IJEASM

International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 5 Issue 7, July 2024

Seismic Assessment of a Twenty-Story Multistory Structure with Shear Wall Support

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Abstract: *The seismic assessment of tall structures with shear wall support is crucial for ensuring their structural integrity and safety during seismic events. This study focuses on the seismic evaluation of a twenty-story multistory structure designed with shear walls to resist lateral forces. Shear walls are fundamental elements in high-rise buildings, providing substantial stiffness and strength against lateral loads such as those induced by earthquakes. The assessment methodology integrates detailed structural analysis techniques, including nonlinear static (pushover) analysis and dynamic analysis using appropriate ground motion records. Nonlinear static analysis helps assess the global behavior and capacity of the structure under progressively increasing lateral forces, while dynamic analysis evaluates its response to realistic earthquake excitations. Key parameters such as inter-story drifts, base shear distribution, and performance levels under different seismic intensities are evaluated to gauge the structure's seismic performance. The findings contribute valuable insights into the effectiveness of shear wall configurations in enhancing the seismic resilience of tall buildings. Recommendations for retrofitting or enhancing the structural design may be proposed based on the assessment outcomes, aiming to improve the building's overall seismic performance and safety. This research underscores the significance of robust seismic assessment methodologies in ensuring the reliability and resilience of high-rise structures designed with shear wall systems.*

Keywords: *Seismic assessment, Shear wall, Multistory structure, Earthquake resilience, Structural integrity.*

1. Introduction

The seismic performance of tall buildings is a critical concern in regions prone to earthquakes. Among various structural systems employed to mitigate seismic risks, shear walls play a pivotal role due to their ability to resist lateral forces effectively. This study investigates the seismic assessment of a twenty-story multistory structure specifically designed with shear wall support. The integration of shear walls in the structural system of high-rise buildings is aimed at enhancing stiffness and damping characteristics, thereby improving overall structural stability during seismic events. Shear walls are vertical elements typically constructed from reinforced concrete or structural steel that span multiple floors vertically. They are strategically located in the building's perimeter or core to resist lateral forces induced by seismic activity. By distributing these forces across the height of the building, shear walls reduce the building's vulnerability to sway and overturning, thereby safeguarding occupants and structural integrity.

The assessment methodology employed in this study encompasses both nonlinear static (pushover) analysis and dynamic analysis using ground motion records representative of the region's seismic hazard. Nonlinear static analysis involves applying incremental lateral forces to simulate the effect of seismic loading, allowing engineers to assess the structure's response at different force levels and identify potential failure modes. Dynamic analysis, on the other hand, considers the time history of ground

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motions to evaluate the building's response under realistic earthquake scenarios, capturing the complex interactions between the structure and the ground motion. Key performance indicators such as inter-story drifts, base shear distributions, and the overall structural response are evaluated to determine the building's seismic performance levels. These metrics provide insights into the structure's ability to withstand seismic forces without compromising safety or functionality. By assessing the performance under varying seismic intensities, engineers can ascertain the adequacy of the shear wall design and propose necessary enhancements or retrofitting measures to improve the structure's resilience.
The findings of this research contribute to advancing the understanding of shear wall systems in high-rise construction and their role in enhancing earthquake resilience. Practical implications include informing building codes and design standards to better accommodate seismic risks, thereby promoting safer and more resilient urban environments. Ultimately, this study aims to contribute towards ensuring the structural safety and longevity of tall buildings in earthquake-prone regions through informed engineering practices and robust seismic assessment methodologies.

2. Objectives

1. Evaluate the efficacy of shear walls in mitigating seismic forces.
2. Utilize seismic analysis techniques within STAAD Pro software for comprehensive building assessment.
3. Analyze key parameters including displacement, torsion, and deflection.

3. Methodology

Various Indian Standard Codes such as IS 1893:2016 (Part 1) and IS 456:2000 were referenced for design purposes. Architectural plans and dimensions of beams and columns were obtained from a construction site of a multistorey building for analysis and design.
The following data was used for modeling the RC framed building:

- Structure Type: Residential and Commercial Building
- Number of Stories: 50
- Seismic Zone: Zone 4
- Floor Height: 3 meters
- Column Size: 700 mm X 500 mm
- Beam Size: 500 mm X 500 mm
- Slab Thickness: 150 mm
- Masonry Wall Thickness: 150 mm
- Live Load: 4.5 kN/m^2
- Floor Finish Load: 1.5 kN/m^2
- Soil Type: Type II (Medium Soil)
- Column Fixity: Assume all columns fixed at the base
- Concrete Characteristic Compressive Strength (f_{ck}): 50 N/mm^2
- Steel Grade: 500 N/mm^2
- Modulus of Elasticity of Concrete: 20000 N/mm^2
- Concrete Density: 26 kN/m^3
- Density of Brick Masonry (ρ): 19.4 kN/m^3
- Poisson's Ratio of Concrete (μ): 0.3
- Modulus of Elasticity of Brick Masonry: 14100 N/mm^2
- Poisson's Ratio of Brick Masonry: 0.2
- Damping Ratio: 5%

4. Result & Discussion

A. Following are the steps used for modelling

- Prepare the grid lines in STAAD Pro.
- Define materials such as concrete and steel.
- Specify frame sections for beams, columns, shear walls, and slabs.
- Design properties for beams, columns, slabs, and shear walls.
- Define load cases including Dead load, Live load, Wind loads, and Seismic loads.
- Assign support conditions as fixed and proceed with model analysis.

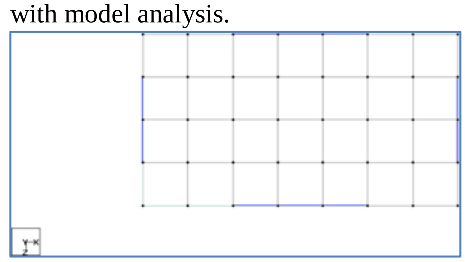

Fig. 1 Grid Plan of Building

B. Load Bearing Shear Wall

The RCC LBSW (Reinforced Concrete Load Bearing Shear Wall) system differs significantly from conventional framed systems, whether with or without shear walls, primarily due to its extensive use of load-bearing walls. These longer, stiffer walls enhance the structure's ability to withstand lateral loads, ensuring that well-detailed RCC LBSW systems deliver buildings with superior rigidity and satisfactory ductility. Many structures employing RCC LBSW systems have demonstrated exceptional performance globally during natural disasters, maintaining expected structural integrity and ensuring life safety.

Step-1: Modeling: Considering the structure type, modeling was conducted using the Geometry and Structural Wizard tool.
Step 2: Nodal Point Generation: In accordance with the column placement plan, respective nodal points have been created on the model.
Step 3: Shear Wall Surface: Shear walls are designed by using the Add Surface tool at specified locations.
Step 4: Property Definition: Properties are defined using the General-Property command in STAAD Pro to meet size requirements for beams and columns.
Step 5: Support and Member Property Creation: Supports are assigned as fixed under each column after defining column properties, selected using the Node Cursor. Cross-sections are assigned based on load calculations and property definitions.
Step 5: 3D Rendering: A 3D view of the structure can be displayed using the 3D Rendering command after assigning member properties.
Step 6: Load Assignment:

i. Dead Load: The dead load consists of the weight of walls, partitions, floor finishes, false ceilings, floors, and other permanent constructions in the building. Dead loads are estimated based on member dimensions and unit weights. Unit weights for plain and reinforced concrete are assumed as 50 kN/m³. According to IS:1893 (Part 1)-2016, dead loads are assigned based on member loads, floor loads, and self-weight of beams.

ii. Live Load: As per IS:875 (Part 2)-1987, a live load of 4.5 kN/m is assigned to the members.

iii. Seismic Load: Seismic loads are defined according to IS:1893 (Part 1): 2016 requirements. Seismic loads are assigned in +X, -X, +Z, and -Z directions with appropriate seismic factors.

iv. Load Combination: Required load combinations for seismic analysis are assigned based on specified loading combinations from Indian standard CODES, also available in STAAD-Pro.

Step 7: Structural Analysis in STAAD-Pro: After adding Analysis/Print commands, the structure is analyzed using the Run Analysis command. Detailed studies of forces and bending moments are conducted in Post Processing mode to evaluate shear forces and bending moment diagrams for structural safety.
Step 8: Structure Design in STAAD-Pro: Design follows IS 456:2000 guidelines for RCC. M50 concrete and Fe500 steel are used with a specified 1.2% steel percentage as per IS Code standards. Design parameters are assigned to each beam and column to finalize the design.
Step 9: Output Generation: An output file is generated containing the structural designs for each individual beam and column member of the structure.

Table 1 Zone Factor, Z

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

The STADD-Pro plan and model for the considered G+49 building is shown below.

- The building plan is of size 20m x 25m.
- Height of the building (h) = 150 m
- Width of the building (dx) = 25 m
- Width of the building (dz) = 20 m

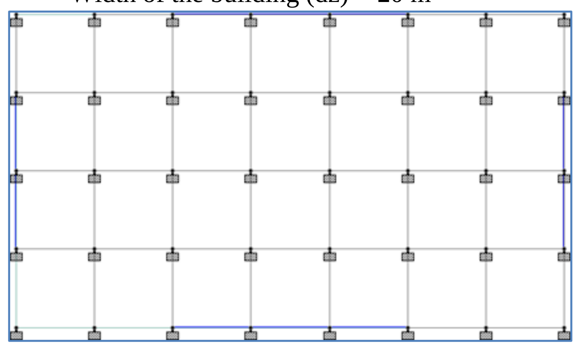

Fig. 2 STAAD Plan

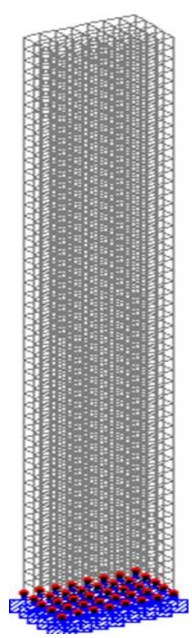

Fig. 3 STAAD Model

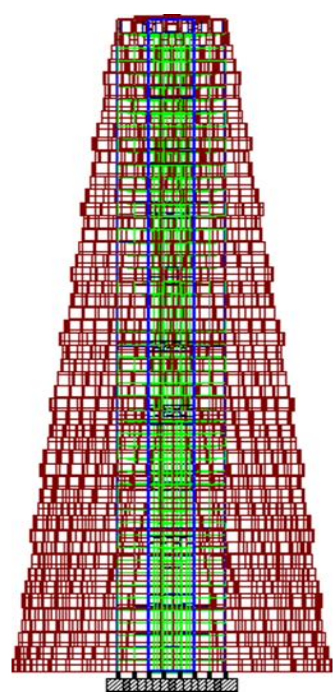

Fig. 4 Axial Force

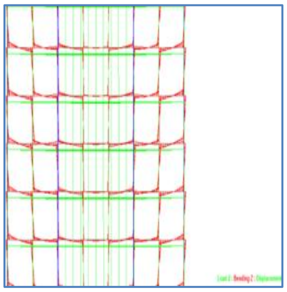
Fig. 5 Bending

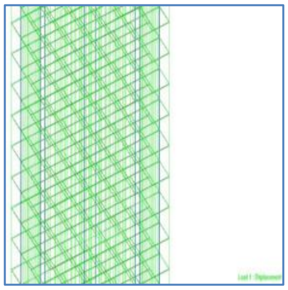
Fig. 6 Displacement

With Ta = 3.02 seconds,

$\frac{Sa}{g} = 4.5$,

Load Factor = 1, and Ah = 0.0308, the fundamental period of vibration for the building is calculated to ensure its seismic resistance. These parameters are input into STAAD-Pro for seismic analysis of the structure located in Zone IV. The seismic forces are computed based on these inputs, representing the earthquake force acting on the structure.

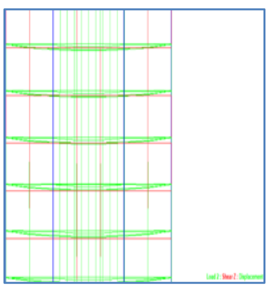
Fig. 7 Shear in Z direction

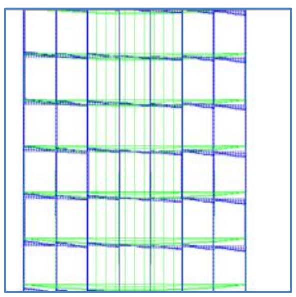
Fig. 8 Shear in Y direction

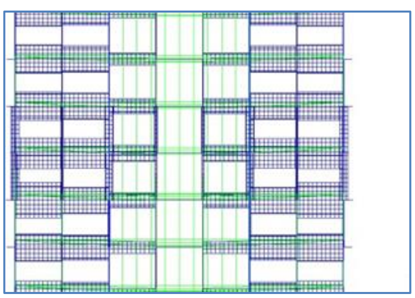
Fig. 9 Torsion

5. Conclusion

Based on the seismic assessment conducted on a twenty-story multistory structure with shear wall support, and the analysis of shear wall effects on a multi-story RC framed building, the following conclusions are drawn:
The integration of shear walls in RC framed structures proves highly effective in enhancing seismic resistance. The seismic analysis revealed that buildings with shear walls exhibit superior ability to withstand earthquake-induced forces compared to bare frame structures. This is evidenced by significantly reduced maximum displacements, indicating enhanced structural stability and safety during seismic events.
Furthermore, the study highlighted the robust capabilities of STAAD.Pro software in accurately predicting reinforcement requirements and evaluating structural responses under dynamic loads. The software's versatility in performing static and dynamic analyses ensures comprehensive assessments that are essential for designing earthquake-resistant structures.
In summary, shear walls play a crucial role in stiffening RC framed buildings against seismic forces, thereby mitigating lateral deflections and enhancing overall structural integrity. This underscores their importance in seismic design practices, offering a reliable solution for safeguarding buildings and ensuring occupant safety during seismic events.

References

[1] Seventekidis, P. et al. (2023). "Model Error Effects in Supervised Damage Identification of Structures with Numerically Trainged Classifiers." Mechanical Systems and Signal Processing.
[2] Xu, S. et al. (2021). "PhyMDAN: Physics-Ingformed Knowledge Transfer Between Buildings for Seismic Damage Diagnosis Through Adversarial Learning." Mechanical Systems and Signal Processing.
[3] Soleimani-Babakamali, M.H. et al. (2022). "A System Reliability Approach to Real-Time Unsupervised Structural Health Monitoring Without Prior Ingformation." Mechanical Systems and Signal Processing.
[4] Fan, G. et al. (2021). "Data-Driven Structural Dynamic Response Reconstruction Using Segment-Based Generative Adversarial Networks." Engingeering Structures.
[5] Tsialiamanis, G. et al. (2022). "On Application of Generative Adversarial Networks for Nonlingear Modal Analysis." Mechanical Systems and Signal Processing.
[6] Martakis, Panagiotis et al. (2023). "Fusing Damage-Sensitive Features and Domaing Adaptation Towards Robust Damage Classification in Real Buildings." Soil Dynamics and Earthquake Engingeering.
[7] Hwang, Seong-Hoon et al. (2018). "Nonmodel-Based Framework for Rapid Seismic Risk and Loss Assessment of Ingstrumented Steel Buildings." Engingeering Structures.
[8] Eftekhar Azam, S. et al. (2018). "Onlinge Damage Detection in Structural Systems via Dynamic Ingverse Analysis: A Recursive Bayesian Approach." Engingeering Structures.
[9] Kusunoki, K. et al. (2018). "A New Method for Evaluating Real-Time Residual Seismic Capacity of Existing Structures Using Accelerometers: Structures

with Multiple Degrees of Freedom." Japan Architect Review.

[10] Pan, H. et al. (2018). "A Wavelet Transform-Based Capacity Curve Estimation Approach Using Seismic Response Data." Structural Control and Health Monitoring.