

Design and Analysis of Multistorey Residential Building Using ETABS

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Abstract - Structural analysis determines how buildings and their components respond to the loads acting on them, principally dead loads, live loads, wind loads (IS 875-1987, Parts 1-3) and seismic loads (IS 1893-2002/2016). ETABS (Extended Three-Dimensional Analysis of Building Systems) is a structural engineering software capable of static and dynamic, linear and non-linear analysis, and is used here for the analysis and design of a G+4 reinforced concrete residential building situated in seismic zone V. With the plan dimensions held constant, both static and dynamic (response-spectrum) seismic analyses were carried out to obtain storey shear, bending moment, storey drift and axial forces at corner, centre and front beams and columns. The results were checked against IS 456:2000 and IS 1893:2002, and storey displacements and drifts were found to be within the permissible limits, confirming that the proposed building is structurally safe.

Key Words: ETABS, seismic analysis, multistorey residential building, base shear, storey drift, RCC design, IS 1893:2002.

1. INTRODUCTION

ETABS (Extended Three-Dimensional Analysis of Building Systems) is an integrated software package for the structural analysis and design of buildings, offering 3D object-based modelling, fast linear and non-linear analysis, and design capabilities for a wide range of materials. Computer-aided design drawings can be imported directly into ETABS, and because many floor levels in a building are typically similar, the software's "similar-storey" concept significantly reduces modelling and design time.

In multistorey construction, lateral loads such as wind and earthquake forces largely govern lateral drift and displacement, and therefore the selection of the structural system. As building height increases, lateral load effects become increasingly significant, and adequate lateral stiffness is essential to keep drift and displacement within serviceable limits. Cracking of concrete under seismic action further reduces member stiffness, so realistic stiffness values are needed to obtain a reliable distribution of member forces.

1.1 Objectives

The objectives of this study are: (i) to model a G+4 reinforced concrete residential building in ETABS; (ii) to analyse the structure for gravity and seismic (zone V) loads as per IS 875 and IS 1893:2002; (iii) to compare shear force, bending moment, torsion and axial load at corner, centre and front beams/columns; and (iv) to verify that storey displacements and drifts remain within the permissible limits prescribed by the Indian codes.

2. LITERATURE REVIEW

A review of prior work on the seismic analysis and design of multistorey buildings using ETABS was carried out to establish the relevance and context of the present study. A summary of the key studies reviewed is presented in Table 1.

Table 1: Summary of Literature Review

Author(s)	Focus of Study	Key Finding
Chandrasekhar Reddy & Lalith Kumar	Seismic analysis of G+30 building (all zones)	Lateral displacement and storey shear increase from zone II to zone V
Danish Irfan et al.	Analysis & design of G+4 RC building	Wind and seismic deflections were within the 20 mm permissible limit
Mehta, Modi, Patel & Prajapati	Multistorey residential building, zone III	Storey drift well below the 0.004h code limit; drift higher in X than Y
Abhishek et al.	Design of G+5 residential building	ETABS results matched manual design as per IS 456/SP-16
Gurudath et al.	G+2 commercial building design	Software results verified against IS 456:2000 within permissible limits
Ali Kadhim Sallal	Ten-storey building under wind & seismic loads	ETABS results closely matched manually computed forces
Torky & Rashed	High-performance stiffness analysis using super floor elements	Demonstrated feasibility of accelerated computation for large floor models

3. MATERIALS AND METHODOLOGY

A symmetrical G+4 reinforced concrete residential building was modelled in ETABS. The floor plan was first prepared in AutoCAD and imported into ETABS, after which material properties, frame sections, slab sections and loads were assigned as summarised in Table 2, followed by linear static and response-spectrum seismic analysis.

Table 2: General Modelling Data

Parameter	Value
Structure	G + 4
Storey height	3 m per floor
Grade of concrete	M30 (IS 456-2000)
Grade of steel	Fe500 (IS 800-2007)
Beam size	350 x 350 mm
Column size	450 x 450 mm

Parameter	Value
Slab thickness	150 mm
Seismic zone	V (Z = 0.36)
Response reduction factor, R	5
Importance factor, I	1

super dead loads as well as combination of various loads are presented at the end structural elements are introduced.



Fig. 1: Plan of the G+4 reinforced concrete building

Table 3: Types of Loads Considered

Load Type	Value	IS Code
Dead load	Self-weight	IS 875 Part-1
Live load	2 kN/m ² (all areas)	IS 875 Part-2
Floor finish	1.5 kN/m ²	IS 875 Part-1
Inner wall load	6.21 kN/m ²	IS 875 Part-1
Outer wall load	12.45 kN/m ²	IS 875 Part-1

The seismic base shear was computed as per IS 1893:2002 (Part 1) using $V_B = A_h \times W$, where $A_h = ZIS_a / (2Rg)$. With $Z = 0.36$, $I = 1$ and $R = 5$ for zone V, the resulting base shear and applied storey forces obtained from ETABS are summarised in Table 4.

Table 4: Calculated Base Shear and Applied Storey Forces

Storey	Elevation (m)	X-Dir (kN)	Y-Dir (kN)
Story 5	15	176.36	176.36
Story 4	12	131.45	131.45
Story 3	9	73.94	73.94
Story 2	6	32.86	32.86
Story 1	3	8.22	8.22

Design base shear V_B was found to be 422.83 kN in both the X and Y directions, with a seismic weight W of 4698.07 kN.

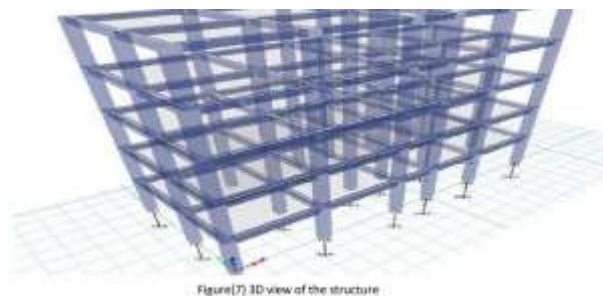


Fig. 2: 3D view of the modelled structure in ETABS

4. RESULTS AND DISCUSSION

The structure was analysed as a standard moment-resisting frame. Maximum design forces on beams and columns at

corner, centre and front locations, for every floor, were extracted from ETABS and are compared below.

Table 5: Peak Shear Force in Beams and Columns (kN)

Location	Beam - Ground	Beam - First	Column - Ground	Column - First
Corner	99.50	102.71	7.12	20.12
Centre	101.53	104.71	18.22	25.95
Front	70.65	69.63	17.56	23.74

Table 6: Axial Load on Columns by Position (kN)

Position	Ground	First	Second	Third	Fourth
Corner	728.39	584.90	444.99	302.58	155.52
Centre	815.11	653.31	496.91	338.14	175.50
Front	962.88	765.97	561.88	362.46	174.12

The peak shear in corner beams occurred at the first floor (102.71 kN) while the peak shear in corner columns occurred at the fourth floor (34.29 kN); a similar trend was observed for centre and front members. Peak bending moments in corner and centre beams occurred at the first floor (85.43 kN-m and 86.09 kN-m respectively), while the peak moment in corner columns occurred at the fourth floor (48.12 kN-m). Axial load in all columns reduced steadily from the ground floor to the fourth floor, as expected, with front columns carrying the highest ground-floor axial load (962.88 kN).

The percentage variation in axial load and bending moment between successive floors, computed for corner, centre and front columns and beams, did not exceed about 52% for axial load reduction between floors and remained within reasonable limits for bending moment, confirming a consistent and safe load path through the structure. Storey drift values obtained from the response-spectrum analysis were well within the 0.004h limit prescribed by IS 1893:2002, and the maximum storey shear was found to occur, as expected, in the lower storeys, decreasing with height.

5. CONCLUSIONS

The G+4 reinforced concrete residential building located in seismic zone V was successfully analysed and designed using ETABS for dead, live and seismic (static and response-spectrum) loads as per IS 875 and IS 1893:2002. Storey displacements and drifts were found to be within the permissible limits, and the shear force, bending moment, torsion and axial load results obtained from the software were consistent with expected structural behaviour, confirming the structure is safe for the considered loading. The study also demonstrates that ETABS considerably reduces the time and effort required for the analysis and design of multistorey buildings compared with manual methods, while allowing floors to be added or removed with ease during preliminary design iterations.

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REFERENCES

1. Abhay Guleria, "Structural Analysis of a Multi-Storied Building using ETABS for different Plan Configurations," International Journal of Engineering Research & Technology (IJERT), vol. 3, no. 5, 2014.
2. U. A. Balaji and Selvarasan, "Design and analysis of multistoried building under static and dynamic conditions using ETABS," International Journal of Technical Research and Applications.
3. Mahesh N. Patil and Yogesh N. Sonawane, "Seismic Analysis of Multistoried Building," International Journal of Engineering and Innovative Technology (IJEIT), vol. 4, no. 9, 2015.
4. IS 1893 (Part 1): 2002/2016, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.
5. IS 456:2000, Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standards, New Delhi.
6. M. H. Raghunandan and Suma, "Seismic Pounding between Adjacent RC Buildings with and without Base Isolation System," International Journal of Research in Engineering and Technology, vol. 4, no. 6, 2015.
7. Sukumar Behera, "Seismic Analysis of Multi-storey Building with Floating Column," National Institute of Technology Rourkela, 2012.
8. H. L. Kheni and A. K. Chandiwalla, "Seismic Response of RC Building with Soft Stories," International Journal of Engineering Trends and Technology (IJETT), vol. 10, no. 12, 2014.
9. S. R. Padol and R. S. Talikoti, "Review Paper on Seismic Responses of Multi-storey R.C.C Building with Mass Irregularity," International Journal of Research in Engineering and Technology, vol. 4, no. 3, 2015.
10. D. R. Panchal and P. M. Marathe, "Comparative Study of R.C.C, Steel and Composite (G+30 Storey) Building," Institute of Technology, Nirma University, Ahmedabad, 2011.
11. H. J. Shah and S. K. Jain, "Design Example of a Six Storey Building," IITK-GSDMA.
12. B. Umamaheshwara and P. Nagarajan, "Design Optimization and Analysis of Shear Wall in High Rise Buildings Using ETABS," International Journal for Research in Applied Science & Engineering Technology, vol. 4, no. 8, 2016.
13. C. V. Lavanya, E. P. Pailey and M. Sabreen, "Analysis and design of G+4 residential building using ETABS," International Journal of Civil Engineering and Technology, vol. 8, no. 4, 2017.
14. P. Agarwal and M. Shrikhande, Earthquake Resistant Design of Structures, PHI Learning Pvt. Ltd., 2012.
15. Ali Kadhim Sallal, "Design and analysis of a ten-storied building using ETABS software-2016," International Journal of Research in Advanced Engineering and Technology, vol. 4, no. 2, 2018.
16. IS 875 (Parts 1-3): 1987/2015, Code of Practice for Design Loads for Buildings and Structures, Bureau of Indian Standards, New Delhi.
17. IS 16700:2017, Criteria for Structural Safety of Tall Buildings, Bureau of Indian Standards, New Delhi.