ETABS-Based Seismic Analysis of A G+6 RCC Commercial Building in Seismic Zone III

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Abstract: This study presents the seismic analysis and design of a G+6 reinforced cement concrete (RCC) commercial building located in Amaravati, Andhra Pradesh, which falls under Seismic Zone III. The structural modelling and analysis are carried out using ETABS software by considering dead load, live load, and seismic loads in accordance with IS 1893 (Part 1): 2016 and IS 456:2000. The Response Spectrum Method is adopted to evaluate the dynamic response of the structure. The maximum storey displacement under dead load is observed as 6.1 mm in the X-direction and 4.42 mm in the Y-direction, while under live load the corresponding values are 4.006 mm and 3.579 mm, respectively. For seismic loading, the maximum storey displacement under RSX is 0.094 mm in X-direction and 0.100 mm in Y-direction, whereas under RSY it is 0.078 mm and 0.153 mm, respectively. The computed storey drift values for all load cases are found to be within the permissible limits specified by IS 1893 (Part 1): 2016. The maximum base shear occurs for load combinations 1.5 (DL + RSX) and 1.2 (DL + LL + RSY). The fundamental natural time period is obtained as 2.343 seconds in Mode 1. The overall bending moment and shear force values are within acceptable limits, indicating satisfactory structural behavior. Based on the analysis results, the G+6 RCC commercial building is structurally safe and stable under seismic loading conditions.

Keywords: *G+6 RCC Commercial Building, Dead Load, Live Load, Seismic Loads, Response Spectrum Method, Bending Moment, Shear Force, Storey Drift, Base Shear, Storey Displacement.*

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I. INTRODUCTION

The occurrence of earthquakes in different parts of India highlights the need for earthquake-resistant structural design, especially in rapidly developing urban regions where multistory buildings are increasingly common. Ensuring the safety and stability of such structures during seismic events has become an important aspect of modern civil engineering practice. In the present study, a G+6 reinforced cement concrete (RCC) commercial building is selected for seismic performance evaluation. A three-dimensional structural model is developed in ETABS software to simulate the behavior of the building under earthquake loading conditions.[2] The study area, Amaravati in Andhra Pradesh, is classified under Seismic Zone III according to IS 1893 (Part 1):2016, which represents a region of moderate seismic intensity. The building consists of RCC beams, columns, slabs, and shear walls forming the primary load-resisting system. Seismic loads are determined in accordance with IS 1893 (Part 1):2016, while the structural design procedures follow the provisions of IS 456:2000. Dynamic analysis of the structure is carried out using the Response Spectrum Method to evaluate the seismic response of the building. Parameters such as lateral displacement, inter-storey drift, natural time period, base shear, and member forces are analyzed to examine the structural behavior and serviceability during earthquake action. Seismic analysis plays a significant role in predicting how structures respond to dynamic ground motions and helps engineers design buildings capable of withstanding earthquake-induced forces without major structural failure. [1, 2]

Seismic analysis is performed to study the behavior, stability, and structural reliability of buildings subjected to

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earthquake forces. A structure experiences different types of loading conditions such as dead load, live load, and earthquake load. Among these, earthquake forces are time-dependent dynamic loads that significantly influence the response of the structure during ground motion. The seismic response of a building is affected by parameters including structural height, lateral stiffness, soil properties, and the seismic classification of the location. In the Indian context, the procedures for seismic evaluation and earthquake-resistant structural design are governed by IS 1893 (Part 1):2016. The code provides detailed recommendations for calculating seismic forces and analyzing structures under earthquake conditions. Important design parameters considered in seismic analysis include the zone factor, importance factor, damping ratio, and response reduction factor, all of which contribute to achieving adequate structural safety and performance during seismic events. [4]

➢ *Introduction to ETABS*

ETABS (Extended Three-Dimensional Analysis of Building Systems) is a specialized structural analysis and design software developed by Computers and Structures, Inc. (CSI). It is widely used by structural engineers for designing the residential, commercial and Institutional buildings such as hospitals, malls and multi-storey buildings. ETABS provides integrated environment for the creation of three-dimensional structural models by assigning material properties, defining loads such as live load, dead load, wind load, snow load, seismic load etc. This software supports both the linear and non-linear analysis and capable of handling structural elements such as beams, columns, slabs, shear walls and bracing systems. [3]

II. LITERATURE REVIEW

Prem Kumar et al. [1] investigated the effect of shear wall placement on the seismic performance of reinforced concrete multi-storey buildings. Using response spectrum analysis, the study compared conventional RCC frames, shear wall systems, and combined structural configurations under earthquake loading. The results showed that proper positioning of shear walls significantly improves structural stiffness, stability, and resistance to lateral forces by reducing displacement and enhancing overall seismic performance.

Nafisa Anjum et al. [2] evaluated the seismic behaviour of a 10-storey reinforced concrete building using ETABS based on BNBC 2020 provisions. The study compared pushover analysis and response spectrum analysis, highlighting that response spectrum analysis is effective for design-level evaluation, while pushover analysis provides better understanding of nonlinear structural behavior and damage progression. Parameters such as storey displacement, drift, and base shear were assessed, confirming the reliability of both methods in seismic performance analysis.

Chandrasekhar Reddy Kamasani and Gullapudi Lalith Kumar [3] studied the analysis of a 30-storey reinforced concrete building using ETABS software. The building was subjected to dead, live, and seismic loads, and key structural responses such as bending moment, shear force, axial force, base shear, and lateral displacement were evaluated. The study also compared results across seismic zones II to V, showing that structural response increases with higher seismic intensity.

K. Satya Mahesh et al. [5] conducted the design and analysis of a G+15 commercial RCC building using STAAD Pro in accordance with Indian Standard Codes. The study focused on structural safety and stability by evaluating parameters such as shear force, bending moment, deflection, and displacement under seismic conditions. The work also included soil investigation, load estimation, reinforcement detailing, structural modelling, and preparation of drawings, along with functional planning features like parking and green spaces.

➢ *Objectives*

- Developed a three-dimensional structural model of the G+6 commercial building in ETABS by incorporating all major structural components such as beams, columns, slabs, and walls.
- Calculated and applied various structural loads, including dead loads, live loads, and seismic loads, in accordance with relevant design standards and Performed seismic analysis of the building using the Response Spectrum Method as per the provisions of IS 1893 (Part 1): 2016.
- Identifying the critical structural members governing seismic response of the building.
- Ensure that the proposed building design meet the minimum requirements and safety factors prescribed by Indian Standard codes of practice.

➢ *Scope of Study*

- Prepared the floor plans in AutoCAD and defined the overall geometry of the building, including base area, total height, and floor heights.
- Analyzed the axial forces, shear forces, and bending moments developed in beams and columns under seismic loading conditions.
- Adopted the Response Spectrum Method for seismic analysis by considering important seismic parameters such as zone factor, importance factor, response reduction factor, and soil conditions.
- Conducted seismic analysis of the G+6 commercial building using ETABS software.
- Interpreted and evaluated the analysis results obtained from ETABS software.

III. METHODOLOGY

This project focuses on the systematic analysis and evaluation of a building subjected to seismic loading Conditions. The study begins with the collection of essential structural and design data, including geometric details, loading information, and material specifications. The building is modelled using ETABS software to simulate its structural behavior accurately. Material characteristics and sectional properties for structural elements such as beams,

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columns, and slabs are then assigned based on design requirements. Different types of loads, namely dead load, live load, floor finish load, and wall load, are applied in accordance with the relevant Indian Standard code provisions. Seismic analysis of the structure is performed using the Response Spectrum Method to assess the response of the building during earthquake conditions. The structural performance is subsequently evaluated by examining parameters such as storey displacement, storey drift, base shear, and internal member forces. Finally, the results obtained from the analysis are interpreted to understand the seismic behavior and overall structural efficiency of the building. The functional planning of the structure consists of a six-storey hospital building designed to meet the required spatial and structural requirements. The architectural plan of the building is prepared using AutoCAD software. The overall dimensions of the building are 50 m × 40 m, while the total built-up area measures 19 m × 36 m. The height of each storey is maintained uniformly at 3.6 m throughout all the floors to ensure proper functional and structural stability of the building. Before starting the modelling process, the necessary data like building details, design data and structural parameters are collected. This data is important for the performance and accuracy of the structure. The design and analysis of the structure is carried out according to the following Indian Standard Codes.

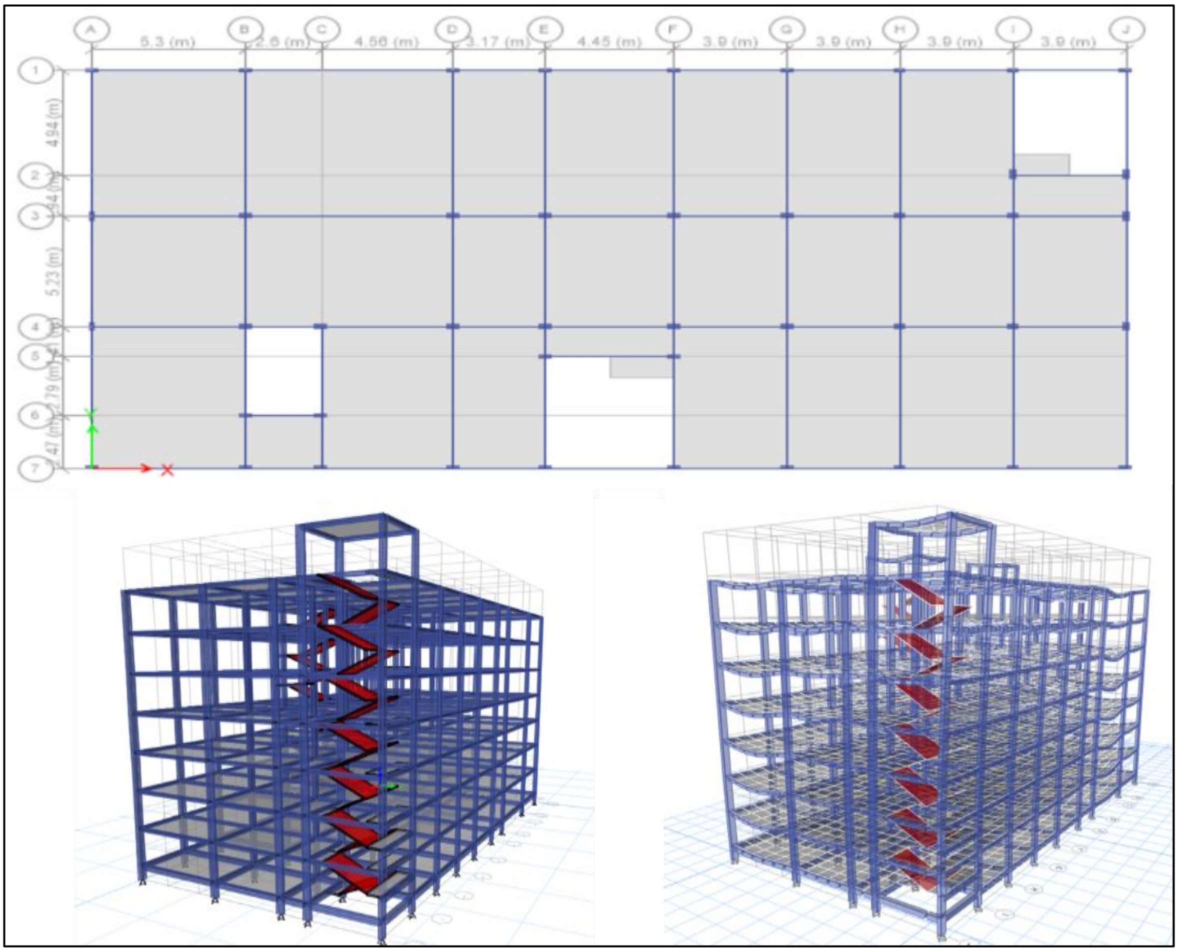

Fig 1 Plan, 3D View & 3D Analysis Model of the Building

ETABS software is widely used for the modelling and analysis of multi-storey structures subjected to various loading conditions. In the present study, the structural model of the hospital building is developed systematically using ETABS. Initially, the grid system is established according to the architectural layout of the building, which helps in positioning structural components such as columns, beams, and slabs accurately. The vertical configuration of the building is then defined by assigning storey data in the software. The structure consists of six floors, each having a uniform storey height of 3.6 m. After defining the geometric layout, material properties for concrete and reinforcement steel are assigned based on the selected design grades. Important material parameters such as density, Poisson's ratio, compressive strength, and modulus of elasticity are specified to achieve accurate analytical results. Section properties for beams, columns, and slabs are subsequently defined, as these properties directly influence the stiffness, strength, and overall response of the structure under loading conditions. The modelling of structural elements is then carried out by placing columns at grid intersections, connecting them with beams, and assigning slab elements over the structural framework. To ensure proper transfer and distribution of lateral loads, rigid diaphragms are assigned at each floor level. This assumption simplifies the analysis procedure and effectively represents the in-plane behavior of reinforced concrete floor slabs during seismic action.

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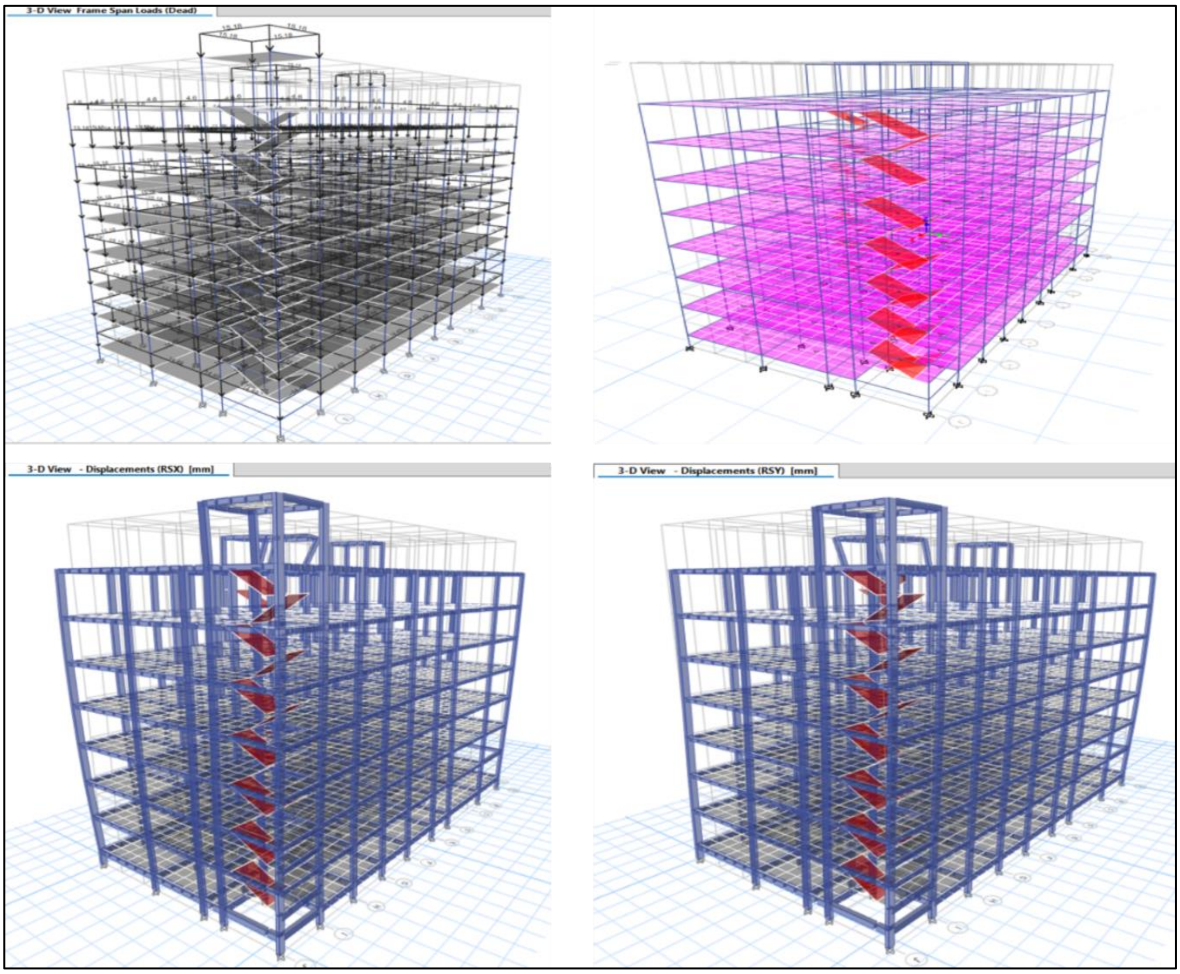

Fig 2 Dead Load, Live load, Seismic Load in X-Y Direction

IV. RESULT AND DISCUSSION

This study focuses on the seismic analysis and structural design of a G+6 reinforced cement concrete (RCC) commercial building situated in Amaravati, Andhra Pradesh. The structural modelling and analytical procedures are performed using ETABS software by considering various loads such as dead load, live load, and seismic load in accordance with the provisions of IS 1893 (Part 1): 2016 and IS 456:2000. The dynamic behavior of the structure under earthquake loading is evaluated using the Response Spectrum Method. [5]

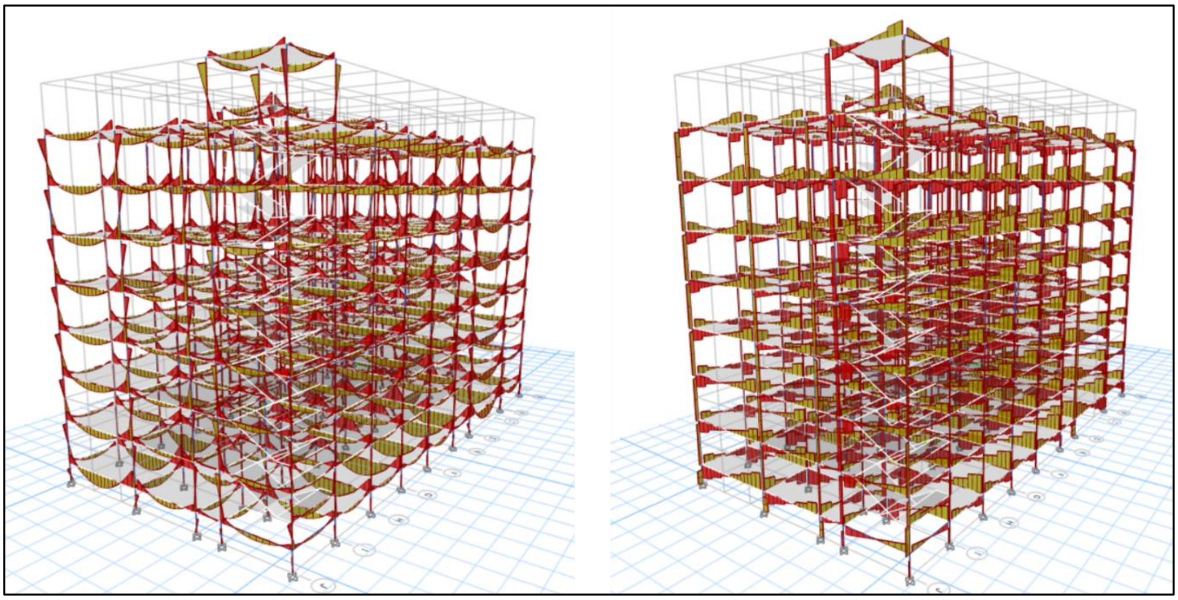

Fig 3 Bending Moment & Shear Force Under Dead Load, Live Load, Seismic Load in X-Y Direction

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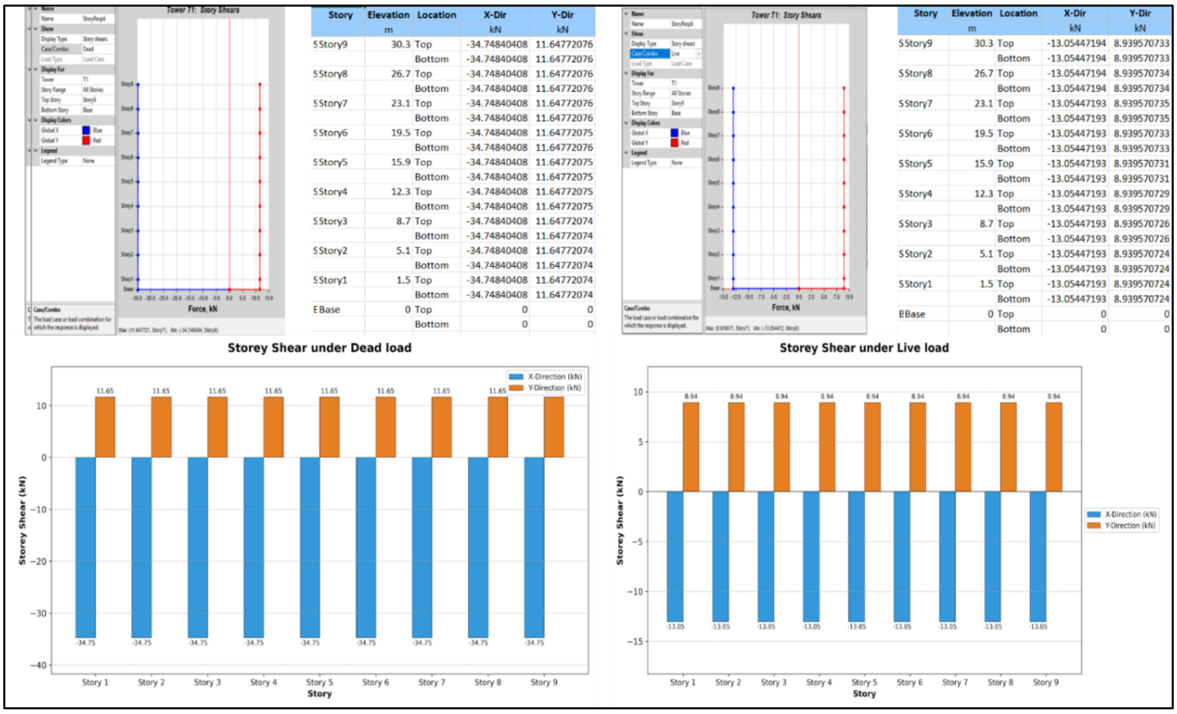

Fig 4 Storey Shear Under Dead Load, Live Load

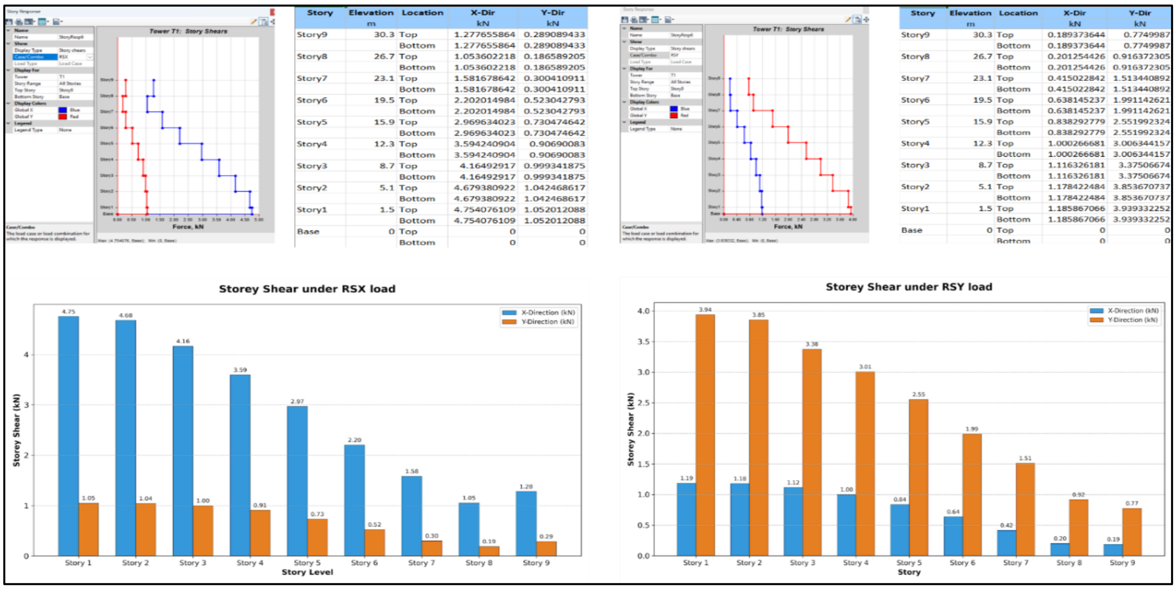

Fig 5 Storey Shear Under Seismic Load in X-Y Direction

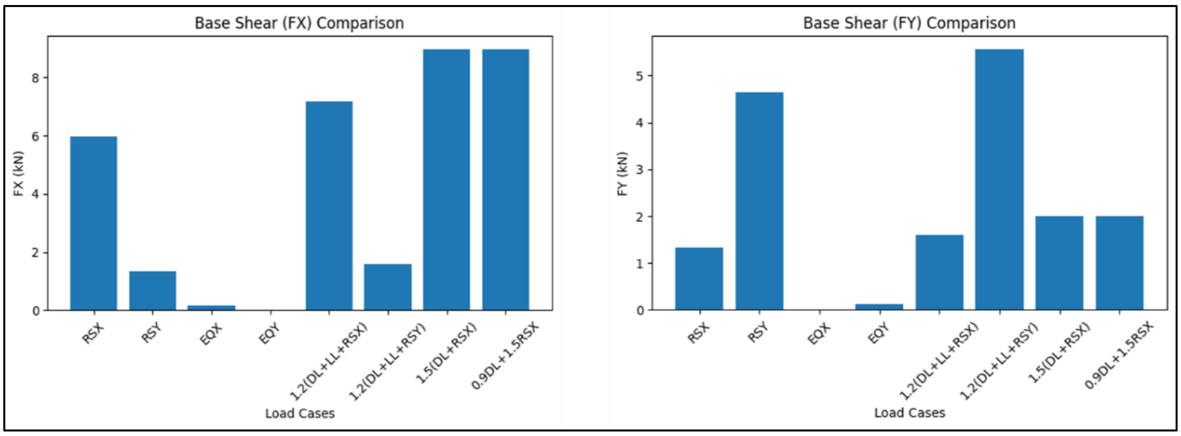

Fig 6 Base Shear in X-Y Direction

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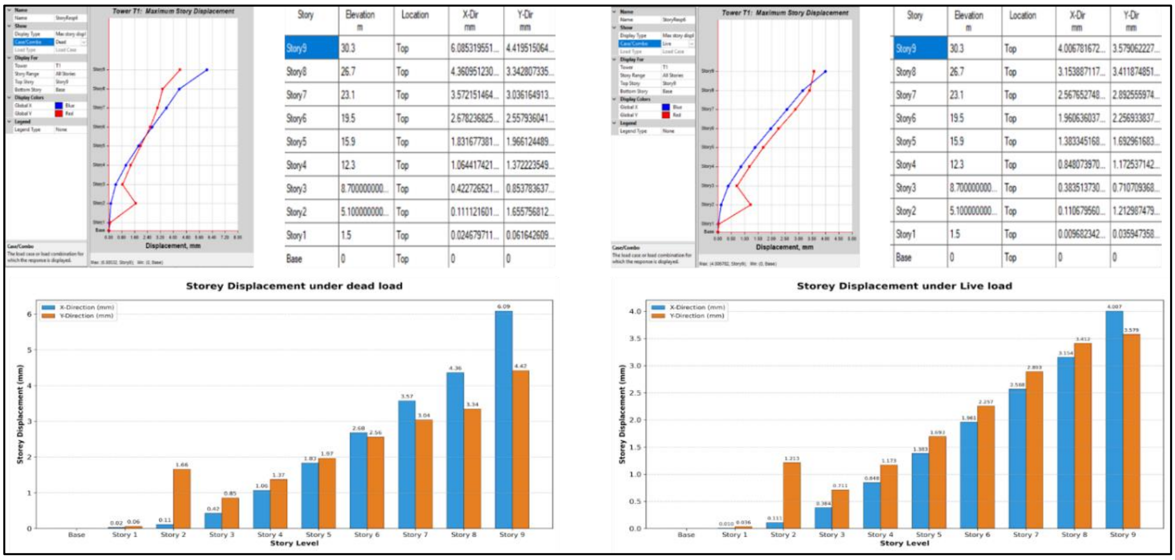

Fig 7 Storey Displacement Under Dead Load, Live Load

Fig 8 Storey Displacement Under Seismic Load in X-Y Direction

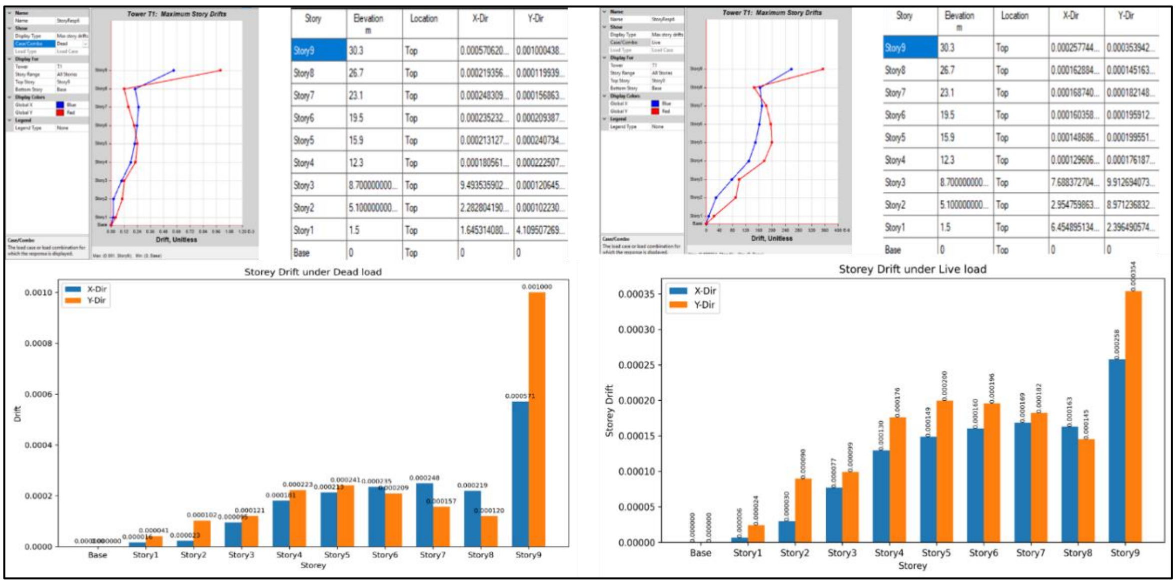

Fig 9 Storey Drift Under Dead Load, Live Load

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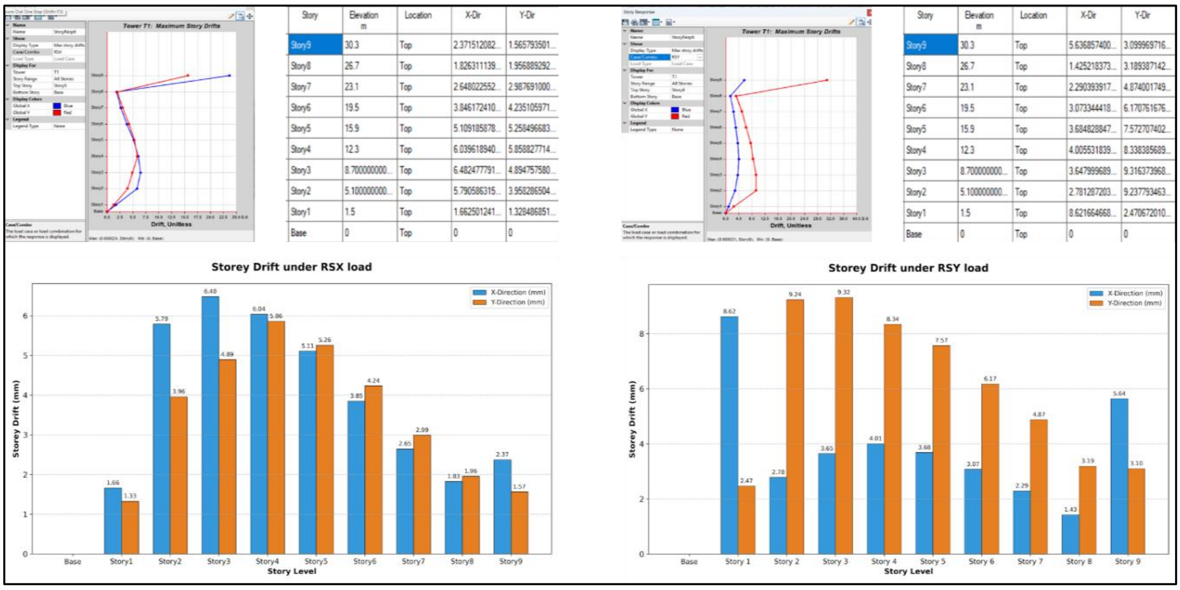

Fig 10 Storey Drift Under Seismic Load in X-Y Direction

V. CONCLUSION

The seismic analysis and performance evaluation of the G+6 RCC commercial building was carried out successfully using ETABS software in accordance with the provisions of IS 1893 (Part 1): 2016. The structural model was developed with appropriate material properties, section properties, and loading conditions to ensure accurate analysis of the building behavior under gravity and seismic forces. The Response Spectrum Method was adopted for seismic analysis, as it provides a realistic representation of the dynamic response of the structure during earthquake loading. The analysis results indicate that the maximum storey displacement gradually increases from the base to the top storey. Under dead load conditions, the maximum storey displacement was observed as 6.1 mm in the X-direction and 4.42 mm in the Y-direction, whereas under live load conditions, the maximum displacement was 4.006 mm in the X-direction and 3.579 mm in the Y-direction. Under seismic loading, the maximum storey displacement for RSX was 0.094 mm in the X-direction and 0.100 mm in the Y-direction, while for RSY it was 0.078 mm in the X-direction and 0.153 mm in the Y-direction.

The storey drift results also demonstrated satisfactory structural performance. The maximum storey drift under dead load was 9.49 mm in the X-direction and 4.10 mm in the Y-direction. Under live load, the drift values were 7.68 mm in the X-direction and 9.91 mm in the Y-direction. Similarly, under seismic loading, the maximum storey drift for RSX was 6.48 mm in the X-direction and 4.89 mm in the Y-direction, while for RSY it was 8.62 mm in the X-direction and 9.31 mm in the Y-direction. The storey shear values under dead load were recorded as -34.748 in the X-direction and 11.647 in the Y-direction, whereas under live load the values were -13.054 in the X-direction and 8.939 in the Y-direction. Under seismic loading, the maximum storey shear for RSX was 4.75 in the X-direction and 1.05 in the Y-direction, while for RSY it was 1.18 in the X-direction and 3.93 in the Y-direction.

The base shear analysis revealed that the maximum base shear in the X-direction occurred under the load combinations 1.5(DL + RSX) and 0.9DL + 1.5RSY, while the maximum base shear in the Y-direction was observed for the load combination 1.2(DL + LL + RSY). Modal analysis showed that the maximum natural time period was obtained in Mode 1 with a value of 2.343 seconds and a corresponding frequency of 2.773 cycles/second. Furthermore, the overall bending moment of the G+6 building was maximum positive moment at the base with a value of 67 kN-m, while the maximum negative bending moment was -133 kN-m. The overall shear force of the building was found to vary between a maximum of 96 kN and a minimum of 48 kN. Based on the obtained analytical results, it was observed that the structure satisfies the required safety criteria, as the lateral displacements and storey drifts were within permissible limits and no excessive deformation was observed. The structural elements were found to be capable of resisting the applied gravity and seismic loads effectively. Therefore, it can be concluded that the G+6 RCC commercial building is structurally safe and stable under seismic loading conditions as per IS 1893 (Part 1): 2016.

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