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DESIGN AND ANALYSIS OF SESIMIC RESISTANCE MULTISTORIED BUILDING

P. Akanksha Meher[1], K. Shiva Kumar[2], V. Niteesh Kumar[3], K. Naveen Kumar[4], L. Sai[5]

Department of Civil Engineering, GMR Institutes of Technology, Rajam, India-532127

ABSTRACT:

This study focuses on the analysis and design of a G+6 earthquake-resistant residential building using STAAD.Pro, adhering to IS 1893:2016 and IS 13920:2016. By applying Response Spectrum Analysis, the dynamic behaviour of the structure during earthquakes is evaluated, while load combinations including dead, live, wind, and seismic loads are considered. Key structural components like beams, columns, slabs, and shear walls are analysed for strength, stiffness, and ductility, with emphasis on proper load transfer mechanisms, ductile detailing, and structural integrity. The study highlights STAAD.Pro's efficiency in simplifying complex calculations and optimizing designs for seismic resilience, offering practical insights for civil engineers in creating earthquake-resistant structures.

Keywords: Base shear, Bending moment, Shear force, Drift ratio, Response reduction factor

Introduction:

The rapid urbanization and increasing population have amplified the demand for multi-storied residential buildings, particularly in seismically active regions. Earthquake-resistant design has become critical in civil engineering to ensure safety and minimize damage. Modern structures integrate seismic analysis to counter dynamic loads caused by earthquakes, emphasizing stiffness, strength, ductility, and energy dissipation. Codes like IS 1893:2016 and IS 13920:2016 regulate such designs, promoting the use of shear walls, braced frames, and moment-resisting frames for effective seismic resistance. STAAD.Pro plays a pivotal role by offering advanced tools for 3D modelling, dynamic analysis, and code-compliant designs, simplifying calculations and enhancing seismic performance. This study aims to analyse and design a G+6 RCC residential building in a high seismic zone using STAAD.Pro, focusing on safety, stability, and compliance with Indian standards, thus contributing to safer urban infrastructure.

Literature review:

- This research examines the seismic analysis and design of a G+6 residential building across different seismic zones of India using STAAD.Pro. It highlights how structural response varies with seismic intensity, demonstrating an increase in base shear from Zone II to Zone V, particularly in mass irregular structures. Key findings include significant rises in shear force and bending moments under higher seismic loads, while drift ratios were minimized by incorporating stiff columns or infill panels. Stored shear was most concentrated at lower floors, diminishing toward the upper levels. Steel percentage ranged from 0.9% to 2.5% for exterior and edge columns, and 1.13% to 2.01% for interior columns, ensuring stability and compliance with seismic demands. The study underscores STAAD.Pro's ability to model and analyse structural behaviour effectively under varying seismic conditions.
- This study focuses on the seismic analysis and design of a G+21 earthquake-resistant RCC building in Lucknow, situated in seismic Zone III. ETABS software was employed for structural modelling and analysis, incorporating gravity and lateral seismic loads. Base shear was calculated using the IS 1893 formula, distributed across stories based on mass and height. Bending moments and shear forces for beams and columns were evaluated using both dynamic and static methods. Additionally, drift ratios and story displacements were verified to comply with permissible limits, ensuring the building's safety and serviceability under seismic conditions.
- This study investigates the seismic analysis and design of a G+4 residential building situated in Zone IV, using ETABS software and adhering to IS 1893:2002 and IS 456:2000 standards. Seismic loads were applied considering medium stiff soil and a Response Reduction Factor of 3.0. The analysis revealed a maximum shear force of 93.8 kN and maximum bending moment of 79.5 kNm, both concentrated at the top floor. Although drift ratios weren't explicitly specified, lateral forces were observed to increase progressively from the bottom to the top floors. Structural components were economically optimized by adjusting column sizes during the design process, ensuring compliance with seismic demands and cost efficiency.
- This study explores the seismic analysis of a G+5 RCC building in Zone V, India's highest seismic risk zone, using STAAD.Pro software. It compares the performance of structures with and without shear walls placed at different positions. Findings revealed that including shear walls significantly reduced maximum base shear, bending moments, and shear forces while improving drift ratios. Among the designs, buildings

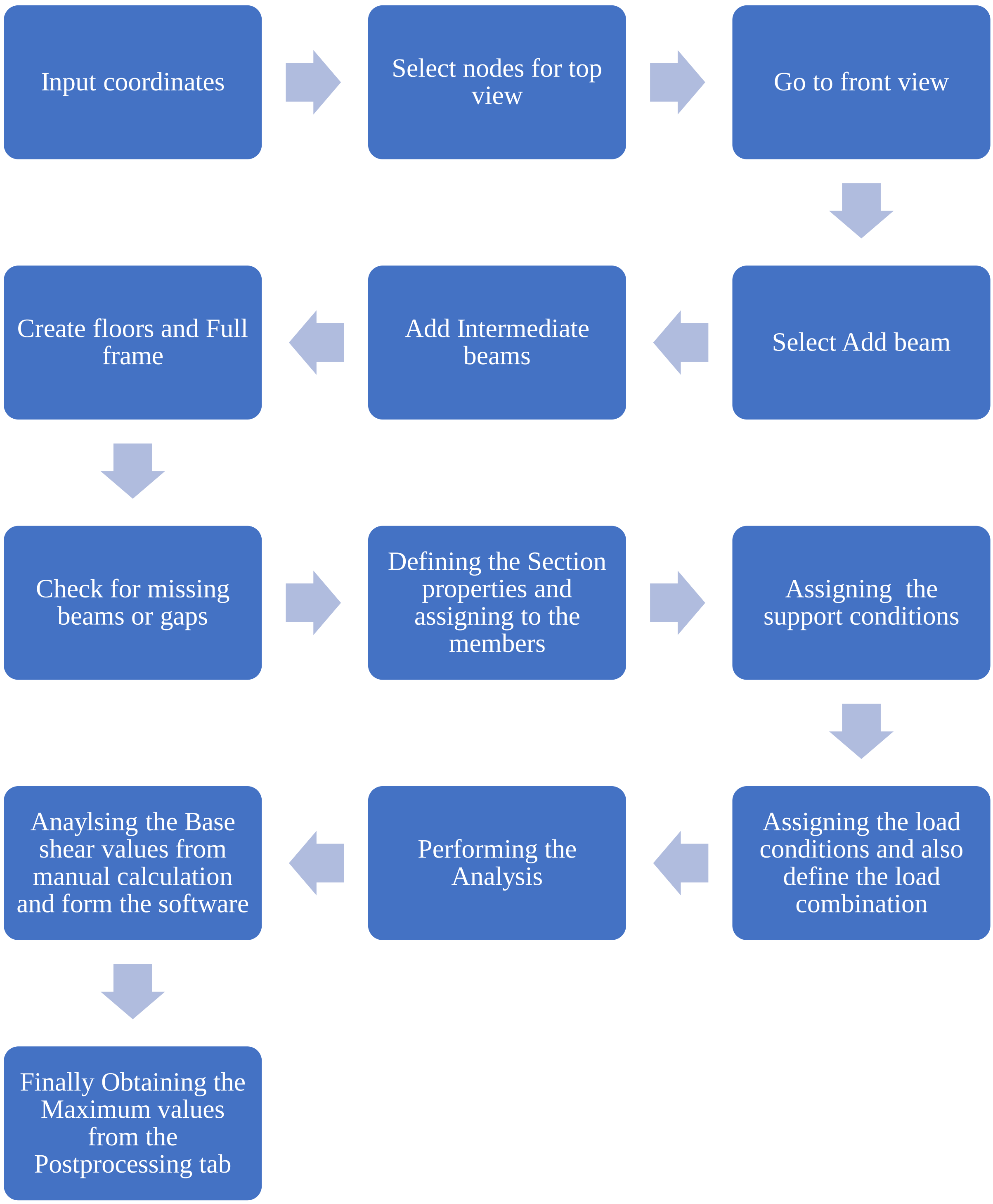
with shear walls at intermediate locations exhibited the least displacement, highlighting the critical role of strategic shear wall placement in enhancing seismic resilience.

- This study focuses on the seismic analysis of a G+5 RCC building in Zone V, the region with the highest seismic intensity in India, using STAAD.Pro software. It evaluates the performance of structures with and without shear walls at various positions. Results revealed that maximum base shear was significantly higher in buildings without shear walls and decreased considerably when shear walls were introduced. The inclusion of shear walls also reduced bending moments and shear forces while improving drift ratios. Structures with shear walls at intermediate positions demonstrated the least displacement, underscoring the critical role of strategically positioned shear walls in enhancing seismic resilience.

Methodology: -

This study evaluates the seismic performance of a six-story reinforced concrete (RC) building using structural analysis software. It focuses on key parameters such as base shear, story drift, lateral stability, and dynamic response. The analysis follows IS 1893:2016 seismic design guidelines. Software-based modelling enhances precision, efficiency, and real-time analysis in structural engineering. The study also emphasizes the importance of load combinations, response reduction factors, and proper detailing. It serves as a practical guide for civil engineering students and professionals in earthquake-resistant design.

Procedural Flow chart for this project



Building Configuration: -

Parameters	Details
Structure type	RC Moment resisting frame
Number of stories	6(Ground + 5 Floors)
Total Height	18 meters
Story Height	3 meters per floor
Plan dimension	15 meters x 10 meters
Seismic zone	Zone III
Soil Condition	Medium soil (Type II as per IS 1893)
Concrete Grade	M25
Steel Grade	Fe 500
Lateral load system	Moment Resisting frame (no shear walls)

Details of the building

Load Considerations: -

Load combinations are vital in seismic design to ensure structural safety under extreme conditions. As per IS 456:2000 and IS 1893:2016, they involve combinations of dead, live, and earthquake loads. Typical combinations like 1.5(DL+LL), 1.2(DL+LL±EL), and 0.9DL±EL account for both vertical and lateral forces. Earthquake loads are applied in both directions (±X, ±Y) to capture worst-case scenarios. Software like STAAD.Pro automates these combinations, including effects like accidental eccentricity. These combinations help design structural elements to resist seismic forces safely and efficiently.

Seismic Parameters Based on IS 1893:2016: -

Accurate definition of seismic parameters is essential for predicting building response during earthquakes. IS 1893:2016 specifies key factors like Zone Factor (Z), Importance Factor (I), Response Reduction Factor (R), and Soil Type. The design horizontal seismic coefficient (Ah) is calculated using Ah = (Z/2) × (I/R) × (Sa/g), where Sa/g depends on the time period (T) and soil type. Base Shear (Vb) is then derived as Ah × W (seismic weight). Parameters like accidental eccentricity and bidirectional loading (+X/–X, +Y/–Y) are also considered. Software automates these inputs for static and dynamic analysis, ensuring safe seismic design.

Results:

The seismic analysis of a six-story residential building in Zone III revealed significant lateral forces, with a maximum base shear of 1214.72 kN, story displacement of 9.51 cm, and bending moments of 28024.26 kN-m. Although within permissible limits, the lack of lateral load-resisting systems increases vulnerability. Recommendations include adding shear walls, bracings, and moment-resisting frames, adhering to IS codes for ductile detailing, and strengthening foundations to improve seismic resilience and ensure safety during earthquakes.

Conclusion:

The analysis underscores that while the six-story residential building in Zone III performs reasonably under seismic loading, significant improvements are necessary to enhance its resilience. The absence of lateral load-resisting systems like shear walls or bracings results in substantial base shear, bending moments, and lateral displacements, which could lead to potential instability. Incorporating shear walls, bracings, and ductile detailing, alongside advanced strategies like dampers or base isolation techniques, would mitigate seismic impact and ensure structural safety. Future designs should prioritize these measures to reduce vulnerability and guarantee serviceability during major earthquakes.

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