ANALYSIS OF HIGH-RISE BUILDING USING ETABS

Sahil Kanojiya[1], Gokuldeep Kurup[2], Onkar Khutwad[3], Kushal Hankare[4], Mr. P.R. Barbude[5]

[1]BE Student, Department of Civil Engineering, DMCE, Maharashtra, India
[2]BE Student, Department of Civil Engineering, DMCE, Maharashtra, India
[3]BE Student, Department of Civil Engineering, DMCE, Maharashtra, India
[4]BE Student, Department of Civil Engineering, DMCE, Maharashtra, India
[5]Assistant Professor, Dept. of Civil Engineering, DMCE, Maharashtra, India

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Abstract - *High-rise buildings have become increasingly prevalent in urban areas due to land scarcity and population growth. These tall structures pose unique design challenges, making their analysis crucial for ensuring structural safety and resilience against various loading conditions, including seismic events. This study focuses on the analysis of a G+21 residential high-rise building using the ETABS software, a powerful tool for structural analysis and design. The primary objective is to conduct both static and dynamic analyses, evaluating the building's performance under different seismic zones (II, III, IV, and V) as per the Indian Standard IS 1893. By considering multiple seismic zones, the study aims to provide a comprehensive understanding of the building's behavior under varying seismic intensities. Static analysis involves determining the building's response to gravitational and lateral loads, while dynamic analysis considers the structure's dynamic characteristics and time-varying nature of seismic forces. The results obtained from both analyses will be compared, allowing for a thorough assessment of the building's performance and identification of critical design considerations.*

Key Words: High-rise building, ETABS, static analysis, dynamic analysis, seismic analysis, IS 1893, seismic zones, response spectrum analysis.

1.INTRODUCTION

High-rise buildings, towering structures that redefine urban skylines, necessitate meticulous engineering and design to ensure safety and functionality. These structures, typically exceeding 75 feet in height, require specialized structural systems to withstand vertical and lateral forces while accommodating various functionalities such as residential, commercial, and mixed-use spaces.

ETABS (CSI), emerges as a paramount tool in the realm of structural engineering. This innovative software simplifies the complexities of structural design, ensuring safety, resilience, and efficiency. Its comprehensive capabilities have revolutionized structural analysis and design practices, shaping modern construction landscapes worldwide.

Understanding seismic hazards is crucial in construction, especially in seismically active regions like India. The Bureau of Indian Standards (BIS) classifies India into seismic zones based on earthquake likelihood and hazard levels. These zones range from low to high-risk categories (Zone II to Zone V), each demanding specific structural considerations to mitigate potential damage.

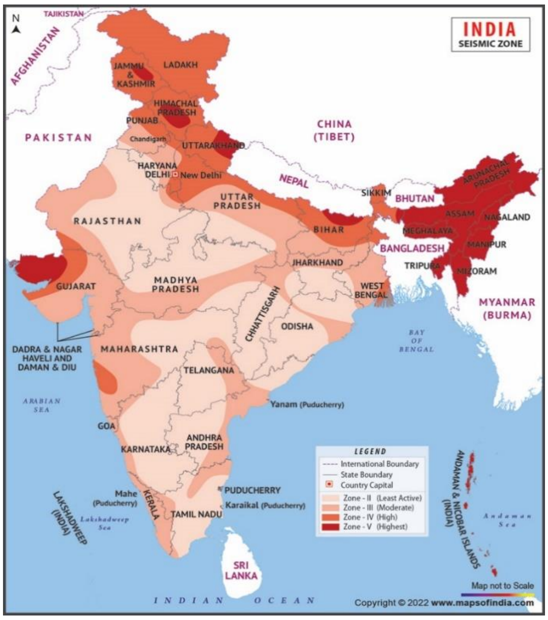

Fig-1.1 Indian Seismic Zone Map

1.1 Objective

i. To check & analysis of the seismic response of multi-storied building using E-tabs.

ii. To Evaluate the structural integrity and safety of the high-rise building under various loading conditions, including dead loads, live loads, and seismic loads, in accordance with relevant building codes and standards.

iii. Optimize the structural analysis to achieve cost-effective and efficient use of materials while maintaining structural safety and performance.

iv. Offer recommendations for design improvements, strengthening measures, or alterations to enhance the building's resilience and safety.

1.2 Overview of project:

This project entails the comprehensive analysis of a G+21 residential building characterized by an asymmetrical plan design. The study focuses on evaluating the structural response of the building under seismic conditions across seismic Zones II, III, IV, and V as defined by Indian standards. Both static and response spectrum methods are employed to assess the building's performance under varying seismic intensities.

General Parameters:

Building configuration	G+21
Structure type	Residential Apartment
Building Length in X direction	21m
Building Length in Y direction	14.75m
Height of structure	70.40m

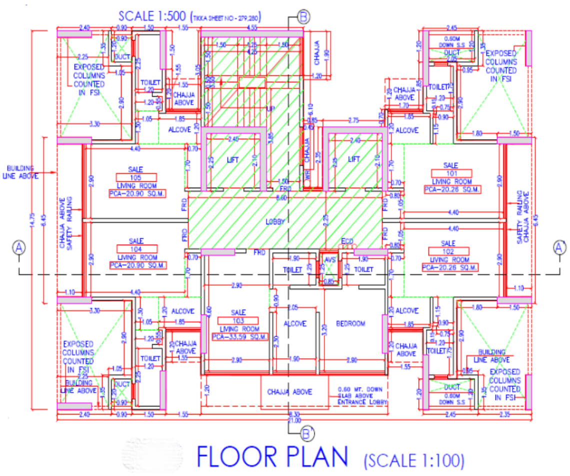

Fig-1.2 Plan of Building

Fig-1.3 Elevation of Building

2. METHODOLOGY

In structural engineering, assessing a building's ability to withstand earthquakes involves two primary approaches: static analysis and response spectrum analysis. Each method predicts a structure's response to seismic activity differently and suits different types of buildings.

2.1 Static Analysis

Static analysis is a simplified technique that estimates the impact of an earthquake using equivalent static forces. This approach calculates a lateral force based on the structure's weight and seismic factors, including local earthquake risk and soil conditions. The forces are distributed along the building's height using empirical formulas, reflecting how seismic forces would realistically affect the structure. This method allows engineers to analyse potential displacements, stresses, and internal forces within the building. Static analysis is typically applied to regular, low to medium-rise buildings where dynamic earthquake effects are less pronounced.

2.2 Response Spectrum Analysis

Response spectrum analysis provides a nuanced look at how buildings withstand seismic forces, by assessing their response to a spectrum of vibrations that mimic various earthquake waves. This method involves creating a response spectrum that illustrates the building's reaction—highlighting maximum movements and forces—followed by a modal analysis to pinpoint its natural vibration frequencies and modes. The culmination of this process is modal superposition, which aggregates these individual responses into a cohesive picture of the structure's potential behaviour under seismic stress.

In summary, static analysis offers a conservative, simplified assessment suitable for regular structures, while response spectrum analysis provides a detailed and accurate evaluation of a building's seismic response, especially beneficial for complex or dynamically sensitive structures.

Table -1: Member Dimension of Structure

Slab Thickness	125mm, 200mm for lift machine room.
Beam dimensions	B1 150x450mm, B2 230x600mm, B3 230x700m.
Storey height	Lower basement: 3.25, Upper basement: 4.35, Typical floor: 3.2 m
Wall thickness	230mm main wall 150mm partition wall
Shear wall thickness	250mm, 300mm
Parapet wall	230mm thick, 1.5m Height

Table -2: Material Properties

Concrete Grade	M30 = 30 MPa Characteristic value of cube compressive strength: Cube 150 x 150 x 150 mm (5%-quartile = no more than 5% of cubes tested at 28 days are expected to fail) f_{ck}, cube = 30 MPa f_{cm} = 38.25 MPa Mean compressive strength: $f_{cm} = f_{ck} + 1.65x5.0$ $[N/mm^2]$ E_{cm} = 27386.12 MPa Mean characteristic modulus of elasticity: 5000√fck M40= 40 MPa f_{ck}, cube = 40 MPa f_{cm} = 48.25 MPa Mean compressive strength: $f_{cm} = f_{ck} + 1.65x5.0$ $[N/mm^2]$ E_{cm} = 31622.78 MPa Mean characteristic modulus of elasticity: 5000√fck Density = 25 KN/m^3
Steel Grade	Fe415 fyk = 415 MPa (Characteristic proof strength at 0.2% yield) E = 200,000 MPa Elastic Modulus (Young's Modulus of Elasticity) Fe500 Type: TMT (Thermo Mechanical Treated) fyk = 500 MPa (Characteristic proof strength at 0.2% yield) E = 200,000 MPa Elastic Modulus (Young's Modulus of Elasticity) Density = 7850 Kg/m3

3. RESULT AND DISCUSSION

3.1 Base Shear Analysis

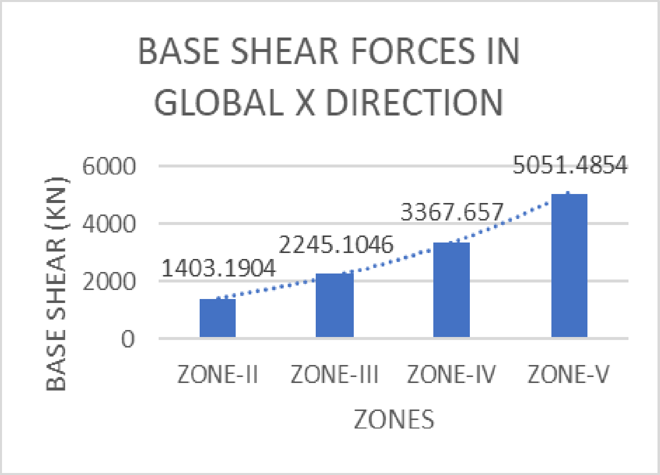

Fig-3.1 Base Shear Forces in X direction

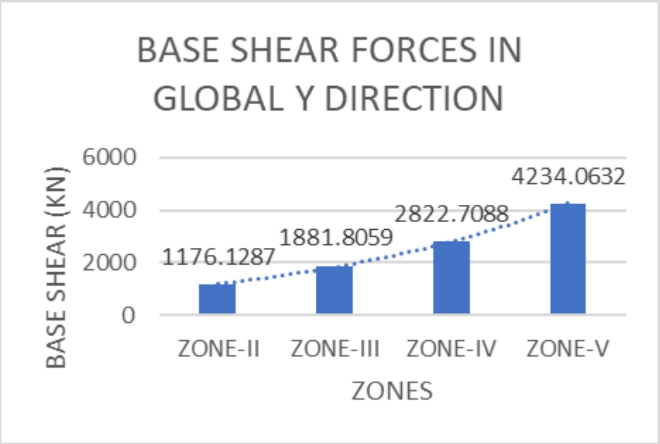

Fig-3.2 Base Shear Forces in Y direction

Observation:

i. Zone II to Zone V showed exponential increase.
ii. Zone II to Zone III: Base shear grows by 60%.
iii. Zone III to Zone IV: Base shear grows by 50%.
iv. Zone IV to Zone V: Base shear grows by 50%.

3.2 Story Shear Analysis

STORY SHEAR (KN)			
SR NO.	ZONE	STATIC ANALYSIS	RESPONSE SPECTRUM
1	ZONE II	1403.1904	1316.9704
2	ZONE III	2245.1046	2107.1526
3	ZONE IV	3367.657	3160.7289
4	ZONE V	5051.4854	4741.0933

Fig-3.3 Story Shear for all Zones

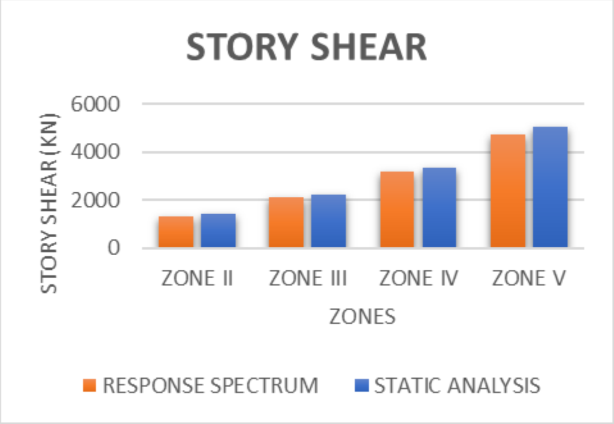

Fig-3.4 Story Shear & Response spectrum for all Zones

Observation:

1. As the seismic zone categorization moves from Zone II to Zone V, story shear increases.
2. Across all zones, static analysis typically forecasts somewhat greater story shear values than reaction spectrum analysis.
3. Difference in Results as a Percentage: 6.13%

3.3 Story Displacement Analysis

DISPLACEMENT (MM)			
SR NO.	ZONE	STATIC ANALYSIS	RESPONSE SPECTRUM
1	ZONE II	25.265	17.534
2	ZONE III	40.425	28.054
3	ZONE IV	60.637	42.081
4	ZONE V	90.955	63.122

Fig-3.5 Story displacement for all Zones

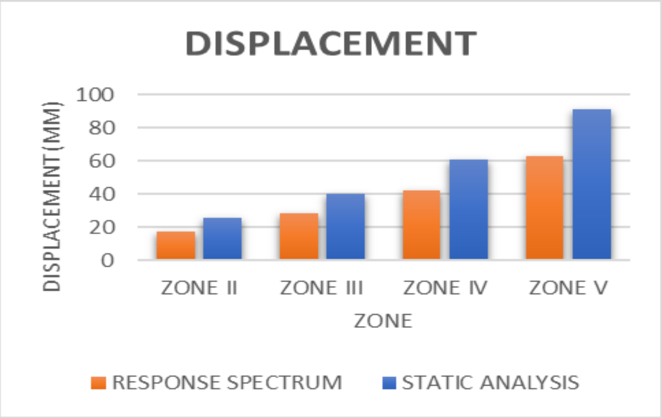

Fig-3.6 Story displacement & response spectrum for all Zones

Observation:

1. As the seismic zone categorization moves from Zone II to Zone V, displacement rises.
2. In all zones, static analysis reliably forecasts higher displacements than reaction spectrum analysis.
3. The percentage Variation in the Outcome: 30.6%

3.4 Story Drift Analysis

STORY DRIFT (MM)			
SR NO.	ZONE	STATIC ANALYSIS	RESPONSE SPECTRUM
1	ZONE II	0.000272	0.000205
2	ZONE III	0.000435	0.000328
3	ZONE IV	0.000653	0.000491
4	ZONE V	0.000979	0.000737

Fig-3.7 Story Drift for all Zones

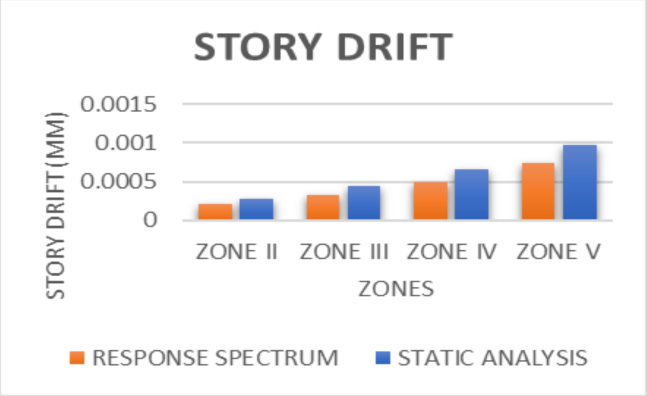

Fig-3.8 Story Drift & Response spectrum for all Zones

Observation:

i. As the seismic zone categorization moves from Zone II to Zone V, there is an increase in story drift.

ii. The values of tale drift from Zone II to Zone V are roughly doubled.

iii. Difference in Percentage of Outcome: 24.60%

4. CONCLUSIONS

Higher zones experience greater seismic forces. According to the investigation, when the seismic zone categorization moves from lower (Zone II) to higher (Zone V), seismic forces such as base shear, story shear, and story drift increase dramatically. Forces and displacements may be overestimated by static analysis. Static analysis often forecasts greater values for story shears, displacements, and tale drifts throughout all seismic zones when compared to reaction spectrum analysis (dynamic technique). Accurate forecasting requires dynamic analysis. Notable expansion between neighboring seismic zones. Moving from one seismic zone to the next higher zone results in a noticeable increase in seismic demands (base shear, story shear, displacement, and drift), according to the analysis. These characteristics typically rise by between 50 and 60 percent between neighboring zones.

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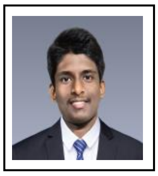
BIOGRAPHIES

Sahil Kanojiya
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)



Gokuldeep Kurup
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)

Onkar Khutwad
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)

Kushal Hankare
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)

Mr. P.R. Barbude
Assistant Professor, Department o Civil Engineering, Datta Megh College of Engineering, Maharashtra India)