

Review on Seismic Behaviour of Multi-Storeyed “Sankalp Bhavan” RCC Buildings Across Different Seismic Zones Using ETABS

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Abstract:

This paper presents a comparative seismic analysis of a G+11 reinforced concrete (RC) multistoried building named “Sankalp Bhavan” located in two different seismic zones of India — Zone II Bhopal (low seismic risk) and Zone V Bhuj (very high seismic risk) as per IS 1893 (Part 1):2016. The study aims to understand the variation in structural behavior, including base shear, story drift, lateral displacement, and modal characteristics under different seismic intensities. The analysis is performed using ETABS 2022 software through both Equivalent Static Method and Response Spectrum Method. The comparative results show a significant increase in lateral forces, storey displacement, and drift in Zone V compared to Zone II, highlighting the need for enhanced stiffness, ductility, and proper detailing in high-seismic regions. The findings emphasize the importance of site-specific seismic zoning in safe and economical design of high-rise structures.

Keywords — Seismic Zone, ETABS, Multi-storeyed Building, Response Spectrum, Base Shear, Storey Drift, Zone II, Zone V, IS 1893:2016.

I. INTRODUCTION

The increasing demand for high-rise buildings in India has led to the need for rigorous seismic analysis to ensure structural safety and serviceability. The Indian subcontinent is divided into four seismic zones (II to V) as per IS 1893 (Part 1):2016, each representing a different level of earthquake intensity. The performance of a structure depends largely on the seismic forces it experiences, which are governed by the zone factor (Z).

The Sankalp Bhavan, a G+11 multi-storeyed RC frame building, is selected for this comparative study. The building's response is analyzed in two distinct seismic zones — Zone II and Zone V — to assess how variations in zone factor influence the overall behavior of the structure.

- This comparative analysis is vital for understanding:

- The impact of seismic zoning on building response.
- The need for structural modifications in high-risk zones.
- The effectiveness of ETABS software in predicting realistic seismic performance.

Effects of Earthquake in Building

Earthquake is a seismic event which generates seismic waves by rupture of tectonic plates inside the earth's crust. In terms of seismic analysis of building earthquake applies seismic forces in multiple directions and seismic analysis brings the study of building's behavior during the time period of seismic activity.

India is Divided into 4 Different active zones as Shown in Map: -

- II – Least Active
- III – Moderate
- IV – High

V – Highest

In present work zone IV is considered to consider high rate of seismic forces applicable on the models & cases. Following is presentation of earthquake behavior of building, graphical way.

II. LITERATURE REVIEW

Several researchers have investigated the impact of seismic zones and lateral loads on multi-storeyed buildings:.

Mohamed Shajahan et.al. (2024)

“Analysis and Design of Multi-Storey Building Using Etabs” The construction of multi-storey buildings is on the rise due to the growing population and rapid development. This is primarily driven by the scarcity of land with higher demand and lower prices compared to individual houses. To ensure safety, cost-effectiveness, and adherence to standards, it is essential to analyze and design these buildings using advanced software such as ETabs. The analysis of a G+10 Reinforced Cement Concrete (RCC) framed structure in this project involves the consideration and application of live loads, dead loads, seismic loads, and wind loads. The objective is to analyse the structural behaviour and ensure compliance with various design codes and standards. The results of analysis are used to confirm the stability of the structure through examination of the Moment Force Diagrams of Axial force, Shear force, Torsion, and Moment. Additionally, the analysis aids in determining the story drifts, story displacements. The provision of reinforcement details is also accomplished through the detailing of beams and columns.

Kiran Devi et al. (2023)

“A Comparative Study on Seismic Analysis of Multistorey Buildings in Different Seismic Zones” The multi-story buildings are constructed to accommodate numerous residents in confined spaces due to the growing population and lack of available land. The population growth and industrial revolution caused a migration of people from rural to urban areas resulting in the need for the construction of multi-story buildings for both residential and commercial uses. The tall buildings, which are not adequately constructed to resist lateral stresses, result in the total collapse of the structure. Buildings that can withstand earthquake forces are created by considering different criteria such as the building's inherent frequency, damping

factor, kind of base, significance of the building and ductility of the structure. Because they have better moment distribution properties, structures designed for ductility need to be designed for lower lateral loads. To ensure safety against the seismic stresses of multi-story buildings, it is essential to understand seismic analysis in order to develop earthquake-resistant structures. Both a regular moment-resisting frame and a special moment-resisting frame were taken into account for the seismic study. In the present study, a G+8 story reinforced concrete (RC) structure in three different seismic zones was compared in terms of percentage longitudinal steel, reinforcement details, and design base shear. The structure was examined for seismic zones III, IV, and V in accordance with the guidelines of IS 1893 (Part 1): 2016. Results showed that base shear increased with the change in the seismic zone from III to V.

Alkari, Alaukik & Meshram, Sangita & Baig, Aasif. (2021). Seismic Analysis of Structure Considering Soil Structure Interaction. IOSR Journal of Engineering. In this paper we have made an attempt to study the soil structure interaction effect of different soil, on structural behaviour of building. When Structure supported on mat foundation subjected to seismic loads. During dynamic loading the consideration of actual support flexibility reduces the overall stiffness of the structure. Therefore, it is necessary to study dynamic soil structure interaction. The main aim of the present study is to analyse the building that is supported on mat foundation for different soil conditions and compare the results of story displacement, column end forces and bending moments in beams. The analysis of the soil structure is done by using STAAD PRO. Analysis package.

B R, Vinod& R, Shobha. (2021). Seismic Analysis of Multi-Story Structure Subjected to Different Ground Motions. Major Construction project in urban India is incorporated with Reinforced Concrete (RC) frames, which experience both static and dynamic forces during their lifetime. Static forces can easily be analysed whereas dynamic force analysis is very time consuming, but it can't be left unanalysed as the results may be catastrophic. Earthquake is an important dynamic force which a building may experience during its lifespan and is therefore its

analysis becomes a critical step in design. The present work in its utmost sense, aim at understanding the influence of different ground motions on the structure over its life span. This providing new parameters and information to help improve design work.

Prashant, D & Hiwase, et.al. (2020). Seismic Analysis and Comparative Study of ESR For Earthquake Zone V In India. *International Journal of Advanced Science and Technology*. 29. 3674-3679. A Water tank simply means a container to store water in huge amount of capacity. As known from very upsetting experiences, liquid storage tanks were collapsed or heavily damaged during the earthquakes all over the world. The economic lifetime of ESR is generally around 40 to 65 years. Damage or collapse of the tanks causes some unwanted events such as shortage of drinking and utilizing water, uncontrolled fires etc. Water tank parameters include the general design of tank and way of construction materials, linings. Various material are used for construction of water tank like:-plastic, concrete, steel, fiber glass. Therefore to avoid all those disadvantages numerous or various studies is been carried out regarding tanks. In this study I have compared Elevated Service Reservoir (E.S.R) of Rectangular & Circular shape of 5 lakh capacity and total height of 18m with 3m staging in Earthquake Zone V by Equivalent static analysis using STAAD.PRO software referring GSDMA guidelines for design of tank and IS 1893 PART2-2014 code. It can be observed that Circular water tank is more economical and preferable.

Gupta, Ankit. (2020). This paper extends to other types of structure the simplified methodology proposed by Constant for the seismic design of tunnels. As a practical example, a large structure of reinforced concrete, of box shape and totally embedded in soil, is analysed. The dynamic pressures acting on walls, roof and floor, due to body and surface waves, are considered in the analyses. A set of seismic load combination hypotheses are proposed to account for the different polarization planes of the seismic waves. The influence of neighbouring.

III. ANALYTICAL APPROACH

The analysis was performed using ETABS 2022 with the following procedures:

Modelling: The building was modelled with 3D frames and rigid diaphragms.

Load Assignment: Dead load, live load, and seismic loads were assigned per IS 875 and IS 1893.

Dynamic Analysis: Response Spectrum method used as per IS 1893:2016.

Modal Analysis: Minimum 12 modes considered, achieving >90% mass participation.

Output Comparison: Base shear, storey drift, and displacements compared between Zone II and Zone V.

A. ETABS setup (step-by-step)

Create geometry & assign sections (beams, columns, slabs, walls if any). Apply releases & continuity as required.

Define mass: Define mass source = self weight (1.0) + appropriate % live load (IS practice: 50% for floors, 0% for roof in many examples) be consistent for both zones.

Load cases:

DL (dead), LL (live), EQ-X (Seismic X), EQ-Y (Seismic Y), Wind if required.

For seismic, either let ETABS auto-generate per IS 1893:2016 (select country code and town, or set seismic parameters manually). Cross-check ETABS' Ah with hand calc using the formula above. Define seismic parameters (for each zone run): set $Z = 0.10$ (Zone II) or 0.36 (Zone V), choose I, R, and soil type. Ensure same R and I in both runs if structure/importance is unchanged.

Analysis type: Equivalent Lateral Force (ELF / Static) for quick check and hand-calc comparisons.

Response Spectrum / Modal Analysis (dynamic) recommended for G+11 to capture higher mode effects. Use modal combination (CQC or SRSS) per ETABS defaults. Ensure number of modes captures ~90% mass.

Law Resource

P-Delta: ON (second-order effects) — particularly for tall RC frames.

Diaphragm: RIGID diaphragm for typical slab unless modeling flexible floor action.

Run analysis; check warnings (inverted/unstable frames, mass missing).

B. Seismic Parameters

(IS 1893:2016) The seismic parameters used in ETABS are based on Indian Standard recommendations:

TABLE I
THE SEISMIC PARAMETERS

Parameter	Zone II	Zone V	Reference
Zone Factor (Z)	0.1	0.36	IS 1893:2016
Importance Factor (I)	1	1	IS 1893:2016
Response Reduction Factor (R)	5	5	SMRF
Soil Type	Type II (Medium Soil)	Type II (Medium Soil)	IS 1893:2016
Damping Ratio	5%	5%	Standard Value

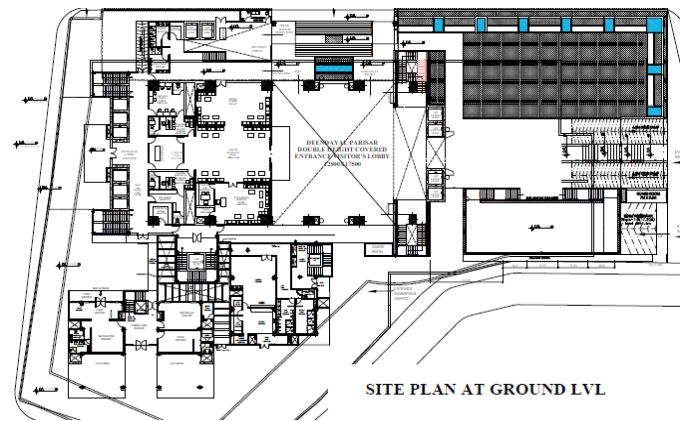


Fig. 2 2D CAD Site Plan of G+11 multi-storeyed "Sankalp Bhavan"

C. Structural Details & Parameters

TABLE III
GEOMETRIC CONSIDERATIONS FOR G+11 RCC FRAMED BUILDING

S.NO	CONTENT		DESCRIPTION
1	Type Of Structure	Multi story High Raised	
		Frame (Moment Resisting Frame),	
2	Number of Story	G+11	
3	Floor Height	3.00m	
4	Base Floor Height	3.3m	
5	Wall Thickness	External-230mm Internal- 115mm	
6	Materials	Concrete (M25for beams) and (M30for columns) reinforcement Fe415	
7	Size of Column	550mm x 600mm	
9	Size of the Beam in all Floors and Roof	440mm x 500 mm	
10	Depth of Slab	125mm	Only Ground Story open
11	Specific Weight of RCC	25KN/m3	Alternate Storys are Infilled.
12	Type of Soil	Medium	R.C.Frame Building



Fig. 1 3D Elevation of G+11 multi-storeyed "Sankalp Bhavan"

IV. CONCLUSIONS

- The base shear and storey forces increase by approximately 3.5 times when the same structure is considered in zone v instead of zone II.
- Storey displacements and drifts are significantly higher in zone v, indicating the necessity for lateral load-resisting systems like shear walls or bracings.
- The fundamental time period remains almost constant across zones, as it depends primarily on geometry and stiffness rather than seismic intensity.
- For zone V, ductile detailing (as per IS 13920:2016) and improved stiffness are essential to maintain drift limits and ensure structural safety.
- The study demonstrates the importance of seismic zoning and confirms etabs as a reliable tool for dynamic analysis of multi-storeyed buildings.

V. FUTURE SCOPE

- Extend the study to include soil-structure interaction (ssi) effects.
- Perform nonlinear time history analysis for more realistic seismic responses.
- Investigate the effect of shear walls, bracings, or base isolators on the seismic performance of high-rise structures in zone v.

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