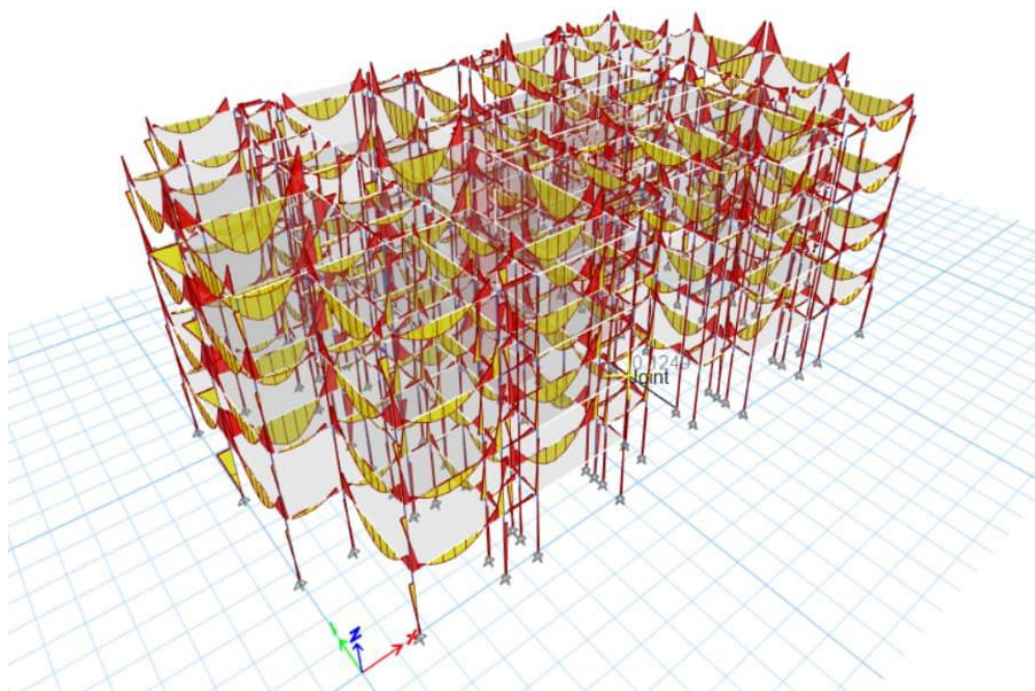


Fig 4. Bending moment diagram (3D View)

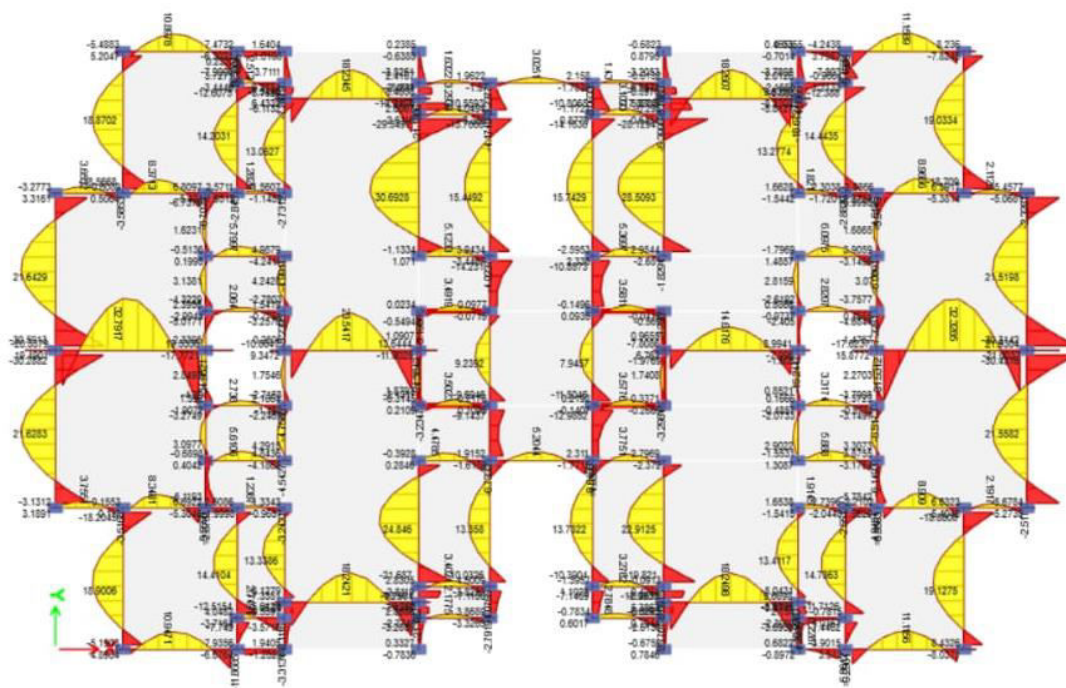


Fig 5. Bending moment diagram (Plan View)

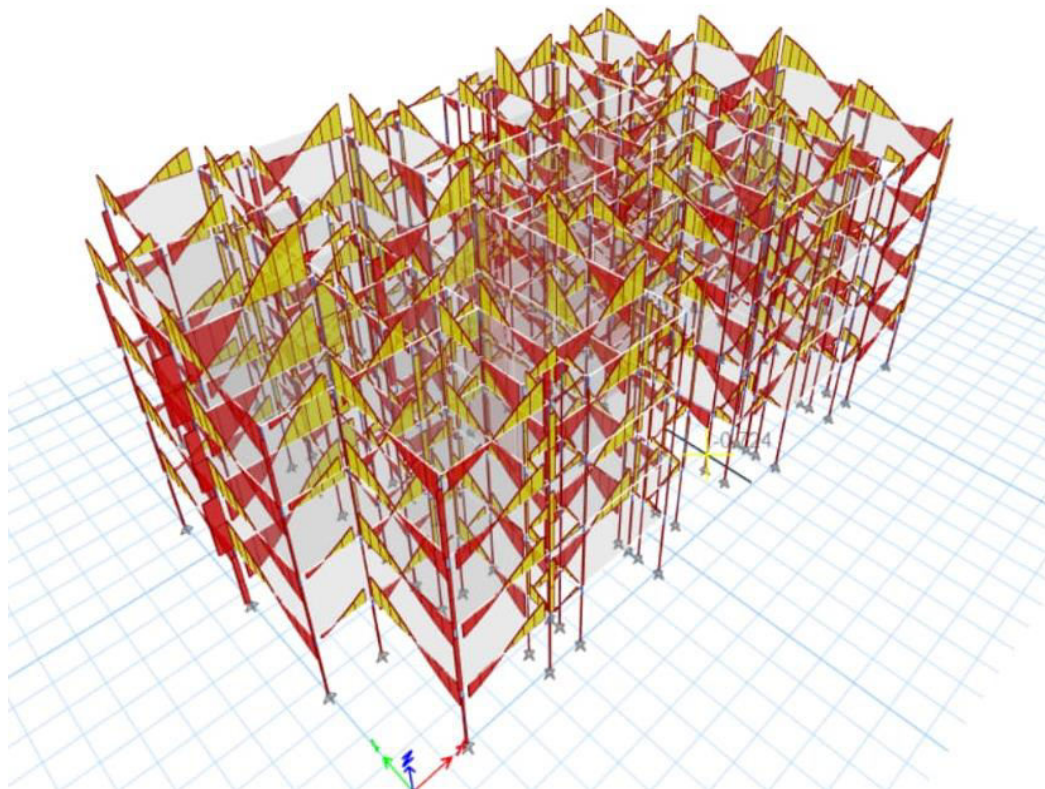


Fig 6. Shear Force Diagram (3D View)

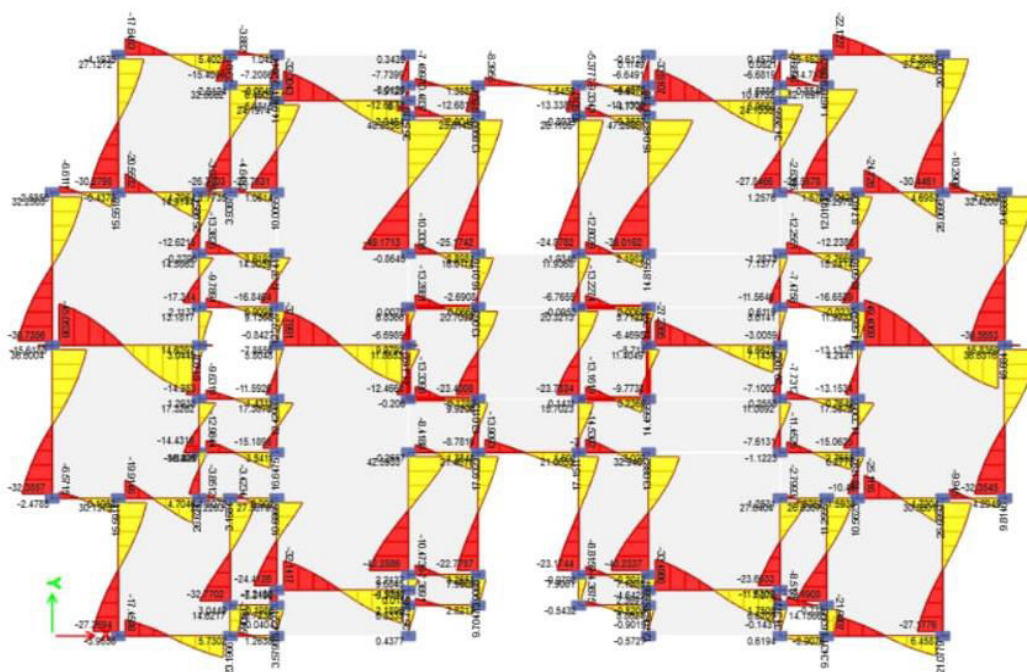


Fig 7. Shear Force Diagram (Plan View)

3. DESIGN OF BEAM

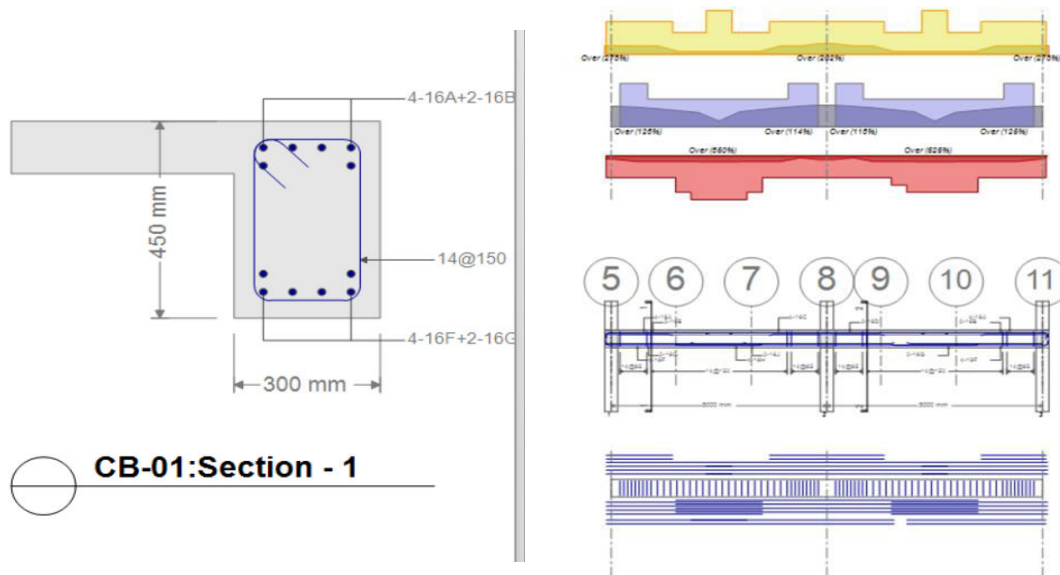
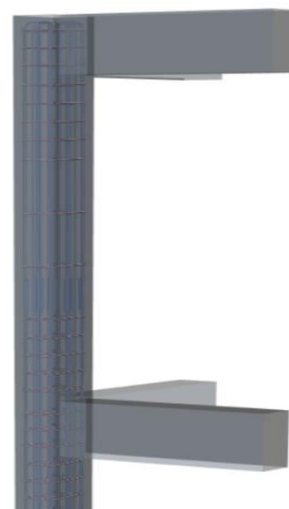
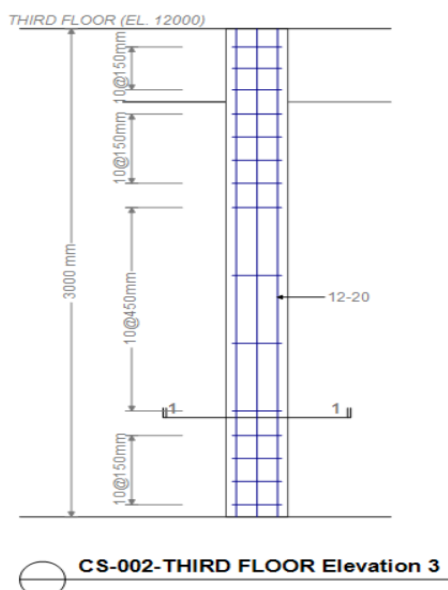


Fig 7. Shear Force Diagram (Plan View)

- Beam provided of size : 300 x 450.
- Number of Bars provided : 6 bars of 16 mm diameter.
- 14 mm Stirrups is provided at 150 mm spacing.

4. DESIGN OF COLUMN



- Column of size: 300 mm x 300 mm.
- Number of bars provided: 12 bars of 20 mm diameter.
- Ties provided: 10 mm diameter bar at 150 mm spacing.

VI. CONCLUSION

1. The planning, analysis and design of beams, columns, slabs, shear wall and footing of a residential building is covered.
2. Through ETABS analysis, effectively evaluated the behaviour of shear walls under seismic and gravity loads, ensuring their ability to resist lateral forces in seismic zone III.
3. This paper demonstrates that shear walls are highly effective in resisting lateral seismic forces, significantly improving the earthquake resistance of buildings.
4. The seismic analysis showed that the building with shear walls performed well under various earthquake scenarios, with minimal deformation & damage.
5. The design is complied with relevant seismic codes such as IS 1893, IS 875, guaranteeing that the building would meet the required safety standards for earthquake resistance.

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