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STRUCTURAL PERFORMANCE OF RCC & STEEL STRUCTURE IN VARIOUS SEISMIC ZONES USING ETABS

Deepak Gajare[1], Harshad Kadam[2], Yash Malvalkar[3], Aditya Lokare[4], Mr. P. V. Muley[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 - *This study investigates the structural performance of reinforced cement concrete (RCC) and steel structures under seismic loads across various seismic zones using ETABS software. Representative RCC and steel structures are modeled and analyzed according to relevant codes and standards. Seismic loads corresponding to different seismic zones are applied, and key performance indicators such as base shear, story drifts, and modal characteristics are evaluated. The results are compared to identify the relative strengths and weaknesses of each structural system in varying seismic intensities. The findings provide insights into the seismic behavior of RCC and steel structures, enabling informed decision-making for structural design and construction practices. The research highlights the optimal structural system for specific seismic zones, considering material properties, construction techniques, contributing to enhanced seismic resilience of built infrastructure.*

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

1. INTRODUCTION

Earthquakes pose a significant threat to the structural integrity and safety of buildings, particularly in seismically active regions. The devastating consequences of seismic events underscore the critical importance of designing structures that can withstand the loads and deformations induced by earthquakes. Reinforced cement concrete (RCC) and steel are two widely used structural materials, each with its unique properties and behavior under seismic loads.

This research project aims to conduct a comprehensive investigation into the structural performance of RCC and steel structures in various seismic zones. The primary objective is to evaluate and compare the seismic response of these two structural systems when subjected to different levels of seismic intensity, ranging from low to high seismic hazard regions.

ETABS incorporates sophisticated numerical methods and algorithms to accurately simulate the behavior of structures under dynamic loads, making it an ideal tool for this research.

In this project, response spectrum analysis will be employed to investigate the seismic performance of reinforced cement concrete (RCC) and steel structures in various seismic zones. The response spectra used in the analysis will be derived from design codes and standards, reflecting the seismic hazard levels of the respective seismic zones under consideration.

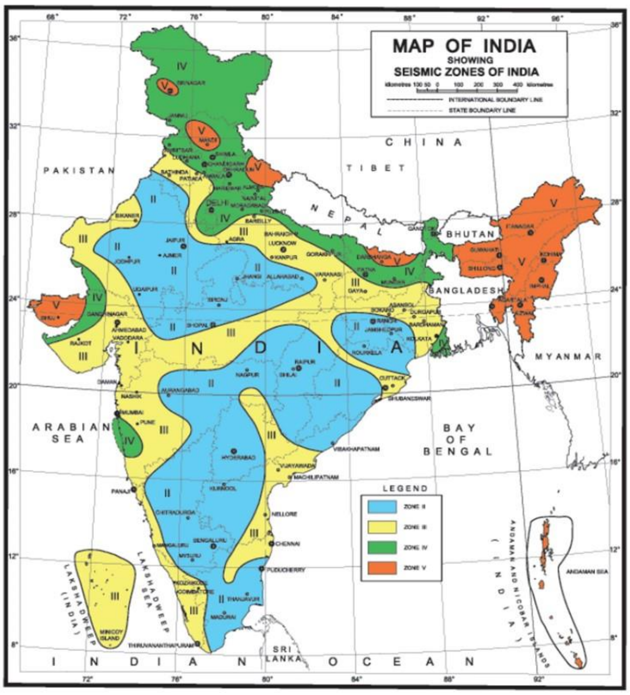

Fig -1.1: Indian Seismic Zone Map

1.1 Objective:

i. To carry out the modelling of RCC & Steel structure, G+29 high rise building, as per Indian Standard Codes, using ETABS software and to check the model for any failures.

ii. To perform the Response Spectrum Analysis for RCC & Steel building for different seismic zones (i.e. Seismic zone III, IV, V) as per IS Codes, on ETABS software.

iii. To assess & evaluate the seismic performance of reinforced concrete (RCC) structures & Steel structures across different seismic zones (i.e. Seismic zone III, IV, V) to check the reaction of concrete and steel members (designed for seismic zone III) in different zones (i.e. Seismic zone IV, V) and to understand their vulnerability to earthquakes.

1.2 Problem Statement:

The design and construction of structures in earthquake-prone regions pose significant challenges due to the risk of seismic events and the potential for catastrophic damage. Reinforced concrete (RCC) and steel are two widely used construction materials for buildings and infrastructure, but their structural performance and behaviour can vary significantly across different seismic zones. This study aims to investigate and compare the seismic performance of RCC and steel G+29 building in various seismic zones through response spectrum analysis.

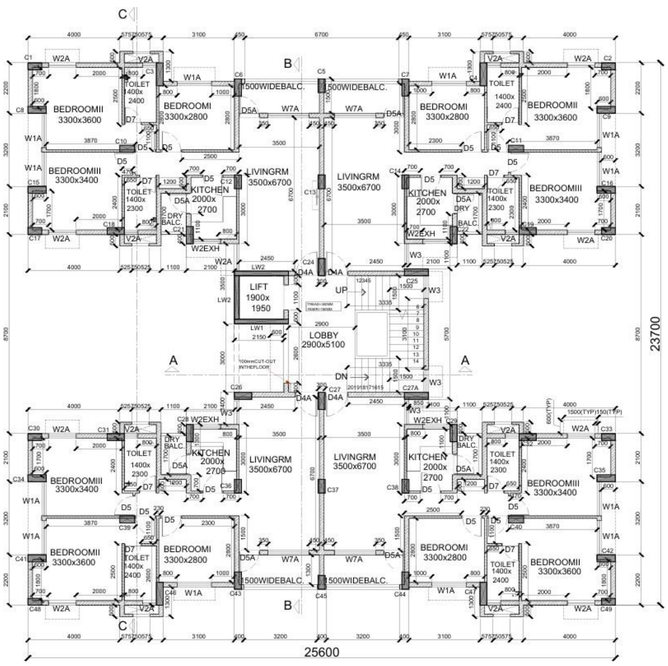

Fig-1.2: Floor plan

2. METHODOLOGY

The methodology involves modeling representative reinforced cement concrete (RCC) and steel structures in ETABS, incorporating accurate geometric and material properties, boundary conditions, and load cases. Seismic load cases for different seismic zones are defined based on relevant building codes and standards. Response spectrum analysis is then performed on both RCC and steel structure models, subjecting them to the defined seismic load cases, and key response parameters such as base shear, story drifts, modal characteristics, and stress distributions are evaluated. The seismic performance of RCC and steel structures is compared across the various seismic zones by analyzing the obtained response parameters, identifying the relative strengths, weaknesses, and potential failure modes of each structural system under varying seismic intensities. Finally, the results are interpreted and the safe structural system for different seismic zones is identified.

2.1 Response Spectrum Analysis

Response spectrum analysis is a powerful technique used in structural engineering to evaluate the dynamic response of structures subjected to seismic ground motions. It involves the use of a response spectrum, which is a graphical representation of the maximum response of single-degree-of-freedom (SDOF) systems with varying natural periods or frequencies when subjected to a specific ground motion. The response spectrum effectively captures the peak responses of SDOF systems with different dynamic properties, allowing for a comprehensive assessment of the structural behavior under seismic loads. Instead of performing a detailed time-history analysis involving complex ground motion records, response spectrum analysis provides an efficient method to estimate the maximum likely response of a multi-degree-of-freedom (MDOF) system, such as a building or bridge.

The analysis involves subjecting the structural model to a design response spectrum, which is typically obtained from seismic design codes or site-specific studies, and calculating the maximum modal responses for each mode of vibration. These modal responses are then combined using appropriate combination rules to obtain the overall structural response, including key parameters such as base shear, story drifts, and member forces.

RCC BUILDING	Beam (M45 Grade)- Main Beam= 400 x 700 mm Secondary Beam= 300 x 500 mm Column (M45 Grade)- Column size. = 600 x 1100 mm Slab (M45 Grade)- Thickness= 225 mm Inner wall (M30 Grade) Thickness= 150 mm Outer wall (M35 Grade) Thickness= 230 mm
STEEL BUILDING	Beam- Main Beam= ISMB 450 Secondary Beam= ISLB 200 Column = ISHB 800 (self-made) Deck- Depth= 200 mm
Seismic Factors	Zone= III (Mumbai) Zone Factor= 0.16 Soil Type= II (Medium soil) Importance factor= 1.2 (for residential building more than 200 persons) Response Reduction Factor= 5 (SMRF)
Seismic Factors	Wind Speed= 44 m/s Terrain category= II Importance Factor= 1 Risk Coefficient= 1 Topography factor= 1

Table -1: Building Parameters

3. RESULT AND DISCUSSION

For RCC Structure:

Zone IV:

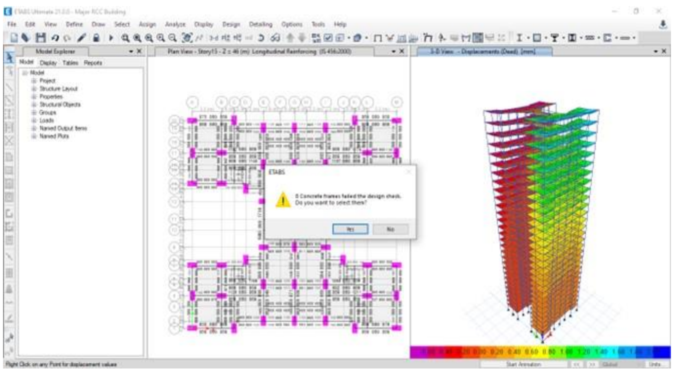

Fig-3.1: Analyzed RCC structure for zone IV

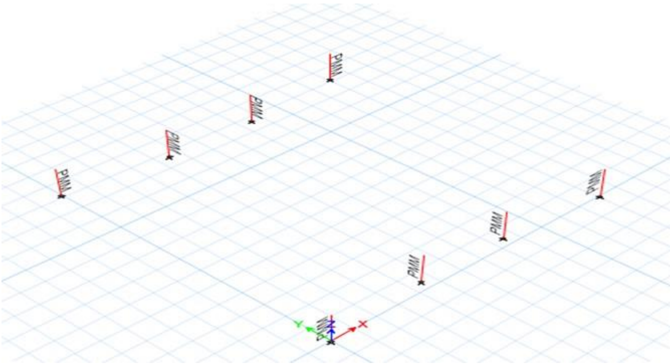

Fig-3.2: Failed members of RCC structure in zone IV

Observation:

When the RCC structure (Designed only for Zone III) is checked for failures in seismic zone IV, the columns on ground floor fails due to overstressing, causing its failure & collapsing.

Zone V:

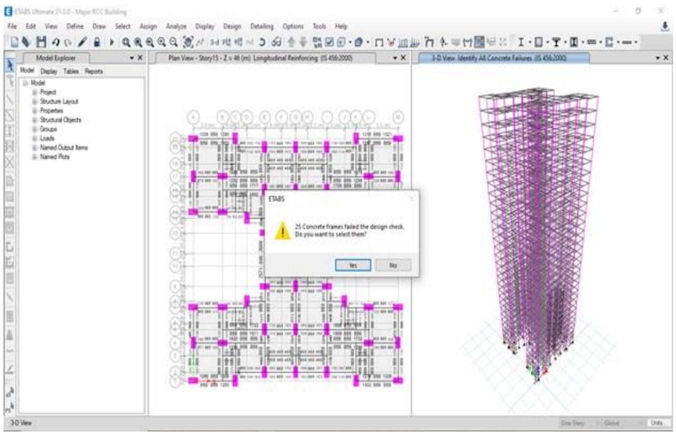

Fig-3.3: Analyzed RCC structure for zone V

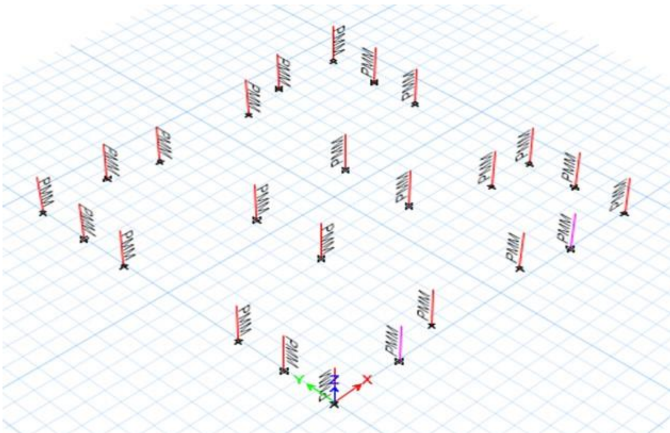

Fig-3.4: Failed members of RCC structure in zone V

Observation:

When the same RCC structure (Designed only for Zone III) is checked for failures in seismic zone V, the concrete members on lower floors fails due to overstressing, causing its failure & collapsing.

For STEEL Structure:

Zone IV:

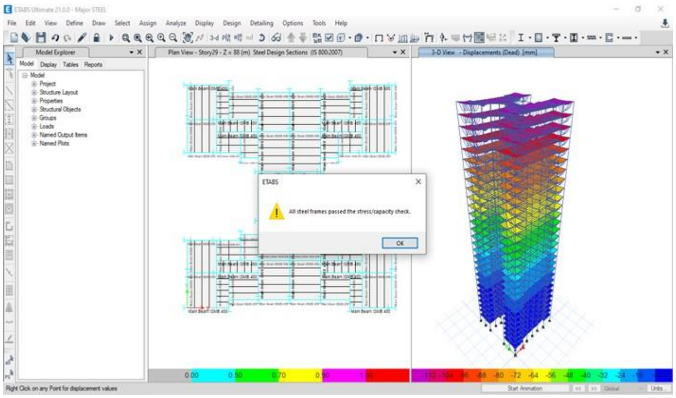

Fig-3.5: Analyzed STEEL structure for zone IV

Observation:

When the Steel structure (Designed only for Zone III) is checked for failures in seismic zone IV, the structure shows NO failure of steel frames, resulting that the Steel structure, designed for zone III, is safe and can also withstand the seismic conditions of zone IV without any failure.

Zone V:

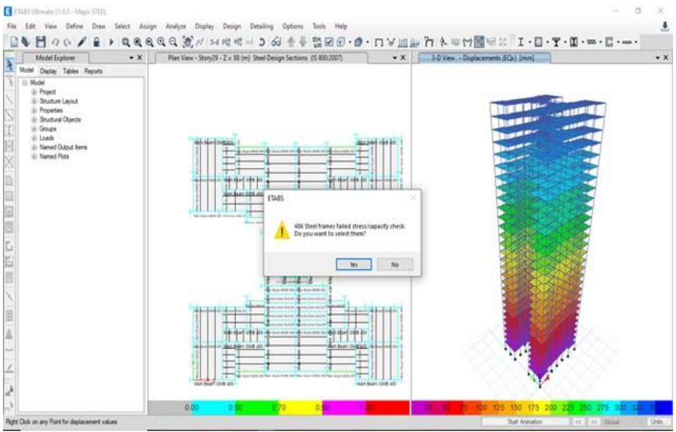

Fig-3.6: Analyzed STEEL structure for zone V

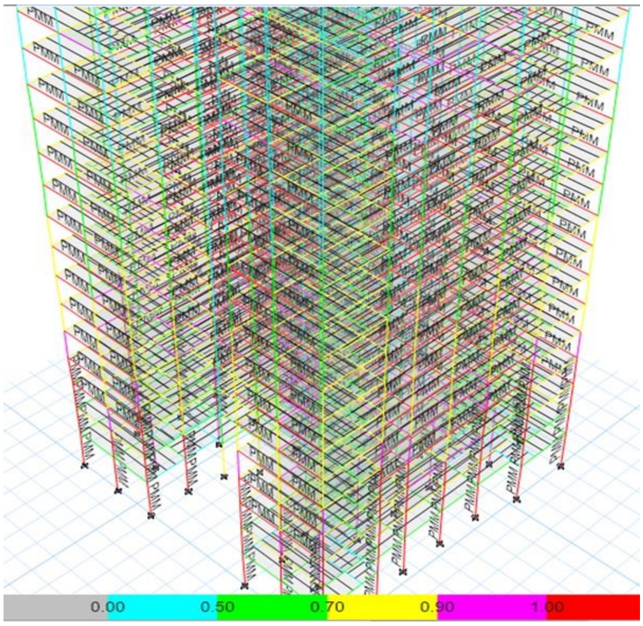

Fig-3.7: Failed members of STEEL structure in zone V

Observation:

When the same STEEL structure (Designed only for Zone III) is checked for failures in seismic zone V, the Steel frames on lower floors fails due to overstressing, causing its failure & collapsing.

4. CONCLUSIONS

Conclusion for the performance of RCC structure and Steel structure, designed only for zone III, in various zones (i.e. Seismic zone IV, V):

For RCC Structure:

As the RCC structure is basically designed for seismic zone III, the structure remains safe in this respective zone.

When the same designed structure is placed in zone IV, it shows the failure of 8 members (Columns) of the structure, all on the Ground floor, it results in collapse of the structure.

When the same designed structure is placed in zone V, it shows the failure of 28 members of the structure, maximum on the Ground floor which results in collapse of the structure. It concludes that the RCC structure designed for zone III is not suitable and safe for seismic zone IV and zone V.

For STEEL Structure:

As the Steel structure is basically designed for seismic zone III, the structure remains safe in this respective zone.

When the same designed structure is placed in zone IV, it shows no failure of steel frames of the structure, resulting that the steel structure designed for zone III can be effective for zone IV as well, without any strengthening.

When the same designed structure is placed in zone V, it shows the failure of 486 steel frames of the structure, maximum on the lower floors which results in collapse of the structure, concluding that the structure designed for zone III is not suitable and safe for seismic zone V.

As designed for zone III both are steel as well as RCC structures are safe in zone III. As foe zone IV RCC structure fails and Steel structure is safe. In zone V both structures fails.

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BIOGRAPHIES

Deepak Vikram Gajare
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)

Harshad Devendra Kadam
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)

Yash Jagdeesh Malvalkar
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)

Aditya Arvind Lokare
(BE Student, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)

Mr. P.V. Muley
(Assistant Professor, Department of Civil Engineering, Datta Meghe College of Engineering, Maharashtra, India)