# Comparative Seismic Analysis of Multi-storey Structure with Different Earthquake zone using ETABS

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*Abstract*—**Advanced studies in India emphasize the delicate nature of tall buildings and the effect of earthquakes in certain regions. Their slender forms combined with low damping make effortless structures highly sensitive portions of the earthquake importance. Their reinforced concrete structures stand tall as the majority in the country. Their set of multi-storied buildings underpin the integrated design concept and advocate the servicing core. Moreover, each building is put under value addition by the designer and the structural frame is meticulously designed to accommodate different forms such as static live and dead loads, as well as the dynamic earthquake forces. This work analyzes the cohesion of buildings, or areal pull together under the influence of seismic forces across the four documented seismic zones of India to determine the structural integrity and safety. This model under observation is a multi-story reinforced concrete framework, which is prescriptively parametrically analyzed with the help of the static and dynamic Equivalent Approximation Approach through the software ETABS and in respect to IS 1893:2016 (Part 1).**

**The research examines how tall buildings respond to seismic forces in India's seismic zones using ETABS. It evaluates parameters such as base shear, lateral displacement, inter-storey drift, and mode shapes for Zones II to V, highlighting differences in structural performance. A G+10 storey RC building is assessed under all four seismic zones. The Response Spectrum Method is applied to analyze structural behavior variations. Separate ETABS models are developed for each zone, keeping geometry and loading conditions identical for direct comparison of base shear, storey drift, time period, and stiffness. The main aim is to evaluate how the same building behaves differently under identical loading when subjected to different seismic zones. The comparison focuses on lateral displacement, inter-storey drift, and base shear.**

*Index Terms*—**Comparative analysis, Earthquake force, load analysis, Lateral displacement, Response Spectrum Analysis, Seismic Analysis, Simulation models, Structural performance, Structural stability.**

## I. INTRODUCTION

Due to their complex designed facility systems and many conflicting criteria, high-rise buildings may be among the most difficult and complicated structures to design and build. In contrast to older, heavier forms, contemporary designs may be seen of as being more susceptible to lateral movements or sway as their thickness. The type of the soil, earthquake-related stresses, and wind-applied forces are therefore important considerations in structural design. Tall buildings overall performance and stability can be greatly impacted by changes in soil conditions and earthquake-related severity, which can also have a substantial impact on the buildings' dynamic and static behavior.

Based on the likelihood and severity of earthquake activity, the Indian Standard IS 1893:2016 (Part 1) categorizes the nation into four seismic zones. In order ensure that structures are designed with an adequate degree of earthquake resistance depending on regional seismic risk, engineers and designers must adhere to this zoning system.

Objectives:

- To evaluate the potential variations in the seismic behavior of reinforced concrete (RC) building models under different design and loading conditions.
- To model and analyze symmetrical bare frame structures located in various seismic zones using the Equivalent Static Method and Response Spectrum Analysis as per IS 1893:2016.
- To examine the influence of seismic zone factors on the earthquake performance of RC buildings across all designated zones.

- To investigate the effect of earthquake intensity on the structural response of a G+10 storey RC building.
- To carry out the modelling, analysis, and design of primary structural components using the ETABS structural analysis software.

## II. LITERATURE REVIEW

The literature review for title "Comparative Seismic Analysis of Multi-storey Structure with Different Earthquake zone using ETABS" are as follows:

Sachin Thengari et. al (2025) discussed the vulnerability of multistorey buildings to seismic events, noting that it remained a major concern for structural engineers, particularly in seismically active regions such as India. It had been emphasized that different seismic zones necessitated varied structural considerations to ensure both safety and serviceability. Several studies had reviewed the seismic analysis of multistorey buildings in accordance with IS 1893 (Part 1): 2016 guidelines. These works had examined different structural configurations, analysis approaches including linear static, linear dynamic, and nonlinear dynamic methods, and key performance parameters such as base shear, storey drift, displacement, and fundamental time period. The literature had consistently highlighted that adopting seismic zone-specific design was crucial for achieving efficiency and economy in construction while maintaining adequate seismic performance.

B. Sri Datta Subrahmanyam et al. (2025) highlighted the importance of constructing earthquake-resistant tall buildings, especially in seismically active areas. Researchers analyzed a G+14 RC-framed building in seismic zone IV using STAAD Pro V8i and the Response Spectrum Method. They evaluated different bracing systems X-bracing, V-bracing, and inverted-V bracing placed at various external positions. The results showed that braced frames had increased base shear and peak storey shear, while storey displacement, drift, bending moments, and time period were reduced compared to unbraced frames. Among the bracing types, X-bracing at mid-bays of exterior faces significantly improved structural stiffness and seismic performance.

Chaitanya A. Khotare et al., (2025) emphasized the growing importance of the Response Spectrum Method in designing earthquake-resistant multi-storey buildings. One study analyzed a 30-storey RC structure using ETABS 2016 under various loads, following IS 1893 (Part 1): 2002. The building was evaluated across seismic zones II to V, with results showing significant variations in base shear, axial force, bending moment, displacement, and tensile forces. The study highlighted the critical role of seismic zoning and the method's effectiveness in enhancing structural strength, stability, and serviceability.

Kiran Devi and Subhankar Petal (2023) emphasized the importance of seismic analysis for ensuring structural safety under earthquake loading. Both ordinary moment-resisting frames and special moment-resisting frames were examined as part of the seismic assessment. In the investigation, a G+8 reinforced concrete structure was analyzed across three seismic zones—III, IV, and V—according to the provisions of IS 1893 (Part 1): 2016. The comparison focused on design base shear, longitudinal steel percentage, and reinforcement detailing. Findings indicated that base shear values increased progressively with the severity of the seismic zone, from Zone III to Zone V.

Shreya Navalgund (2022) acknowledged that earthquakes are among the most powerful natural phenomena, often causing significant structural damage. Observations from past seismic events revealed that many buildings experienced partial or total collapse, underscoring the need to evaluate how structures respond under earthquake loading. Various methods had been developed for seismic analysis of structures. In one study, a multi-storey building was analyzed using both the Response Spectrum Method and the Time History Method, with the latter employing acceleration data from the Bhuj Earthquake. The analysis was carried out in accordance with IS 1893 (Part 1): 2002. The study primarily focused on comparing the structural response parameters obtained from both analytical approaches to assess their effectiveness and applicability.

K. S Patil et. al (2021) stated that the Time History Method provided detailed information on structural forces and displacements throughout the entire duration of ground motion, typically at equal intervals ranging from 0.05 to 0.1 seconds. They utilized STAAD.Pro, a structural analysis and design software, to model and analyze the seismic response of buildings. The objective of the study was to gain practical insight into handling integrated building design software and to understand the impact of seismic forces on a building's lifecycle. The research focused on analyzing the behavior of a G+7 storey building under various load conditions using Time History Analysis. Specifically, the study identified bending and shear forces and also addressed the design of structural sections to enhance the building's serviceability. Time-acceleration data were used as input for the analysis, and the structural performance was evaluated based on different mode shapes and corresponding time-acceleration responses.

Asadullah Dost and Anil Kumar Chaudhary (2021) analyzed G+15, G+20, and G+25 residential buildings using ETABS based on IS 1893 (Part 1): 2002, assuming the structures were in seismic zone IV. Using ETABS software, the buildings were modeled and analyzed to comply with the seismic provisions outlined in the code. They emphasized that high-rise buildings are significantly affected by lateral forces from wind and earthquakes, making lateral stability a critical aspect of structural design.

Shantnu Pannase et al. (2020) conducted an investigation focusing on the design of earthquake-resistant multi-storied reinforced concrete (RCC) buildings. The study analyzed basic 2D structural frames with varying floor heights and spans using ETABS software. Key structural parameters such as support reactions, horizontal displacements, and the effects of lateral forces on columns and beams were evaluated. The findings reinforced the importance of integrating seismic analysis into structural design to improve earthquake resilience in multi-storey RCC buildings.

## III. METHODOLOGY

The multi-floor RCC structure consists of a G+10 building, modeled with four different structural configurations corresponding to four seismic zones. All models maintain the same dimensions, column and beam sizes, and overall geometry. The specifications of the constructed structure are presented in Table 1 & 2, detailing the structural components, materials, and characteristics used in the study. The structural representation of the structure has been done using the structural software structural modelling software (ETABS) as per the data.

Model 1 – Building with seismic Zone II
Model 2 – Building with seismic Zone III
Model 3 – Building with seismic Zone IV
Model 4 – Building with seismic Zone V

Table 1 Seismic Zone and their Factor

| Zone factor | ZONE II | ZONE III | ZONE IV | ZONE V |
|---|---|---|---|---|
| Z | 0.10 | 0.16 | 0.24 | 0.36 |

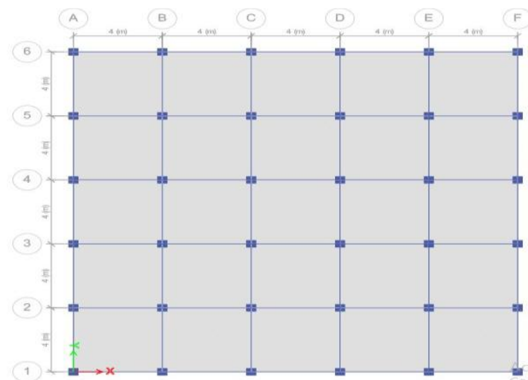

Fig. 1 Plan view

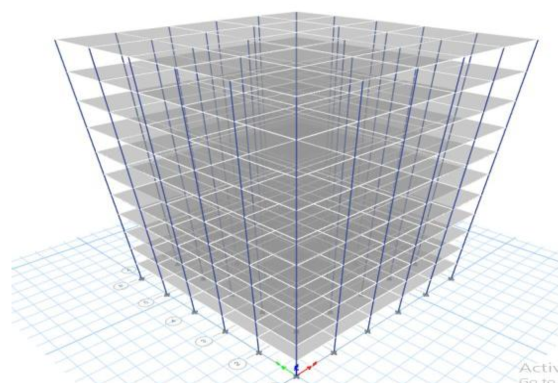
Fig. 2 3D view

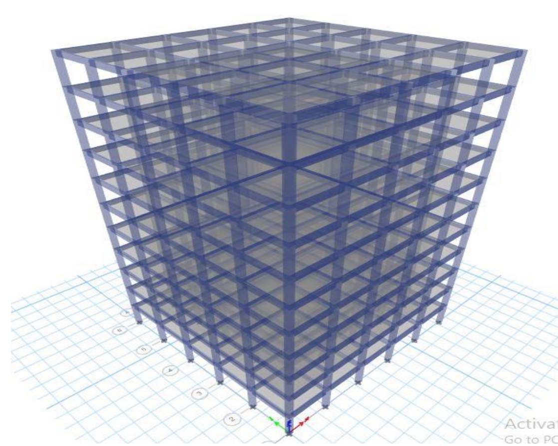
Fig. 3 Extrude view

Table 2 Building Parameters

| | |
|---|---|
| Type of frame | R.C.C Frame |
| Type of Structure | Multistorey Residential Building |
| Geometry of Building | Symmetrical |
| Total storeys | G+10 |
| Building Height | 33m |
| Dimension in X | 20m |
| Dimension in Y | 20m |
| Size of Building | 20x20m |
| Typical Storey Height | 3 m |
| Slab Thickness | 150mm |
| Beam Size | 300x450mm |
| Column Size | 450x450mm, 300x600mm |
| Type of Wall | Bricks Masonry |
| Thickness of wall | 230mm |
| Grade of Concrete | M-30(1:1.5:3) |
| Grade of Steel | Fe-550 |
| Method of Analysis | Response Spectrum Analysis |
| Type Of Soil | II ( Medium ) |

## IV. RESULTS AND DISCUSSION

In the structural modeling software ETABS, four structural configurations were developed corresponding to different seismic zones. Analyses were conducted to evaluate parameters such as inter-story drift, floor-level horizontal displacement, floor-level lateral forces, and base shear. Each structural model was designed for its respective seismic condition using the Response Spectrum Method, incorporating all relevant load combinations. The results from these analyses were subsequently compared, and the variations in each response parameter can be summarized as follows.

Table 3 Data of Storey Displacement, Storey Drift and Storey Shear of Zone II

| Storey | Storey Displacement (mm) | Storey Drift | Storey Shear (KN) |
|---|---|---|---|
| Storey11 | 55.068 | 0.000605 | 389.805 |
| Storey10 | 53.256 | 0.000986 | 734.659 |
| Storey9 | 50.298 | 0.001329 | 1015.845 |
| Storey8 | 46.302 | 0.001611 | 1240.008 |
| Storey7 | 41.471 | 0.001839 | 1413.792 |
| Storey6 | 35.964 | 0.002012 | 1543.8400 |
| Storey5 | 29.925 | 0.002133 | 1636.785 |
| Storey4 | 23.521 | 0.002206 | 1699.237 |
| Storey3 | 16.902 | 0.002225 | 1737.734 |
| Storey2 | 10.251 | 0.002109 | 1758.622 |
| Storey1 | 3.905 | 0.001302 | 1767.647 |
| Base | 0 | 0 | 0 |

Table 4 Data of Storey Displacement, Storey Drift and Storey Shear of Zone III

| Storey | Storey Displacement (mm) | Storey Drift | Storey Shear (KN) |
|---|---|---|---|
| Storey11 | 88.103 | 0.000968 | 623.688 |
| Storey10 | 85.200 | 0.001577 | 1175.455 |
| Storey9 | 80.469 | 0.002126 | 1625.353 |
| Storey8 | 74.092 | 0.002575 | 1984.0139 |
| Storey7 | 66.366 | 0.002942 | 2262.067 |
| Storey6 | 57.538 | 0.003221 | 2470.144 |
| Storey5 | 47.879 | 0.003412 | 2618.857 |
| Storey4 | 37.673 | 0.003529 | 2718.780 |
| Storey3 | 27.054 | 0.003561 | 2780.375 |
| Storey2 | 16.372 | 0.003374 | 2813.796 |
| Storey1 | 6.249 | 0.002083 | 2828.235 |
| Base | 0 | 0 | 0 |

Table 5 Data of Storey Displacement, Storey Drift and Storey Shear of Zone IV

| Storey | Storey Displacement (mm) | Storey Drift | Storey Shear (KN) |
|---|---|---|---|
| Storey11 | 132.154 | 0.001452 | 935.533 |
| Storey10 | 127.799 | 0.002366 | 1763.183 |
| Storey9 | 120.704 | 0.003189 | 2438.030 |
| Storey8 | 111.138 | 0.003863 | 2976.020 |
| Storey7 | 99.549 | 0.004414 | 3393.101 |
| Storey6 | 86.308 | 0.004829 | 3705.216 |
| Storey5 | 71.819 | 0.005118 | 3928.285 |
| Storey4 | 56.464 | 0.005294 | 4078.70 |
| Storey3 | 40.582 | 0.005341 | 4170.562 |
| Storey2 | 24.558 | 0.005061 | 4220.694 |
| Storey1 | 9.374 | 0.005341 | 4242.352 |
| Base | 0 | 0 | 0 |

BASE SHEAR

Comparison of the base lateral force effects for the four different structural configurations of the constructed structure across seismic Zones II to V. The value of constructed facility in Zone II 1680 KN considered as the reference for comparing the base lateral force effect illustrates in Fig 4 and Table 7 shows the comparative base value from structural modelling software (ETABS). The comparison of base lateral force effects indicates that, relative to Zone II, the constructed facility experiences an increase of 60% in Zone III, 140% in Zone IV, and 260% in Zone V.

Table 6 Data of Storey Displacement, Storey Drift and Storey Shear of Zone V

| Storey | Storey Displacement (mm) | Storey Drift | Storey Shear (KN) |
|---|---|---|---|
| Storey11 | 198.231 | 0.002178 | 1403.300 |
| Storey10 | 191.699 | 0.003549 | 2644.774 |
| Storey9 | 181.057 | 0.004783 | 3657.045 |
| Storey8 | 166.708 | 0.005795 | 4464.031 |
| Storey7 | 149.323 | 0.006621 | 5089.652 |
| Storey6 | 129.462 | 0.007244 | 5557.824 |
| Storey5 | 107.729 | 0.007678 | 5892.428 |
| Storey4 | 84.697 | 0.007941 | 6117.255 |
| Storey3 | 60.873 | 0.008012 | 6255.843 |
| Storey2 | 36.838 | 0.007592 | 6331.041 |
| Storey1 | 14.061 | 0.004687 | 6363.529 |
| Base | 0 | 0 | 0 |

Table 7 Base lateral force effect value extracted from structural modelling software (ETABS) across Building type

| S.No | Building Models | Base Shear (KN) |
|---|---|---|
| 1 | ZONE II | 1680.219 |
| 2 | ZONE III | 2690.146 |
| 3 | ZONE IV | 4033.118 |
| 4 | ZONE V | 6050.044 |

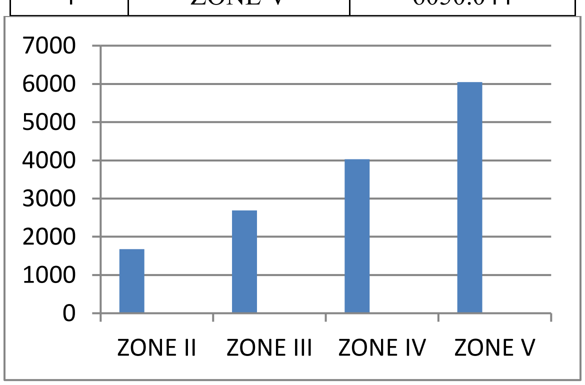


Fig. 4 Graphical Comparison of Base Shear across Zone Type

STOREY DISPLACEMENT

The storey displacement comparison for the four structural models across different seismic zones is presented in Table 8 and Fig. 5. The minimum horizontal shift values observed are 55 mm for Zone II, 88 mm for Zone III, 132 mm for Zone IV, and 198 mm for Zone V. Compared to the base model in Zone II, the floor-level horizontal displacement increases by 60% in Zone III, 140% in Zone IV, and 260% in Zone V.

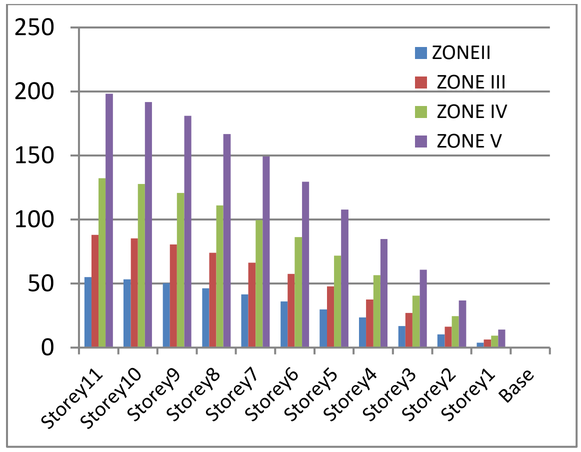


Fig. 5 Graphical Comparison of Storey Displacement across Building type

Table 8 Storey Displacement value extracted from structural modelling software (ETABS) across Building type

| STOREY | ZONE II | ZONE III | ZONE IV | ZONE V |
|---|---|---|---|---|
| Storey11 | 55.068 | 88.103 | 132.154 | 198.231 |
| Storey10 | 53.256 | 85.200 | 127.799 | 191.699 |
| Storey9 | 50.298 | 80.469 | 120.704 | 181.057 |
| Storey8 | 46.302 | 74.092 | 111.138 | 166.708 |
| Storey7 | 41.471 | 66.366 | 99.549 | 149.323 |
| Storey6 | 35.964 | 57.538 | 86.308 | 129.462 |
| Storey5 | 29.925 | 47.879 | 71.819 | 107.729 |
| Storey4 | 23.521 | 37.673 | 56.464 | 84.697 |
| Storey3 | 16.902 | 27.054 | 40.582 | 60.873 |
| Storey2 | 10.251 | 16.372 | 24.558 | 36.838 |
| Storey1 | 3.905 | 6.249 | 9.374 | 14.061 |
| Base | 0 | 0 | 0 | 0 |

STOREY DRIFT

The values of storey drift (relative inter-storey sway) and their graphical representation are presented in Table 9 and Fig. 6. Floor 3 exhibits the maximum relative storey drift across all zones. Compared to the Zone II model, the relative storey drift increases by 60% in Zone III, 140% in Zone IV, and 260% in Zone V.

Table 9 Storey Drift value extracted from structural modelling software (ETABS) across Building Type

| STOREY | ZONE II | ZONE III | ZONE IV | ZONE V |
|---|---|---|---|---|
| Storey11 | 0.000605 | 0.000968 | 0.001452 | 0.002178 |
| Storey10 | 0.000986 | 0.001577 | 0.002366 | 0.003549 |
| Storey9 | 0.001329 | 0.002126 | 0.003189 | 0.004783 |
| Storey8 | 0.001611 | 0.002575 | 0.003863 | 0.005795 |
| Storey7 | 0.001839 | 0.002942 | 0.004414 | 0.006621 |
| Storey6 | 0.002012 | 0.003221 | 0.004829 | 0.007244 |
| Storey5 | 0.002133 | 0.003412 | 0.005118 | 0.007678 |
| Storey4 | 0.022061 | 0.003529 | 0.005294 | 0.007941 |
| Storey3 | 0.002225 | 0.003561 | 0.005341 | 0.008012 |
| Storey2 | 0.002109 | 0.003374 | 0.005061 | 0.007592 |
| Storey1 | 0.001302 | 0.002083 | 0.005341 | 0.004687 |
| Base | 0 | 0 | 0 | 0 |

STOREY SHEAR

The storey lateral force effects for all four structural configurations are presented in Table 10 and Fig. 11. Compared to the base model in Zone II, the story shear increases by 60% in Zone III, 140% in Zone IV, and 260% in Zone V.

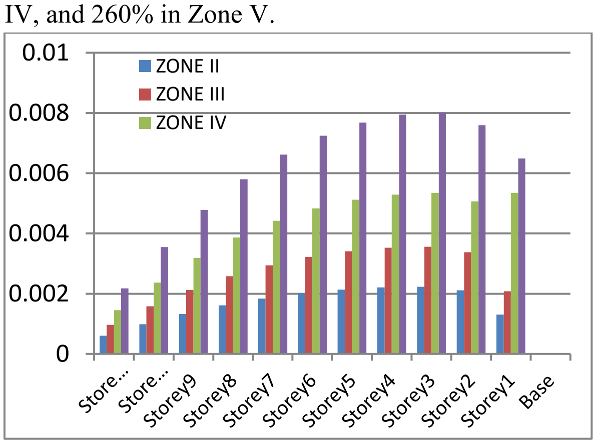


Fig. 10 Graphical Comparison of Storey Drift across different Zone

Table 4.20 Storey Shear value extracted from structural modelling software (ETABS) across Building Type

| STOREY | ZONE II | ZONE III | ZONE IV | ZONE V |
|---|---|---|---|---|
| Storey 11 | 389.805 | 623.688 | 935.533 | 1403.300 |
| Storey 10 | 734.659 | 1175.455 | 1763.183 | 2644.774 |
| Storey 9 | 1015.84 | 1625.353 | 2438.030 | 3657.045 |
| Storey 8 | 1240.008 | 1984.0139 | 2976.020 | 4464.031 |
| Storey 7 | 1413.792 | 2262.067 | 3393.101 | 5089.652 |
| Storey 6 | 1543.84 | 2470.144 | 3705.216 | 5557.824 |
| Storey 5 | 1636.785 | 2618.857 | 3928.285 | 5892.428 |
| Storey 4 | 1699.237 | 2718.780 | 4078.70 | 6117.255 |
| Storey 3 | 1737.734 | 2780.375 | 4170.562 | 6255.843 |
| Storey 2 | 1758.622 | 2813.796 | 4220.694 | 6331.041 |
| Storey 1 | 1767.647 | 2828.235 | 4242.352 | 6363.529 |
| Base | 0 | 0 | 0 | 0 |

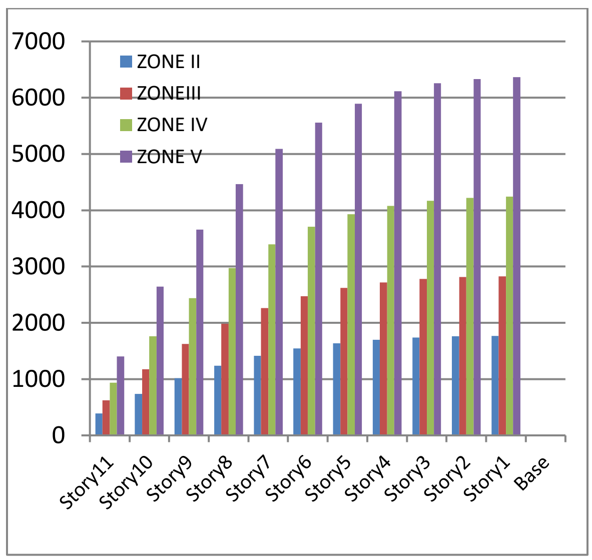


Fig. 11 Graphical Comparison of Storey Shear across different Zone

V. CONCLUSIONS

This study presents a detailed seismic assessment of a G+10 RCC multi-storey building subjected to different seismic zones in India, ranging from Zone II to Zone V. The analysis was conducted using the Response Spectrum Method in ETABS, following the guidelines of IS 1893:2016. The objective was to evaluate the impact of seismic intensity on the building's structural performance, focusing on base lateral forces, lateral floor displacements, inter-storey drifts, and overall stability.

Based on numerical performance indicators, the following conclusions were drawn:

- The findings indicate that as the seismic zone factor increases, structures located in higher seismic zones such as Zone IV and Zone V experience significantly greater base lateral forces, lateral floor displacements, and inter-storey drifts compared to those in Zone II or Zone III. This underscores the critical importance of incorporating seismic forces into design, particularly in regions of high seismicity.
- It was observed that structural performance under seismic loading is highly influenced by factors such as building configuration, stiffness, mass distribution, and dynamic properties. As the seismic zone increases, the requirement for effective lateral force-resisting systems, proper structural detailing, and ductility-enhancing measures becomes increasingly important to ensure safety and performance.
- The behavior of buildings varies significantly across different seismic zones, making seismic assessment an essential aspect of structural design. This study enhances understanding of how multi-storey structures respond to varying seismic intensities and emphasizes the need for zone-specific design practices to improve earthquake resilience of built infrastructure.
- The floor tier lateral force effect of quake-related zone V can be described as 3.8 times higher than zone II.
- The floor tier relative inter-floor sway of quake-related zone V can be described as higher than 3.5 times heigher than Zone II.
- Base reaction of Zone V can be described as 3.86 times higher than Zone II.
- Column reinforcement percentage required in Zone II can be described as 0.8% and for Zone IV it can be described as 5.66%.

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