Comparative Study of Earthquake Resistant Buildings Using Staad-Pro Software

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Abstract— The vulnerability of buildings to seismic activity remains a critical concern in regions prone to earthquakes. Engineering interventions aimed at enhancing the earthquake resistance of structures are paramount for minimizing casualties and economic losses. This study presents a comparative analysis of earthquake-resistant buildings of varying heights, employing the powerful structural analysis tool, STAAD-PRO software. The research focuses on assessing the structural performance of buildings subjected to seismic loads across different heights. Various structural parameters such as base shear, inter-story drift, and displacement are evaluated to gauge the effectiveness of earthquake-resistant design strategies. The analysis considers buildings with heights ranging from low-rise to high-rise structures, reflecting real-world scenarios encountered in seismic-prone regions. The methodology involves modeling the buildings using STAAD-PRO, a widely-used software for structural analysis and design. Different earthquake loadings corresponding to various seismic zones are applied to simulate realistic seismic events. By systematically altering building heights and configurations, the study aims to elucidate the impact of height on structural response and seismic performance. Furthermore, the study investigates the efficacy of different earthquake-resistant design techniques such as shear walls, bracings, and damping systems in mitigating seismic forces. Comparative assessments are made to identify optimal design strategies for structures of varying heights, considering factors such as construction cost, material utilization, and architectural constraints. The outcomes of this research provide valuable insights into the behavior of earthquake-resistant buildings under seismic loading conditions, especially concerning the influence of building height on structural response. The findings aim to contribute to the development of more robust and resilient building designs, thereby enhancing the safety and sustainability of structures in earthquake-prone regions.

Index Terms- Earthquake resistant buildings, STAAD-PRO software, Structural analysis, Seismic performance, Building height, Base shear, Inter-story drift, Seismic loads, Design strategies, Resilient structures

I. INTRODUCTION

Earthquakes pose significant threats to the safety and stability of buildings, particularly in regions prone to seismic activity. In response to this challenge, engineers and researchers continually strive to develop innovative design techniques and materials to enhance the earthquake resistance of structures. This project aims to contribute to this ongoing effort by conducting a comparative study of earthquake-resistant buildings using STAAD-PRO software, focusing specifically on how varying building heights influence structural performance.

The height of a building plays a crucial role in its response to seismic forces. As buildings increase in height, they become more susceptible to lateral loads induced by earthquakes, presenting unique challenges in terms of structural design and stability. Understanding how different design strategies perform under seismic loading conditions across various building heights is essential for developing effective and reliable seismic-resistant structures.

STAAD-PRO is a widely-used software tool in the field of structural engineering, renowned for its robust capabilities in simulating complex structural behavior under different loading scenarios. By leveraging the power of STAAD-PRO, this project seeks to conduct comprehensive structural analyses of buildings with varying heights, evaluating key parameters such as base shear, inter-story drift, and displacement.

The comparative study will involve modelling buildings of different heights and configurations, simulating realistic seismic events corresponding to various seismic zones. Through systematic analysis and evaluation, the project aims to identify optimal earthquake-resistant design strategies that balance structural integrity, construction cost, and architectural considerations.

The outcomes of this research are expected to provide valuable insights into the behaviour of earthquake-resistant buildings under seismic loading conditions, particularly in relation to building height. By elucidating the strengths and limitations of different design approaches, the project aims to contribute to the development of safer, more resilient structures capable of withstanding seismic hazards, thereby enhancing the overall resilience of communities in earthquake-prone regions.

II. OBJECTIVES

1. Evaluate seismic loads and conduct calculations for buildings of different heights (G+4, G+6, and G+8) using STAAD-PRO software.
2. Compare the structural components of buildings at different heights (G+4, G+6, and G+8) to assess variations in design requirements and material usage.
3. Compare the shear forces (SF) and bending moments (BM) experienced by structural elements in buildings of varying heights (G+4, G+6, and G+8) under seismic loading conditions.
4. Conduct a comparative study of lateral displacement across buildings of different heights (G+4, G+6, and G+8) to analyze the structural response to seismic forces.

III. METHODOLOGY WORK STUDY

Linear Methodology:
1. Linear analysis is primarily used for static and dynamic structural analysis where material and geometric behaviour remains within the linear elastic range.
2. It assumes that material properties (e.g., Young's Modulus) do not change with the applied load, and displacements are directly proportional to loads. Linear analysis is suitable for most common structural design tasks, such as calculating forces, deflections, and stresses in buildings, bridges, and other structures.
3. It provides quick and relatively straightforward results for typical structural problems.

Nonlinear Methodology:
1. Nonlinear analysis is used when structural behaviour deviates from linear elastic assumptions, such as large deformations, material yielding, or geometric nonlinearity.
2. There are different types of nonlinear analyses, including geometric nonlinearity (large deformations), material nonlinearity (plasticity), and boundary condition nonlinearity (e.g., support settlements).
3. Nonlinear analysis is crucial for studying the behaviour of structures under extreme loads, like earthquakes or impact loads, and for designing structures with complex geometries.

Hence by studying both methods we decided to adopt Non-Linear Method for the structural analysis which is commonly used for earthquake analysis or seismic analysis.

IV. SPECIFICATIONS

Specifications of G+3 Residential Building:
A) Properties of Materials:
- Grade of concrete= 20 MPa
- Grade of steel= 415 MPa

B) Specifications of Beam:
- Primary Beam: 380mm X 230mm

C) Secondary Beam: 600mm X 300mm
- Specifications of Column:
- Centre Columns: 380mm X 230mm

D) Specifications of Slab:
- Floor Slab: 150mm
- Waist Slab: 150mm

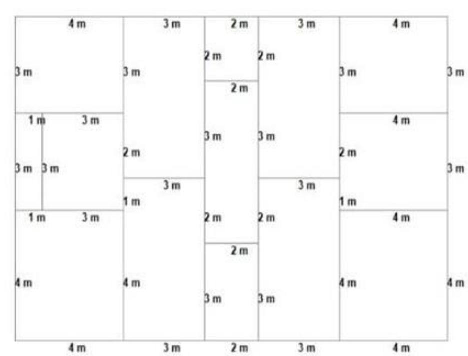

Fig 1: Plan

V. RESULTS

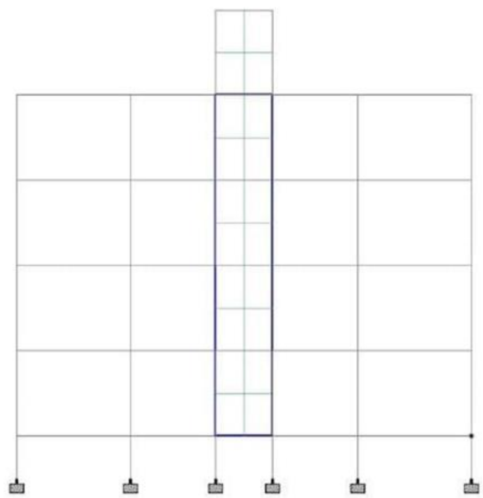

Fig 2: Section A-A

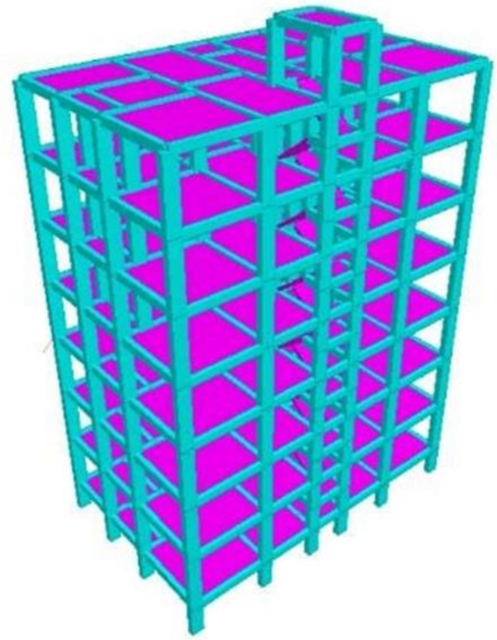

Fig 4: Modelling of G+6

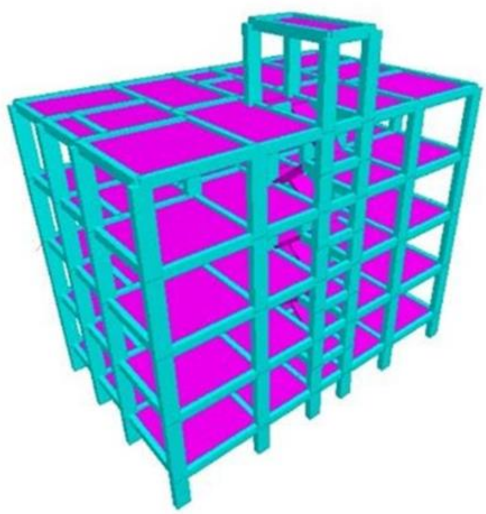

Fig 3: Modelling of G+4

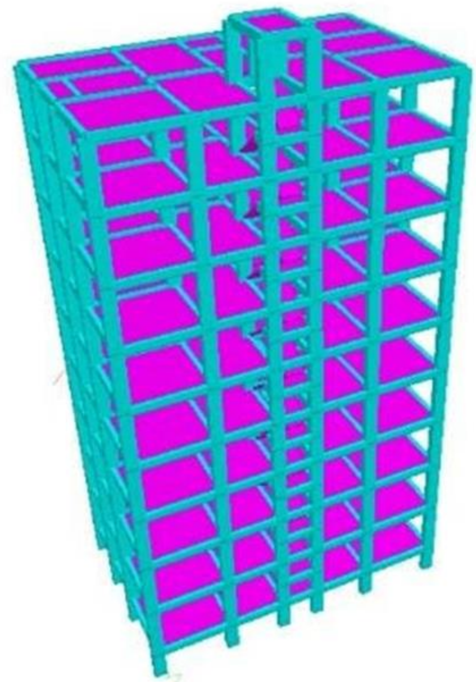

Fig 5: Modelling of G+8

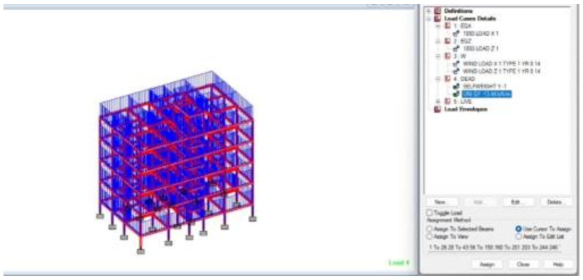
Fig 6: Detailing of G+4

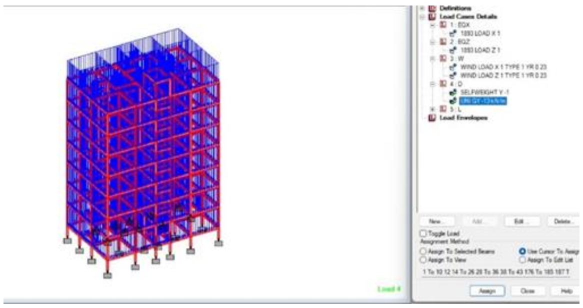
Fig 7: Detailing of G+6

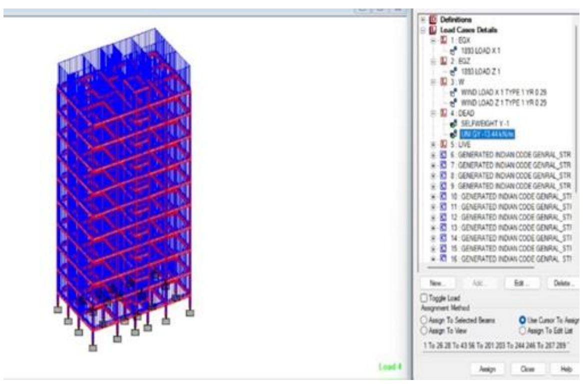
Fig 8: Detailing of G+8

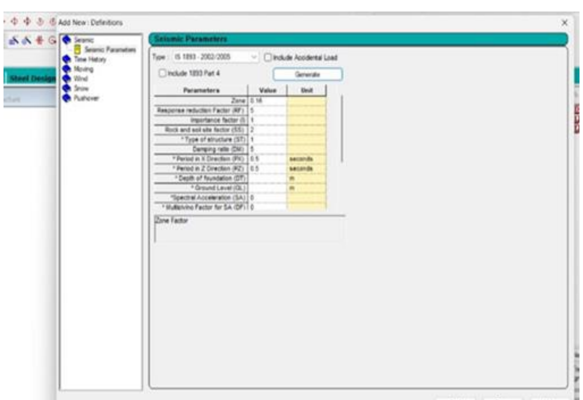
Fig 9: Foundation Design

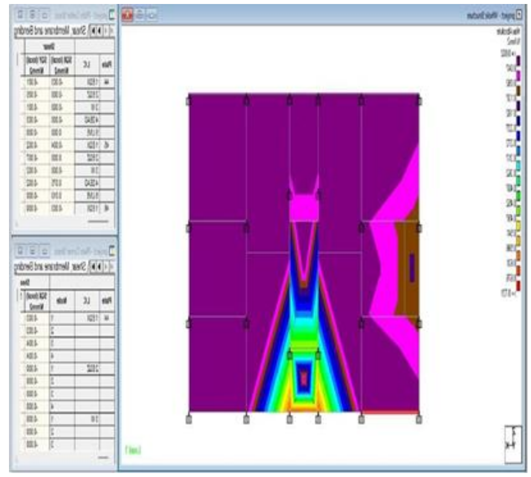
Fig 10: Slab Design For G+4

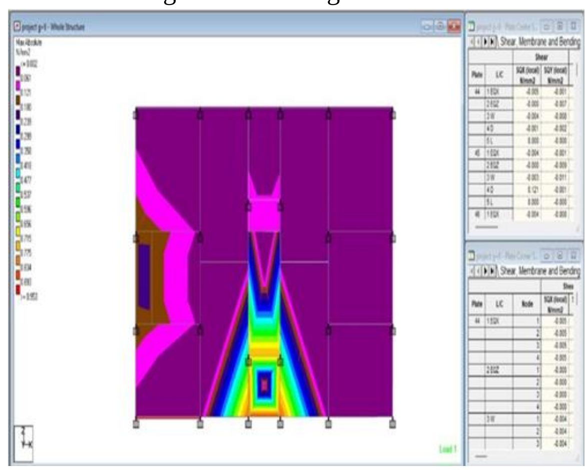
Fig 11: Slab Design For G+6

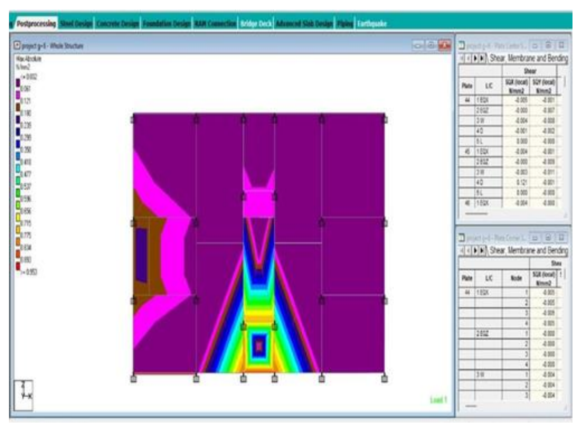
Fig 12: Slab Design For G+8

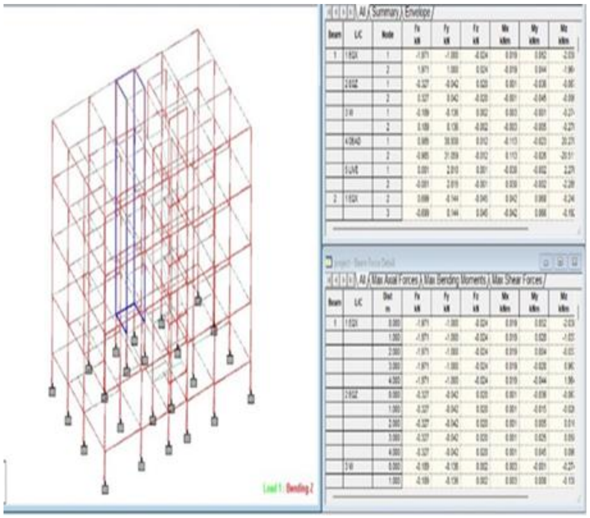

Fig 13: Beam Column Design For G+4

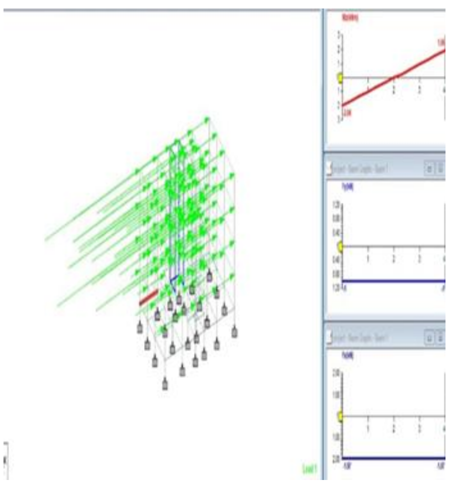

Fig 14: Beam Column Design For G+6

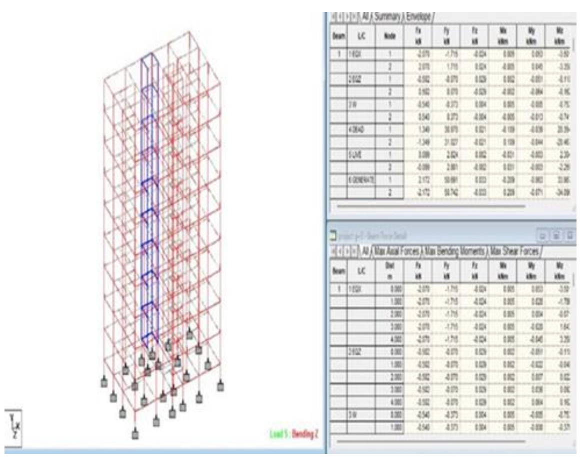

Fig 15: Beam Column Design For G+8

CONCLUSON

The comparative study utilizing STAAD-PRO software has provided invaluable insights into the seismic performance of buildings across varying heights. Through meticulous analysis and simulation, several key conclusions have been drawn, shedding light on effective strategies for enhancing earthquake resistance in structural design.

1. Height Dependency of Seismic Response: The study revealed a clear correlation between building height and seismic vulnerability. Taller structures exhibited amplified dynamic responses, necessitating tailored design approaches to mitigate seismic risks effectively.

2. Importance of Rigorous Analysis: STAAD-PRO's sophisticated analysis capabilities enabled comprehensive examination of structural behavior under seismic loading conditions. By simulating realistic earthquake scenarios, the software facilitated accurate prediction of critical parameters such as displacement, acceleration, and inter-story drift, crucial for informed decision-making in design optimization.

3. Role of Structural Systems: Various structural systems, including moment-resisting frames, shear walls, and braced frames, were evaluated for their efficacy in resisting seismic forces. The study highlighted the importance of selecting appropriate lateral load-resisting systems based on building height, soil conditions, and architectural constraints.

4. Influence of Material Properties: Material properties, such as concrete strength, steel reinforcement detailing, and damping characteristics, significantly influenced structural response to seismic excitation. Optimal material selection and detailing emerged as pivotal factors in enhancing the seismic performance of buildings, especially in high-seismicity zones.

5. Integrated Design Approach: The study underscored the importance of adopting an integrated design approach that considers not only structural robustness but also architectural, geotechnical, and constructional aspects. Collaboration between architects, structural

engineers, and geotechnical experts is essential for developing holistic seismic-resistant solutions that balance safety, functionality, and aesthetics.

6. Continued Research and Innovation: While the study provides valuable insights, further research is warranted to explore emerging technologies and innovative design strategies for advancing earthquake resilience. Incorporating advanced analysis techniques, such as performance-based design and nonlinear dynamic analysis, can enhance the accuracy and reliability of seismic assessments.

In conclusion, the comparative study using STAAD-PRO software underscores the critical role of advanced computational tools in advancing earthquake engineering practices. By systematically analyzing the seismic performance of buildings across varying heights, the study contributes to the development of robust and resilient structural design methodologies, ultimately fostering safer built environments in seismic-prone regions.

REFERENCES

[1] Kuthe, B., &Budhlani, D. L. (2018). Performance Based Seismic Analysis and Design of RC Structures. Academia.Edu,3(7), 16–20.

[2] Conference, I., Energy, O. N., & Safety, I. (2018). Salvatio ’ 18

[3] Pisode, M., Surana, M., Haldar, P., & Singh, Y. (2017). Comparative Assessment of Seismic Fragility of Rc Frame Buildings Designed for Older and Revised Indian Standards; ISET Journal of Earthquake Technology, 54(534), 17–29.

[4] Mathew, C. C., & Pp, A. (2017). An analytical study of linked column frame system in multi storey multi bay RC building. International Research Journal of Engineering and Technology (IRJET), 4(6).

[5] Pradeep, S., &Kunal, P. (2017). Analytical study of seismic behaviour of RCC frame with short column effect. International Journal of Civil Engineering and Technology, 8(3), 362–372.

[6] Jain, S. K. (2016). Earthquake safety in India: achievements, challenges and opportunities. Bulletin of Earthquake Engineering, 14(5), 1337–1436.

[7] Joel Shelton, J., &Hemalatha, G. (2016). Behavior of linked-column system subjected to seismic force. Indian of Science and Technology, 9(6)

[8] Singh, S. B. (2015). A review on the existing seismic resistant construction techniques. 3(12), 59–68.

[9] Swapnil U. Rathod, Prof. P R. Barbude (2020); Seismic Assessment Of Existing Multistory Building by Non Linear Analysis

[10] Hardik M. Gohil Jignesh A. Amin (2018); Assessment of Seismic Damage Indices for RC Frame Building Using Non Linear Static Analysis

[11] Baraskar, N. B., & Kawade, P. U. R. (2015). Structural Performance of RC Structural wall system over conventional Beam Column System in G + 15 storey Building. 3(4).

[12] Jain, S., & ... (2005). Proposed Draft Provisions and Commentary on Ductile Detailing of RC Structures Subjected to Seismic Forces. Report IITKGSDMA-EQ, 1–63.

[13] Jain, S., & ... (2005). Proposed Draft Provisions and Commentary on Ductile