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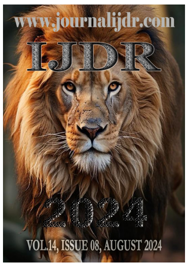

RESEARCH ARTICLE

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SEISMIC RESPONSE SPECTRUM ANALYSIS (ZONE V) OF A G+10 STEEL FRAMED STRUCTURE USING DIFFERENT GRADES OF STEEL

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ABSTRACT

Seismic Response Spectrum Analysis (SRSA) is a critical component in assessing the seismic performance of structures, especially in earthquake-prone regions. This project report presents a comprehensive analysis of a G+10 steel-framed structure using the widely utilized structural analysis software, ETABS. The primary objective of this study is to evaluate the structural response to seismic loading and provide insights into the dynamic behaviour of the building for Earthquake Zone 5. The methodology section outlines the steps followed in conducting the seismic response spectrum analysis using ETABS. This includes the generation of the seismic response spectrum curves, selecting appropriate ground motion records, modelling the G+10 steel-framed structure, assigning material properties, and applying the seismic loads in accordance with relevant building codes and standards. The modelling and analysis process are thoroughly documented, including the establishment of finite element models that accurately represent the structural system. The project utilizes realistic material properties and load combinations, ensuring that the analysis results are meaningful and applicable to real-world scenarios.

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INTRODUCTION

An earthquake is a sudden and violent shaking of the ground that is caused by the rapid release of energy in the Earth's crust. Earthquakes can range in magnitude from minor tremors to major events that can cause widespread damage and loss of life. High-rise structures are particularly vulnerable to earthquakes because they are tall and flexible. When the ground shakes, a high-rise building will sway back and forth. The taller the building, the more it will sway. This swaying can cause significant damage to the building's structure and components. High-rise steel framed structures are buildings that use a steel frame to support their weight and resist lateral loads such as wind and earthquakes. Steel is a strong and lightweight material, making it ideal for use in tall buildings. Steel framed structures are typically made up of vertical columns and horizontal beams that are connected together with bolts or rivets. The columns support the weight of the building and the beams transfer the load to the columns. The frame can be either rigid or braced. A rigid frame is one in which the beams and columns are connected together in a way that allows them to resist bending moments. A braced frame is one in which the beams and columns are connected together with diagonal braces that help to resist lateral loads. Steel framed structures are used for a variety of high-rise buildings, including office buildings, apartment buildings, hotels, and hospitals. They are also used for some industrial buildings and bridges.

Response Spectrum Analysis: Response spectrum analysis (RSA) is a method for estimating the peak response of a structure to a transient dynamic event, such as an earthquake or shock. It is a linear-dynamic statistical analysis method that measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure. RSA is based on the concept of a response spectrum, which is a plot of the maximum response of a single degree of freedom (SDOF) system to a given ground motion, as a function of the SDOF system's natural frequency and damping ratio. Response spectra can be generated for acceleration, velocity, or displacement, and can be plotted for a single ground motion or for an ensemble of ground motions. To perform RSA, the structure is first analysed to determine its natural frequencies and damping ratios. This can be done using a variety of methods, such as modal analysis. Once the natural frequencies and damping ratios are known, the response spectrum for the given ground motion is used to determine the peak response of each mode of vibration. The peak responses of the individual modes are then combined to obtain the overall peak response of the structure. RSA is a relatively simple and efficient method for estimating the peak response of a structure to a transient dynamic event. It is widely used in the design of structures to resist earthquakes and other dynamic loads.

Objectives

The goals of the learning are listed as following:

1) Conduct a detailed response spectrum analysis of a G+10 steel framed structure, utilizing different grades of steel from Fe500 at the ground floor to Fe250 at the top floor.
2) Assess the maximum story displacements and story drifts for the structure under seismic loading conditions in Zone V.
3) Determine the impact of varying steel grades on the seismic performance of the structure, focusing on displacement patterns and overall stability.

Identification of Research gap and Scope of the Present Study: The scholarly article entitled "Seismic Assessment of Tall Buildings with and without Infill Walls," authored by Wakchaure M.R. and Ped S.P., delves into a comparative study of a high-rise edifice, exploring its response to seismic forces in both infilled and non-infilled configurations. In contrast, our current study specifically aims to analyse a high-rise steel structure subjected solely to seismic loading. A key distinction lies in our choice of materials, as we have opted for different grades of steel for various floors, driven by economic considerations. Unlike the reference study, which employed a uniform grade of RCC and steel throughout the entire structure, our research suggests that using diverse steel grades is a more cost-effective approach in high-rise steel structures facing seismic loading in Earthquake Zone V. This departure in material composition and loading conditions highlights an unexplored aspect in existing literature, motivating our investigation to comprehensively address this research gap. Our study's scope includes a thorough examination of structural performance, with a specific focus on the implications of employing diverse steel grades in high-rise constructions under seismic loading, providing valuable insights to the field. Our review of existing research literature has revealed a notable absence of publications employing distinct grades of steel within the same structure for structural elements of identical cross-section. Identifying this gap in previous research, we have undertaken a comprehensive analysis to fill this void. In our study, we have examined a completely steel structure, including the slab, incorporating different grades of steel at various floors, as outlined in Table 1.

Table 1. Structural Details

Sl. No	Item	Specifications
01	Material	Structural Steel
02	No. of Stories	G + 10
03	No. of Bay in X – Direction	05
04	No. of Bay in Y – Direction	05
05	Bay spacing in X – Direction	5000mm
06	Bay spacing in Y – Direction	5000mm
07	Floor Height	3500mm
08	Depth of Slab	150mm
09	Size of Column	600mm X 600mm
10	Size of Beam	600mm X 600mm
11	Slab Section	Fe 400

METHODOLOGY

Initially, a comprehensive model of the G+10 steel framed structure is created in ETABS, incorporating specific design parameters such as number of stories, bay spacing, story height, and material properties. Structural properties, including section sizes and material strengths, are defined and assigned to the model. Seismic loads are applied according to IS 1893:2016, and relevant load combinations are considered. Friction dampers, fluid viscous dampers, and tuned mass dampers are then integrated into the model to enhance its seismic performance. The structure is analyzed under seismic Zone V conditions, and critical response parameters such as maximum story displacement, story drifts, story shears, overturning moments, and story stiffness are extracted. The results are evaluated to determine the effectiveness of the different dampers in mitigating seismic impacts, ensuring the structure's compliance with safety standards.

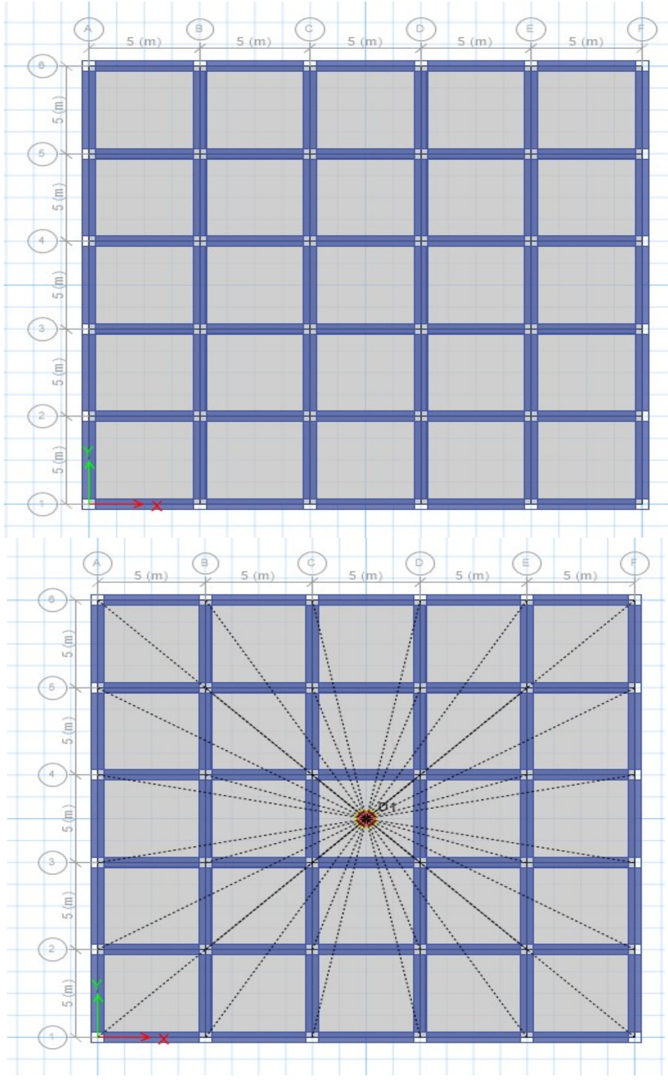

Figure 1. Floor Plan and Diaphragm Details

RESULTS AND DISCUSSION

The provided results pertain to the response spectrum analysis conducted in Zone V for the specified G + 10-story steel-framed structure.

Response spectrum analysis: In this section, the results of base shear, story displacements, story drifts were presented for Steel Framed Section. The building was analysed for seismic zone V. As per clause 6.4.3 of IS 1893-2002.

Maximum Story Displacement: The results show at the base level, there is no displacement, which is expected as it is the fixed support. As we move up from the ground floor (3.50m elevation) to the top floor (38.5m elevation), the story displacement values increase from 5.145mm to 52.388mm. This gradual increase indicates that higher floors experience greater lateral movement due to seismic forces, which aligns with the dynamic characteristics of tall structures. The use of higher-grade steel (Fe500) at the lower stories provides the necessary strength to handle higher loads and moments, while the transition to lower grade steel (Fe250) at higher stories helps optimize material usage without compromising structural integrity. The results show that despite the varied steel grades, the structure maintains a controlled increase in displacement, ensuring that the maximum story displacement remains within acceptable limits for seismic performance. This indicates that the design strategy effectively distributes seismic forces, leveraging the material properties to enhance the building's overall resilience.

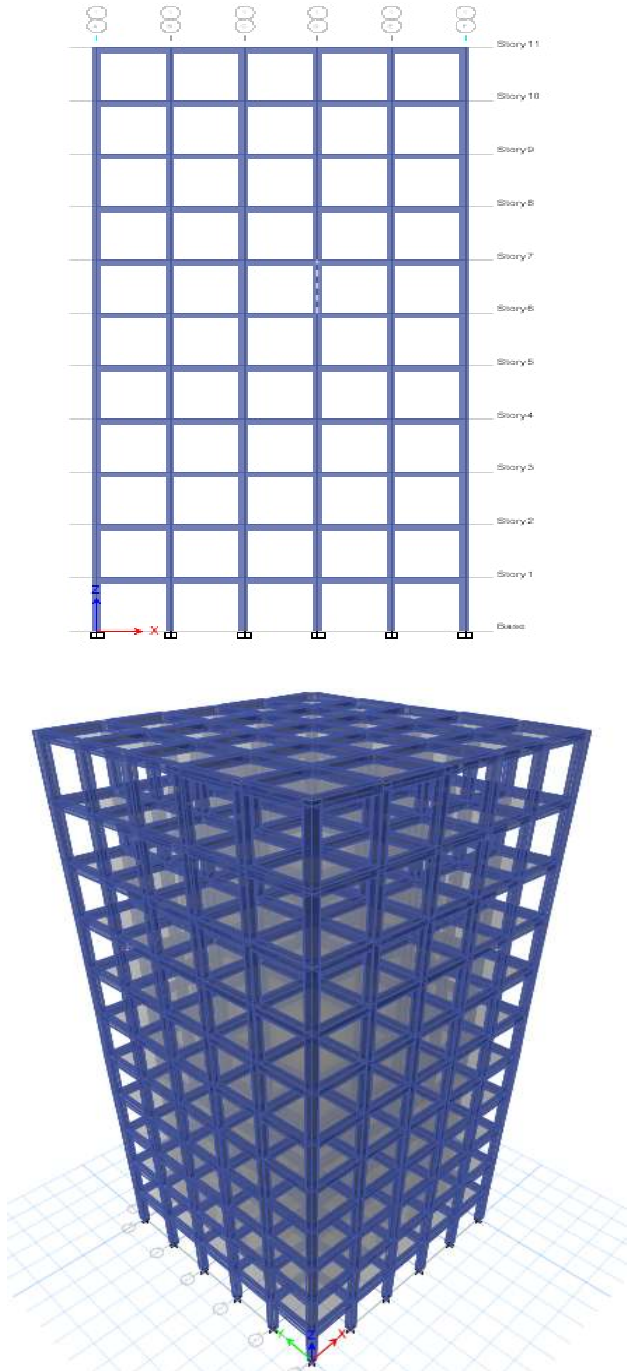

Figure 2. Front Elevation and 3D Elevation of the Structure

Table 2. Structural Configurations

Grade of Steel for different floors		
Sl. No.	Grade of Steel	Floor Number
01	Fe 500	For Ground Floor
02	Fe 450	For 1st & 2nd Floor
03	Fe 400	For 3rd & 4th Floor
04	Fe 350	For 5th & 6th Floor
05	Fe 300	For 7th & 8th Floor
06	Fe 250	For 9th & 10th Floor
07	Fe 400	Slab Section

Table 3. Maximum Story Displacement

Story No.	Elevation (m)	Story Displacement (mm)
Base	0.00	0.0000
GS	3.50	5.1450
1	7.00	10.859
2	10.5	16.683
3	14.0	22.503
4	17.5	28.215
5	21.0	33.704
6	24.5	38.832
7	28.0	43.443
8	31.5	47.361
9	35.0	50.396
10	38.5	52.388

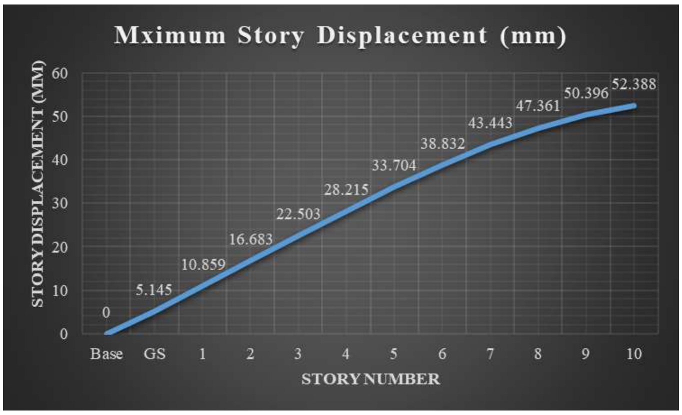

Figure 3. Maximum Story Displacement

Maximum Story Drifts

Table 4. Maximum Story Drift

Story No.	**Elevation (m)**	**Story Displacement (mm)**
Base	0.00	0.000000
GS	3.50	0.001029
1	7.00	0.001270
2	10.5	0.001294
3	14.0	0.001293
4	17.5	0.001269
5	21.0	0.001220
6	24.5	0.001140
7	28.0	0.001025
8	31.5	0.000871
9	35.0	0.000674
10	38.5	0.000443

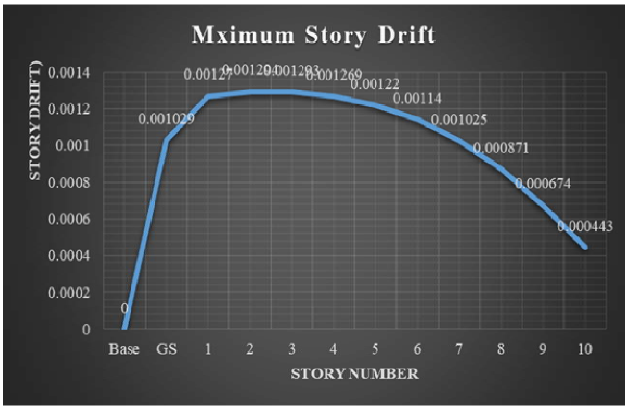

Figure 4. Maximum Story Drifts

The results of the Response Spectrum Analysis for the G+10 steel framed structure, with different grades of steel ranging from Fe500 at the ground floor to Fe250 at the top floor, indicate a distinct pattern in maximum story displacement. Starting from the base with zero displacement, there is a gradual increase up to the third floor, peaking at 0.001294 mm. Beyond the third floor, the displacements gradually decrease as the height increases, with the highest story showing a displacement of 0.000443 mm. This trend suggests that the use of higher-grade steel (Fe500) at the lower levels effectively limits the displacement, while the transition to lower grades (Fe250) at higher levels contributes to the overall stability by reducing the displacement progressively. The overall displacement values are well within acceptable limits, demonstrating the structure's ability to withstand seismic forces in Zone V conditions. The gradual reduction in story displacement towards the upper floors highlights the efficient design strategy, ensuring the structure’s integrity and performance during seismic events.

CONCLUSION

Based on the sectional details provided in Table 1 and considering the structure's location in Earthquake Zone V, in accordance with IS 1893:2002, the following conclusions can be deduced:

- The maximum story displacements and drifts are well within acceptable limits as per seismic standards for Zone V, indicating the structure’s ability to withstand significant seismic forces.
- The variation in steel grades across different floors does not compromise the overall stability of the structure. This approach enhances the economic efficiency of the construction while maintaining the necessary structural integrity.

REFERENCES

Abhay Guleria [2014] : International Journal of Engineering Research & Technology (IJERT) “Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations”

Baldev D. Prajapati1 & D. R. Panchal [2013] : International Journal of Advances in Engineering & Technology (IJAET) – “Study of Seismic and Wind Effect on Multi Storey R.C.C., Steel and Composite Building” –

Design of Steel Structure (McGraw Hill Publications) by S K Duggal.

https://www.youtube.com/watch?v=0johDvRgyws

https://www.youtube.com/watch?v=C_qaFPXQ7YY&t=1853s

https://www.youtube.com/watch?v=ddpTitkxshk&t=1296s

https://www.youtube.com/watch?v=Rx18gpzeqlM

IS : 875 (Part 2) - 1987 (Reaffirmed 2008) — Indian Standard Code of Practice for Design Loads (Other Than Earthquake) For Buildings And Structures (Part 2) Imposed Loads (Second Revision).

IS : 875 (Part 3) — Indian Standard Code of Practice for Design Loads (Other Than Earthquake) For Buildings And Structures (Part 3) Wind Loads (Third Revision).

IS 800 : 2007 — General Construction in Steel — Code of Practice (Third Revision).

IS 875 (Part 1) : 1981 (Incorporating IS: 1911 - 1967) (Reaffirmed 2008) — Design Loads (Other Than Earthquake) For Buildings and Structures Part 1 Dead Loads - Unit Weights of Building Materials and Stored Materials [February 1989 (Second Revision)].

Jagadish J. S, Tejas D. Doshi [2013] : International Journal of Engineering Research & Technology (IJERT) – “A Study on Bracing Systems on High Rise Steel Structures”

Khushbu Jania, Paresh V. Patel [2013] : Sciverse ScienceDirect – “Analysis and Design of Diagrid Structural System for High Rise Steel Buildings” –

M.K.S & S.I units IS Steel Tables. IS 1893 : 2002 (Part 1) — Criteria for Earthquake Resistant Design of Structures (Part 1 – General Provisions for Buildings) (Sixth Edition).

Structural Design and Drawing – Reinforced Concrete and Steel (Universities Press – Third Edition) by N Krishna Raju

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