Evaluating the Seismic Behavior of RC Structures: A Comparative Study of Framed Tube and Shear Wall Systems for Varying Numbers of Stories

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Research Article

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Abstract

Through a comparison of framed tube systems and shear wall systems for various story counts, this work evaluates the seismic behaviour of reinforced concrete (RC) structures. The goal is to use the ETABS software to evaluate how well these structural systems perform when subjected to seismic and wind loads. Analysis of storey displacements, a crucial performance metric for both lateral load resisting systems, is the study's main objective. To analyse structures, we use the Response Spectrum Method. The findings show that the framed tube structure outperforms the shear wall system in terms of seismic resistance, showing decreased displacements, greater drift ratios, increased base shear forces, and improved structural ductility. These results imply that framed tube structures can be used as workable substitutes for tall buildings situated in seismic regions. To avoid excessive deformation and failure, it is necessary to include enough stiffness and strength in the design phase. The study also highlights how crucial it is to look into how material properties, loading patterns, and interactions between the structure and the ground affect these systems' seismic stability. The findings of this study show the earthquake resistance and dependability of framed tube structures and have major implications for high-rise building design and construction in seismic regions.

Introduction

In the realm of structural engineering, the seismic behaviour of reinforced concrete (RC) constructions has recently attracted a lot of interest. It is crucial for buildings to be able to withstand seismic pressures and limit damage during earthquakes, especially in areas prone to seismic activity. Framed tube systems and shear wall systems are two structural systems that have been created and used to improve the seismic performance of buildings. Due to their inherent strength and rigidity, framed tube structures, which feature a core of connected vertical and horizontal framing sections, have shown promise seismic resistance. This structural design effectively distributes lateral loads throughout the entire structure, lowering the possibility of localized damage and enhancing structural integrity. Shear wall systems, on the other hand, are made up of vertical walls that are integrated into the structure of the building and are stiff and strong enough to resist lateral forces. In order to efficiently reduce displacements and maintain structural integrity during seismic occurrences, these systems provide greater lateral stiffness.

While both framed tube and shear wall systems have been widely employed and studied, a comprehensive comparative analysis is essential to understand their respective seismic behaviors. By conducting an extensive examination and comparison of the seismic performance of RC structures using framed tube systems and shear wall systems, this work seeks to fill this knowledge gap. The analysis will be conducted for buildings with diverse numbers of stories, taking into account the impact of various heights on the general behaviour.

This study's main goal is to evaluate how these two lateral load resisting systems respond to seismic and wind loads. We'll look at storey displacements, which are important indicators of structural performance, to see how well each solution works to lower displacement and control drift ratios. Additionally, structural
ductility and base shear forces will be assessed in order to determine how well the systems can dissipate energy and withstand seismic impacts.

The results of this study have significant practical implications for high-rise building design and construction in seismically active regions. This study seeks to offer useful insights into the selection and optimisation of structural systems to ensure the safety and resilience of buildings subjected to seismic loading by contrasting the seismic behaviour of framed tube and shear wall systems. Understanding these systems' advantages and

**Methodology**

1. 1. Different storeys (40, 50, and 60) are taken into consideration for the analysis of framed tube structure and shear wall structure. Every floor is regarded as being 3.6 metres tall.

2. 2. Framed tube structures and shear wall structures are simulated using ETABS software with regard to RCC structures under the premise that the structure is located on hard soil in accordance with IS:1893 (part 1)-2016.

3. 3. Using Etab 2016 Software, seismic analysis of the models will be done for the various zones (II, III, IV, and V).

4. 4. The software's statistics for base shear, maximum Storey displacement, and maximum Storey drift are tabulated to understand how lateral load resisting systems perform differently and to determine the most suitable lateral resisting system.

5. Conclusions are drawn based on the outcomes of the various models.

**2.1 Model details**

Dimension of Plan = 40m X 40m

Story Height = 3.6m

Spacing of columns along X-direction = 8.0m

Spacing of columns along Y-direction = 8.0m

- Live Load: - 4 kN/m2
- Floor Finish: - 1 kN/m2
- Wall load: - 5 kN/m

Seismic Parameters as per IS-1893 Part-I 2016:

- Soil Type: - Hard Rock
- Importance Facto: - 1.5
- Response Reduction Factor: - 5
Wind Parameters as per IS-875 Part-III 2015:

- Wind Speed: - 44 m/sec
- Terrain Category: - IV
- Risk Coefficient (K1): - 1
- Topography Factor (K3): - 1
- Important Factor (K4): - 1

**Results**

All models are subjected to wind and seismic loads for analysis, and all models are analysed using the ETAB 2016 software. The study results for each building model, including displacements, storey drifts, and base shear, are compared.

**4.1 Displacement**

Indian regulations limit the maximum displacement in a multistorey building for seismic $H/250$ and for wind is $H/500$

From the analysis results of ETAB 2016 maximum displacement is for seismic zone V.

**4.2 Story Drift**

Storey drift is the horizontal movement of a floor relative to the floor below due to external forces such as wind or earthquake.

Maximum Story Drift is 0.004 Times the story height i.e., $0.004 \times 3.6 = 0.0144$ as per IS.1893-Part I 2016.

Max Story Drift

**4.3 Story Shear**

The maximum projected lateral force on the base of a structure as a result of seismic activity is estimated as base shear.

**Conclusion**

From the analysis results,
• Lateral Displacement: The framed tube structure outperforms the shear wall structure by reducing lateral displacement by 40 percent. This highlights the superior effectiveness of the framed tube system in resisting lateral loads compared to other structural systems.

• Story Drift: Both the shear wall and framed tube structures exhibit acceptable story drift levels. However, the framed tube structure achieves a remarkable reduction of 28 percent in maximum storey drift, further emphasizing its effectiveness in maintaining structural stability.

• Base Shear: The framed tube structure experiences a higher base shear due to the rising seismic weight. Nevertheless, when compared to the shear wall structure, the base shear of framed tube structures only increases by 4.48 percent, indicating its favorable performance.

• Shear Lag Effect: In framed tube structures, the corner columns bear a higher axial force than nearby columns, leading to a 21 percent increase in axial force compared to the adjacent column. While this effect should be considered in the design, it does not diminish the overall effectiveness of the framed tube system.

Declarations

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Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Author contributions

All authors contributed to the study conception and design. Modeling, data collection and analysis were performed by Sourabh S Sutar and Rahul D. Patil. The first draft of the manuscript was written by Sourabh S Sutar and Rahul D. Patil commented on previous versions of the manuscript. authors read and approved the final manuscript.

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References


Figures

Figure 1

Framed tube Structure (Kim J., Park J., & Moon K.W. 2009)
Figure 2

Shear Lag Behaviour (Shin M., Kang T. H.-K., & LaFave J. M. 2010)