

Analysis of G+30 high-rise buildings by using ETABS for various frame sections in Zone IV and Zone V

Mr. Rushikesh Prashant Swami¹, Dr. Sharma K. M.²

¹ Mr. Rushikesh Prashant Swami, Civil Engineering, Dattakala Shikshan Santha's
Dattakala Group of Institutions faculty of Engineering
Swami Chincholi, Tal-Daund, Dist-Pune

² Dr. Sharma K. M. , Civil Engineering, Dattakala Shikshan Santha's
Dattakala Group of Institutions faculty of Engineering
Swami Chincholi, Tal-Daund, Dist-Pune

ABSTRACT - Rapid urbanization and limited land availability in metropolitan regions have significantly increased the demand for high-rise structures, particularly in earthquake-prone areas. The structural performance of tall buildings under seismic loading depends largely on the stiffness, strength, and geometric configuration of the structural framing system. This study presents the seismic analysis and comparative evaluation of a G+30 reinforced concrete (RCC) high-rise building using ETABS software by considering different frame section configurations under Seismic Zone IV and Zone V conditions as per IS 1893 (Part 1):2016.

A three-dimensional analytical model of the building was developed in ETABS with appropriate material properties, loading conditions, and boundary assumptions. The structure was analyzed for dead load, live load, wind load, and seismic load combinations according to IS 875 and IS 1893 provisions. Various frame section geometries, including rectangular, square, and flanged sections, were incorporated to evaluate their influence on the seismic response of the structure. Linear static analysis and response spectrum analysis were carried out to assess the dynamic behavior of the building under different seismic intensities.

The seismic performance of the structure was evaluated based on key response parameters such as storey displacement, storey drift, base shear, bending moment, and time period. The comparative study indicates that buildings located in Zone V experience considerably higher lateral displacement, drift, and base shear than those in Zone IV due to increased seismic intensity. It was also observed that frame sections with higher stiffness and moment of inertia significantly reduce structural deformation and improve overall seismic resistance. Among the considered configurations, optimized frame geometries demonstrated better control over displacement and drift while maintaining structural stability within permissible code limits.

The study highlights the importance of selecting appropriate frame section configurations in the design of high-rise RCC buildings located in seismic regions. The findings provide practical guidance for structural engineers in developing safer, more stable, and economical earthquake-resistant tall structures using modern analytical tools like ETABS.

KEYWORDS: High-rise Building, RCC Structure, ETABS, Seismic Analysis, Seismic Zone IV, Seismic Zone V, Frame Sections, Storey Drift, Storey Displacement, Base Shear, Response Spectrum Analysis, Earthquake Resistant Design, Structural Performance, Reinforced Concrete Building, IS 1893:2016

1.INTRODUCTION

Rapid urbanization and population growth have increased the demand for high-rise buildings in metropolitan cities. Due to limited land availability, vertical construction has become an effective solution for residential and commercial development. However, high-rise structures are more vulnerable to lateral forces such as earthquakes and wind loads because of their height and flexibility. Therefore, proper structural analysis and design are essential to ensure the safety and stability of tall buildings.

India is located in a seismically active region, and many parts of the country fall under Seismic Zones IV and V as per IS 1893 (Part 1):2016. Buildings constructed in these zones must be designed carefully to resist earthquake forces and minimize structural damage. The seismic performance of a building mainly depends on its stiffness, strength, ductility, and structural configuration.

Reinforced Cement Concrete (RCC) framed structures are commonly used in high-rise construction due to their durability and structural efficiency. The geometry and dimensions of frame sections such as rectangular, square, and flanged sections significantly influence the behavior of buildings under seismic loading. Different frame sections provide different levels of stiffness and resistance against lateral forces, which affects storey displacement, drift, and base shear.

With the advancement of structural analysis software, the analysis and design of tall buildings have become more accurate and efficient. ETABS is one of the most widely used software tools for modeling and analyzing multi-storey structures under various loading conditions. It provides reliable results for seismic analysis and helps engineers evaluate the structural behavior of buildings effectively.

In seismic design, controlling lateral displacement and inter-storey drift is very important to maintain structural stability and occupant safety during earthquake excitation. Proper selection of beam and column sections can improve the overall stiffness and performance of the structure. Comparative analysis of different frame configurations helps in identifying the most suitable structural system for earthquake-resistant construction. Therefore, this study aims to evaluate and compare the seismic behavior of different frame sections for a G+30 RCC building under Zone IV and Zone V conditions using ETABS software.

The study also focuses on understanding how seismic intensity influences the structural response of tall buildings in different zones. The results obtained from the analysis can help structural engineers in selecting efficient frame sections for safer and more economical high-rise construction.

2. LITERATURE SURVEY

Rapid urbanization and population growth have significantly increased the demand for high-rise buildings in metropolitan cities. Due to limited land availability, vertical development has become essential for residential and commercial infrastructure. High-rise buildings are more sensitive to lateral forces such as earthquakes and wind loads because of their height and flexibility. During seismic activity, these structures experience considerable displacement, storey drift, base shear, and bending moments, which directly influence structural safety and stability. Therefore, proper seismic analysis and

earthquake-resistant design of reinforced concrete (RCC) high-rise buildings have become important areas of research in structural engineering.

India is located in a seismically active region, and many parts of the country fall under Seismic Zones IV and V according to IS 1893 (Part 1):2016. Buildings located in these regions are subjected to severe earthquake forces and therefore require efficient structural systems to resist seismic effects effectively. The seismic behavior of RCC buildings depends on several factors such as frame geometry, stiffness, ductility, material properties, and lateral load-resisting systems. Proper selection of beam and column sections plays an important role in improving the seismic resistance of tall structures.

With the advancement of structural engineering software, seismic analysis has become more efficient and accurate. ETABS is one of the most widely used software tools for modeling and analyzing multi-storey RCC buildings because it supports linear static and dynamic analysis methods. Several researchers have used ETABS software to study the behavior of structures under different loading conditions and seismic zones.

Mahesh et al. (2015) carried out a comparative study on the seismic response of multi-storey buildings using manual calculations and ETABS software [1]. The authors observed that ETABS provides more accurate and reliable structural behavior with reduced calculation time. The study emphasized the importance of software-based seismic analysis for earthquake-resistant design.

Viswanathan et al. (2017) studied the seismic behavior of multi-storey structures with different slab systems using ETABS software [2]. The researchers analyzed G+6, G+9, and G+12 buildings and evaluated parameters such as storey displacement and storey shear. The study concluded that taller structures experience greater lateral displacement and flexibility.

Babu et al. (2017) analyzed RCC building frames considering flexible and rigid support conditions [3]. The results indicated that structures with flexible supports experience larger lateral displacement compared to rigid supports. The research highlighted the importance of soil-structure interaction in earthquake-resistant structural design.

Lavanya et al. (2017) presented the analysis and design of a residential multi-storey building using ETABS software under seismic loading conditions [4]. The researchers observed that modifying beam and column dimensions significantly improves stiffness and reduces displacement and storey drift. The study concluded that optimized member dimensions improve seismic resistance and structural performance. Lingeshwaran et al. (2017) focused on the seismic analysis of RC framed structures supported on raft foundations [5]. The researchers concluded that suitable structural configuration and proper analysis methods improve the stability and seismic performance of multi-storey structures.

Gopal et al. (2017) discussed the analysis and design procedure of a G+5 residential building using ETABS software [6]. The authors highlighted that ETABS simplifies the structural analysis process and provides accurate results for evaluating seismic behavior.

Raja et al. (2019) investigated earthquake-resistant design approaches for multi-storey buildings using ETABS software [7]. The researchers concluded that proper seismic detailing and efficient structural design improve the safety and stability of RCC structures subjected to earthquake loading.

Naveen et al. (2019) analyzed the seismic response of buildings with irregular configurations using ETABS software [8]. The researchers concluded that structural irregularities increase the possibility of severe structural damage during earthquakes due to uneven distribution of stiffness and forces.

Shwetha et al. (2019) conducted analysis and design of multi-storey buildings under seismic loading using ETABS software [9]. The results indicated that buildings in higher seismic zones experience greater displacement and base shear because of increased seismic intensity.

Pratap et al. (2020) carried out dynamic analysis of G+20 buildings with shear walls placed at different locations using ETABS software [10]. The researchers observed that properly positioned shear walls significantly reduce storey displacement and drift by increasing structural stiffness.

Nishanth et al. (2020) analyzed commercial buildings with different slab arrangements under seismic and wind loads using ETABS software [11]. The results showed that waffle slab systems provide improved performance in terms of displacement, drift, and base shear.

Kumar et al. (2019) performed response spectrum analysis of G+20 and G+30 buildings under earthquake loading [12]. The study revealed that taller structures experience greater displacement, drift, and base shear compared to low-rise buildings.

Bansal and Jain (2020) examined the influence of seismic zones on the behavior of RCC buildings [13]. The study observed that buildings in Zone V experience significantly higher displacement and drift due to greater seismic intensity.

Chopra and Mehta (2018) investigated the effect of different column shapes such as square, rectangular, and flanged sections on seismic performance [14]. The researchers observed that rectangular and flanged sections provide greater stiffness and reduced storey drift compared to square sections.

Rao et al. (2020) analyzed RCC frames with varying beam and column dimensions to study their influence on displacement and base shear [15]. The researchers concluded that optimized section dimensions improve structural stiffness and seismic resistance without significantly increasing construction cost.

From the reviewed literature, it is evident that the seismic performance of high-rise RCC buildings is greatly influenced by structural configuration, frame geometry, stiffness, and load-resisting systems. Most researchers concluded that increasing building height results in greater displacement, storey drift, and base shear, thereby requiring enhanced stiffness and ductility. Previous studies also established that ETABS is an efficient and reliable software tool for seismic analysis and performance evaluation of high-rise structures.

The literature also indicates that frame section geometry significantly influences seismic response. Rectangular and flanged sections generally provide better stiffness and reduced drift compared to square sections. Moreover, buildings located in higher seismic zones experience larger displacement and require stronger lateral load-resisting systems to maintain structural safety.

However, limited research has been carried out on the comparative seismic analysis of G+30 RCC high-rise buildings considering different frame section geometries under both Zone IV and Zone V conditions. Therefore, the present study aims to

analyze and compare the seismic behavior of a G+30 RCC building using ETABS software by evaluating important seismic response parameters such as storey displacement, storey drift, base shear, and time period for different frame section configurations.

3. RESEARCH GAP & PROBLEM STATEMENT

3.1 Research Gap

From the reviewed literature, it is observed that many researchers have studied the seismic behavior of multi-storey RCC buildings using ETABS software under different loading conditions and seismic zones. Previous studies mainly focused on slab systems, shear walls, irregular structures, soil conditions, and lateral load-resisting systems. Several researchers also evaluated seismic response parameters such as storey displacement, storey drift, base shear, and bending moments for buildings of different heights.

However, limited studies have been carried out on the comparative seismic analysis of G+30 RCC high-rise buildings considering different frame section geometries such as rectangular, square, and flanged sections under both Seismic Zone IV and Zone V conditions. Most of the available research focuses on low-rise or medium-rise structures, while fewer studies examine the effect of frame section variation on the seismic performance of tall RCC buildings.

In addition, very limited research is available on identifying the most efficient frame section configuration for controlling displacement, drift, and base shear in high seismic regions using ETABS software. Therefore, there is a need for a detailed comparative study on the seismic behavior of G+30 RCC buildings with different frame sections under severe earthquake conditions.

3.2 Problem Statement

High-rise RCC buildings located in earthquake-prone regions are subjected to significant lateral forces during seismic activity, which may lead to excessive displacement, storey drift, bending moments, and structural instability. The seismic performance of such buildings mainly depends on the stiffness, strength, and geometry of the structural frame sections. Different beam and column section configurations influence the overall structural behavior and resistance against earthquake forces.

Although ETABS software is widely used for seismic analysis of RCC structures, limited studies have compared the performance of different frame section geometries such as rectangular, square, and flanged sections for G+30 high-rise buildings under Zone IV and Zone V seismic conditions.

Therefore, the present study focuses on the seismic analysis of a G+30 RCC high-rise building using ETABS software to evaluate and compare important seismic response parameters such as storey displacement, storey drift, base shear, and time period for different frame section configurations. The study aims to identify the most suitable and efficient frame section for improving seismic performance and structural safety in high seismic zones.

4. METHODOLOGY

4.1 Introduction

The methodology adopted in the present study focuses on the seismic analysis and comparative performance evaluation of a G+30 reinforced concrete (RCC) high-rise building using ETABS software under Seismic Zone IV and Zone V conditions as specified in IS 1893 (Part 1):2016. The research primarily investigates the influence of different frame section geometries such as rectangular, square, and flanged sections on the seismic behavior of tall buildings. Due to rapid urbanization and increasing vertical development in metropolitan regions, the structural safety of high-rise buildings under earthquake loading has become a major concern in structural engineering. The behavior of such structures during seismic excitation depends significantly on lateral stiffness, ductility, mass distribution, and frame configuration.

In this study, a three-dimensional analytical model of the RCC building was developed in ETABS by incorporating material properties, geometric dimensions, loading conditions, and seismic parameters according to Indian Standard code provisions. Linear static analysis and dynamic response spectrum analysis were carried out to evaluate the structural response under earthquake loading. Important seismic response parameters such as storey displacement, storey drift, base shear, bending moment, and natural time period were extracted and compared for different frame section configurations. The adopted methodology provides a

systematic approach for identifying the most effective frame geometry for improving structural stability and seismic resistance in high-rise RCC buildings.

4.2 Building Modeling in ETABS

The structural model considered for the present study consists of a G+30 reinforced concrete framed building modeled using ETABS software. The building was assumed to be regular in both plan and elevation to eliminate the effects of structural irregularities and to focus specifically on the influence of frame section geometry on seismic response. The analytical model was developed using beam and column frame elements along with rigid diaphragm assumptions at each floor level. The structural members were assigned appropriate sectional dimensions and material properties based on Indian Standard code recommendations.

The building consists of thirty upper storeys above ground level with a ground floor height of 4 m and typical floor heights of 3 m. Reinforced concrete of grade M30 and high-yield strength steel reinforcement of grade Fe500 were considered for the structural components. The slab thickness was assumed as 230 mm, while the beam and column dimensions were varied according to the selected frame section configuration. Medium soil condition was considered in the analysis as per IS 1893 provisions. The supports at the base of the structure were assumed to be fixed, thereby neglecting foundation flexibility effects. The ETABS model was prepared separately for rectangular, square, and flanged frame section configurations while maintaining all other structural parameters constant to enable accurate comparative evaluation.

4.3 Material Properties and Structural Parameters

The material properties adopted in the analysis were defined according to IS 456:2000 provisions for reinforced concrete structures. Concrete grade M30 was selected for beams, columns, and slabs due to its suitability for high-rise construction. Fe500 grade reinforcement steel was considered for structural reinforcement because of its high tensile strength and ductility characteristics. The unit weight of reinforced concrete was assumed as 25 kN/m³.

The modulus of elasticity of concrete was calculated using the standard expression given in IS 456:

$$E_c = 5000\sqrt{f_{ck}}$$

where E_c represents the modulus of elasticity of concrete and f_{ck} represents the characteristic compressive strength of concrete in MPa.

The Poisson's ratio of concrete was considered as 0.2. The seismic parameters adopted in the study included an importance factor of 1.5, response reduction factor of 5, and damping ratio of 5%. The building was analyzed under Seismic Zone IV and Zone V conditions according to IS 1893 (Part 1):2016. Wind load parameters were assigned according to IS 875 (Part 3):1987 with a basic wind speed of 55 m/s.

4.4 Loading and Load Combinations

The structure was analyzed under dead load, live load, wind load, and seismic load conditions according to Indian Standard code provisions. Dead loads included the self-weight of structural members, floor finish loads, wall loads, and slab loads. ETABS automatically calculated the self-weight of the structural components based on material density and sectional dimensions. The live load intensity was considered as 5 kN/m² according to IS 875 (Part 2):1987 provisions for residential and commercial occupancy conditions.

Wind loads were assigned according to IS 875 (Part 3):1987 based on the building height, terrain category, and basic wind speed. Seismic loads were calculated according to IS 1893 (Part 1):2016 for both Zone IV and Zone V conditions. The design horizontal seismic coefficient was determined using the expression:

$$A_h = \frac{ZIS_a}{2Rg}$$

where A_h is the horizontal seismic coefficient, Z is the seismic zone factor, I is the importance factor, R is the response reduction factor, and S_a/g represents the average response acceleration coefficient.

The seismic base shear acting on the structure was calculated using:

$$V_b = A_h W$$

where V_b is the design base shear and W is the seismic weight of the structure.

Appropriate load combinations were generated in ETABS according to limit state design principles for

evaluating the structural behavior under combined loading conditions.

4.5 Seismic Analysis Procedure

The seismic analysis of the G+30 RCC building was carried out using both linear static analysis and dynamic response spectrum analysis methods in ETABS. Linear static analysis was initially performed to estimate the approximate seismic forces acting on the structure under earthquake loading. However, because high-rise buildings exhibit significant dynamic characteristics, response spectrum analysis was adopted to obtain more realistic seismic response behavior.

Response spectrum analysis is a dynamic analysis method that evaluates the maximum structural response corresponding to different vibration modes of the building. The response spectrum curves specified in IS 1893 (Part 1):2016 for medium soil conditions were incorporated into the ETABS model. The dynamic characteristics of the structure such as modal mass participation, natural frequencies, and vibration modes were determined during the analysis.

The approximate fundamental natural time period of the RCC building was estimated using the empirical expression provided in IS 1893:

$$T = 0.075h^{0.75}$$

where T represents the fundamental natural time period in seconds and h represents the height of the building in meters.

The seismic responses obtained from the analysis included storey displacement, inter-storey drift, base shear, bending moment, and modal time period. Separate analyses were carried out for rectangular, square, and flanged frame section configurations under both Zone IV and Zone V conditions.

4.6 Frame Section Configurations

The primary objective of the present study is to evaluate the influence of frame section geometry on the seismic behavior of high-rise RCC buildings. Therefore, three different frame section configurations namely rectangular sections, square sections, and flanged sections were considered in the analysis. The geometry of structural members significantly affects the stiffness, strength, and moment of inertia of the building, which directly influences lateral displacement and drift under earthquake

loading.

Rectangular frame sections provide directional stiffness and are commonly used in high-rise construction due to their structural efficiency. Square sections offer uniform stiffness in both directions but may exhibit comparatively lower moment resistance under severe seismic excitation. Flanged sections possess higher moment of inertia and improved stiffness characteristics, thereby reducing lateral deformation and increasing structural stability.

Separate ETABS models were developed for each frame configuration while maintaining identical loading conditions, material properties, and geometric parameters. Comparative analysis of these frame sections was carried out to identify the most efficient structural configuration capable of minimizing displacement and drift while improving seismic resistance.

4.7 Evaluation of Seismic Response Parameters

The seismic performance of the structure was evaluated based on several important response parameters obtained from ETABS analysis. Storey displacement was studied to determine the lateral movement of each floor level under seismic excitation. Excessive displacement indicates reduced stiffness and increased structural flexibility. Inter-storey drift was evaluated because it represents the relative displacement between adjacent floors and is one of the most critical parameters governing seismic safety.

Storey drift was calculated using:

$$\theta = \frac{\Delta_i - \Delta_{i-1}}{h}$$

where θ represents storey drift, Δ_i and Δ_{i-1} represent lateral displacements of consecutive storeys, and h is the storey height.

Base shear was analyzed to determine the total lateral seismic force acting at the base of the structure. Bending moments developed in beams and columns were evaluated to understand force distribution and structural demand under earthquake loading. The natural time period of the building was also studied to evaluate the dynamic flexibility and vibration characteristics of different frame configurations.

The obtained results for Zone IV and Zone V were

comparatively evaluated to determine the influence of seismic intensity and frame geometry on overall structural performance.

4.8 Summary of Methodology

The methodology adopted in the present study provides a systematic framework for analyzing the seismic behavior of G+30 RCC high-rise buildings using ETABS software. Three different frame section configurations were modeled and analyzed under Zone IV and Zone V earthquake conditions according to IS 1893 (Part 1):2016 provisions. Linear static analysis and response spectrum analysis were carried out to evaluate the dynamic response of the structure. Important seismic response parameters such as storey displacement, storey drift, base shear, bending moment, and time period were extracted and compared to identify the most effective frame configuration for earthquake-resistant high-rise construction. The adopted methodology enables a comprehensive understanding of how frame geometry influences structural stiffness, stability, and seismic performance in tall RCC buildings.

5.RESULTS AND DISCUSSION

5.1 General

The seismic analysis of the G+30 reinforced concrete (RCC) high-rise building was carried out using ETABS software for different frame section configurations under Seismic Zone IV and Zone V conditions according to IS 1893 (Part 1):2016 provisions. The primary objective of the analysis was to investigate the influence of frame geometry on the seismic behavior and structural performance of the building under earthquake loading. Separate analytical models were developed for rectangular, square, and flanged frame sections while maintaining identical material properties, loading conditions, and geometric parameters. Linear static analysis and dynamic response spectrum analysis were performed to evaluate the seismic response of the structure.

The structural performance was assessed based on important seismic response parameters such as storey displacement, storey drift, base shear, bending moment, and natural time period. Comparative evaluation of these parameters was carried out to understand the variation in seismic behavior under different frame section

configurations and seismic zones. The obtained results indicate that seismic intensity and structural stiffness significantly influence the lateral response of high-rise RCC buildings. It was observed that structures located in Zone V experienced higher displacement, drift, and base shear compared to Zone IV because of increased seismic excitation. The study further demonstrates that frame section geometry plays a vital role in improving stiffness, reducing deformation, and enhancing overall seismic resistance.

5.2 Storey Displacement

Storey displacement represents the lateral movement of different floor levels during earthquake excitation and is one of the most important parameters in evaluating the seismic stability of high-rise structures. Excessive displacement may result in structural instability, damage to non-structural components, and serviceability problems. The ETABS analysis results showed that the storey displacement gradually increased from the base towards the top storey for all frame configurations due to the cumulative effect of lateral seismic forces acting along the building height.

The buildings analyzed under Zone V exhibited significantly larger displacement compared to Zone IV because the seismic zone factor for Zone V is higher, resulting in greater lateral force demand. The square frame section showed comparatively higher displacement values because of lower directional stiffness and reduced moment resistance. The rectangular section demonstrated moderate displacement behavior due to balanced stiffness characteristics, while the flanged section exhibited the least displacement among all configurations.

The improved performance of flanged sections can be attributed to their higher moment of inertia and enhanced flexural stiffness, which effectively reduced lateral deformation during seismic excitation. The results indicate that increasing structural stiffness significantly improves the lateral stability of high-rise RCC buildings. Therefore, frame geometry plays an important role in controlling displacement and ensuring seismic safety under severe earthquake conditions.

5.3 Storey Drift

Storey drift is defined as the relative lateral displacement between two consecutive storeys during earthquake motion. It is considered one of the most critical parameters in seismic design because excessive drift can cause cracking of structural members, damage to partitions and cladding, and overall structural instability. According to IS 1893 (Part 1):2016, the storey drift must remain within permissible limits to ensure safety and serviceability of the structure.

The inter-storey drift was calculated using the relation:

$$\theta = \frac{\Delta_i - \Delta_{i-1}}{h}$$

where θ represents the storey drift, Δ_i and Δ_{i-1} represent the lateral displacement of consecutive storeys, and h is the storey height.

The ETABS analysis results revealed that storey drift increased gradually along the height of the structure and attained maximum values near the middle and upper storeys. Zone V produced considerably higher drift compared to Zone IV because of stronger seismic acceleration and larger lateral displacement.

Among the analyzed frame configurations, the square section experienced the highest storey drift due to its lower stiffness characteristics. The rectangular section provided moderate drift control, while the flanged section exhibited the minimum drift values because of its improved lateral stiffness and greater resistance against deformation. The enhanced flexural rigidity of flanged sections effectively minimized inter-storey movement and improved overall seismic performance.

The obtained results indicate that increasing frame stiffness significantly reduces drift and enhances structural stability during earthquake excitation. All the analyzed configurations satisfied the permissible drift limits specified in IS 1893 provisions.

5.4 Base Shear

Base shear represents the total horizontal seismic force acting at the base of the structure during earthquake excitation. It is one of the most important parameters used to evaluate the overall seismic demand imposed on the structural system. The magnitude of base shear mainly depends on the seismic zone factor, building mass, structural stiffness, and dynamic characteristics of the

structure.

The design base shear was calculated using the expression:

$$V_b = A_h W$$

where V_b represents the design base shear, A_h is the horizontal seismic coefficient, and W is the seismic weight of the structure.

The analysis results indicated that the base shear values under Zone V were significantly higher than those under Zone IV because of increased seismic intensity. The higher seismic coefficient associated with Zone V generated greater inertia forces throughout the structure, resulting in larger base reactions.

Among the frame configurations considered in the study, the flanged section exhibited comparatively higher base shear values because stiffer structures tend to attract larger seismic forces. However, despite attracting higher seismic loads, the flanged configuration effectively controlled displacement and drift due to its superior stiffness characteristics. The square section experienced relatively lower base shear but showed greater lateral deformation and flexibility.

The results demonstrate that efficient seismic design requires a proper balance between stiffness, strength, and ductility. Although increased stiffness may attract larger seismic forces, it significantly improves structural stability and reduces excessive lateral deformation during earthquake excitation.

5.5 Bending Moment

Bending moment is an important structural response parameter that represents the flexural demand developed in beams and columns due to lateral seismic loading. During earthquake excitation, high-rise buildings experience significant overturning effects and lateral forces, which generate large bending moments particularly in lower storeys and critical structural members.

The ETABS analysis results showed that bending moments increased progressively from the top storeys towards the base of the structure due to the accumulation of seismic forces along the building height. Buildings analyzed under Zone V developed

considerably higher bending moments compared to Zone IV because of stronger seismic excitation and increased lateral force demand.

The square frame section experienced larger bending moments due to greater structural flexibility and increased displacement behavior. The rectangular section exhibited moderate flexural response, while the flanged section demonstrated improved bending resistance because of its larger effective depth and increased moment of inertia.

The enhanced stiffness characteristics of flanged sections improved force distribution and reduced excessive flexural deformation within the structural members. The results clearly indicate that frame section geometry significantly influences the bending behavior and seismic resistance of high-rise RCC buildings.

5.6 Natural Time Period

The natural time period of a building is defined as the time required to complete one cycle of free vibration during dynamic motion. It is an important parameter influencing seismic response because it determines the interaction between the structure and earthquake ground motion. Buildings with greater flexibility generally possess larger time periods, whereas stiffer structures exhibit lower time periods.

The approximate fundamental natural time period of the RCC building was determined using the empirical expression recommended in IS 1893:

$$T = 0.075h^{0.75}$$

where T represents the natural time period in seconds and h represents the total height of the building in meters.

The ETABS analysis results indicated that the square frame section exhibited the highest natural time period because of its comparatively lower stiffness and increased flexibility. The rectangular section demonstrated moderate dynamic behavior, while the flanged section showed the lowest natural time period due to its enhanced stiffness characteristics.

The reduction in time period observed in flanged sections indicates improved structural rigidity and greater resistance against dynamic deformation during earthquake excitation. Buildings with lower natural time periods generally experience reduced lateral displacement and improved seismic stability.

The comparative analysis confirms that frame geometry significantly affects the dynamic characteristics of high-rise RCC buildings. Structures with higher stiffness exhibit improved vibration control and better seismic performance under severe earthquake conditions.

6.CONCLUSION

The present study focused on the seismic analysis and comparative evaluation of a G+30 reinforced concrete (RCC) high-rise building using ETABS software under Seismic Zone IV and Zone V conditions according to IS 1893 (Part 1):2016 provisions. Different frame section configurations namely rectangular, square, and flanged sections were analyzed to investigate their influence on the seismic behavior and structural performance of the building. Linear static analysis and dynamic response spectrum analysis were carried out to evaluate important seismic response parameters such as storey displacement, storey drift, base shear, bending moment, and natural time period.

From the analysis results, it was observed that seismic intensity significantly influences the lateral response of high-rise RCC buildings. Buildings analyzed under Zone V experienced considerably higher storey displacement, inter-storey drift, base shear, and bending moment compared to Zone IV because of increased seismic excitation and higher seismic zone factors. The increase in lateral force demand under severe seismic conditions resulted in greater structural deformation and dynamic response.

The study also revealed that frame section geometry plays a major role in controlling seismic behavior and improving structural stability. Among the analyzed frame configurations, the square section exhibited comparatively larger displacement, higher drift, and greater flexibility because of lower stiffness characteristics. The rectangular section demonstrated moderate seismic performance with balanced stiffness and strength behavior. In contrast, the flanged section showed superior seismic performance due to its higher moment of inertia and enhanced lateral stiffness.

The flanged frame configuration effectively reduced lateral displacement and storey drift by improving the overall rigidity of the structure. Although the flanged section attracted comparatively higher base shear because of increased stiffness, it provided better

resistance against seismic deformation and improved overall structural stability. The reduced natural time period observed in the flanged configuration further confirmed its improved stiffness characteristics and dynamic performance.

The obtained results indicate that increasing structural stiffness significantly enhances the seismic resistance of high-rise buildings and reduces excessive deformation during earthquake excitation. Proper selection of frame section geometry is therefore essential for achieving safe, stable, and economical earthquake-resistant structural systems in high seismic regions.

The study further confirms that ETABS software provides an efficient and reliable platform for seismic analysis and performance evaluation of multi-storey RCC buildings. The software effectively models structural behavior under dynamic loading conditions and enables accurate assessment of important response parameters required for earthquake-resistant design.

Overall, the research concludes that flanged frame sections provide better seismic performance compared to rectangular and square sections for G+30 RCC high-rise buildings located in Seismic Zone IV and Zone V. The enhanced stiffness and flexural resistance of flanged sections significantly improve lateral stability, reduce storey drift, and enhance structural safety under earthquake loading. Therefore, optimized frame geometry should be considered an important design parameter in the seismic design of tall RCC structures located in earthquake-prone regions.

The findings of the present study can assist structural engineers and designers in selecting suitable frame configurations for safer and more efficient high-rise construction. The study also contributes to the understanding of how frame geometry and seismic intensity influence the dynamic behavior of RCC tall buildings under earthquake loading conditions.

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