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Performance Evaluation of G+20 Rcc Structures: A Static and Seismic Analysis Using Etabs Software

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***Abstract:** The structural design of high-rise buildings, particularly those using reinforced cement concrete (RCC), requires meticulous evaluation under various loading conditions to ensure safety and functionality. This study delves into the static and seismic performance of a G+20 RCC framed structure using ETABS software. The research examines the impact of different loads on the structure, focusing on displacement, shear force, and bending moment. By integrating seismic analysis into the design process, the study highlights the resilience of RCC structures against dynamic forces and provides a comprehensive understanding of structural behavior under extreme conditions.*

***Keywords:** RCC Framed Structure, Static Analysis, Seismic Analysis, ETABS, High-Rise Buildings, Structural Performance.*

1. INTRODUCTION

Urbanization has led to an increasing demand for high-rise buildings, particularly in densely populated cities where space is limited. These structures not only require careful planning and design but also need to be resilient against various forces that they will encounter throughout their lifespan. Reinforced Cement Concrete (RCC) has become a preferred material in high-rise construction due to its excellent compressive strength and durability. However, designing structures that are both safe and economical remains a significant challenge, particularly when considering the impact of seismic activities.

This study explores the performance of a G+20 RCC framed structure under both static and seismic loads, utilizing ETABS software for a detailed analysis. By evaluating the structure's response to these forces, the research aims to provide insights into the necessary design considerations that ensure safety, stability, and structural integrity in high-rise buildings.

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Objectives

The primary objectives of this research are: Static Performance Analysis: To analyze the static performance of the G+20 RCC framed structure, focusing on key structural parameters such as displacement, shear force, and bending moment. Seismic Performance Evaluation: To evaluate the seismic performance of the structure, considering the building's location in a high-risk seismic zone, and to assess its resilience against dynamic forces. Comparison of Load Impacts: To compare the impact of static and seismic loads on the structural integrity, identifying potential areas of improvement in the design. Design Optimization: To propose design optimizations based on the findings, enhancing the overall safety and performance of the structure.

2. RELATED WORK

This literature review summarizes relevant studies, codes, and guidelines to provide a comprehensive understanding of the analysis, design, and seismic behavior of multi-story reinforced cement concrete (RCC) buildings, with a specific focus on using ETABS software for structural performance evaluation. It explores the methodologies, techniques, and outcomes discussed in various papers, highlighting the importance of seismic analysis, static load assessment, and the role of ETABS in optimizing designs.

Reddy and Kumar (2017) analyzed G+30 high-rise structures using ETABS to evaluate their performance across Zones IV and V, which are classified as high-seismic regions in India. The study explored the impact of different frame sections on the stability and performance of tall structures under varying seismic intensities. Their findings emphasize the importance of selecting appropriate structural systems for enhanced seismic performance, which aligns with the requirements of IS 1893 (2002) for earthquake-resistant design in multi-story buildings【1】.

Gopal and Lingeshwaran (2017) focused on the analysis and design of G+5 residential buildings using ETABS, demonstrating the software's capability to handle both gravity and lateral loads effectively. The study also highlights the importance of load combinations in designing safe and economical structures, referring to the IS 875 (1987) standards for dead and live loads【2】.

Mallkarjun and Prakash (2016) discussed an optimized column design approach for a multi-storied building (UNG-2+G+10) to minimize material costs while maintaining structural safety. Their study provides valuable insights into the benefits of using advanced design strategies and tools like ETABS to ensure economic feasibility. This research is relevant to G+20 structures, where the efficient use of materials and optimized load distribution are critical for cost-effective construction【3】.

Bhandarkar, Ratanpara, and Qureshi (2016) performed seismic analysis using ETABS on multi-story buildings. Their research highlighted the significance of designing for seismic loads, especially in regions prone to earthquakes. The study emphasizes compliance with IS 1893 (2002) guidelines, which outline criteria for seismic design, and underscores the need for incorporating shear walls in high-rise structures to enhance lateral stability【4】【8】.

The work by Reddy, Prasad, and Rao on blast-resistant design techniques further emphasizes the robustness of ETABS in simulating various extreme loading conditions. The study serves

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as a useful reference for designing structures with enhanced resistance to dynamic loads, contributing to the safe design of tall RCC buildings under both seismic and blast conditions 【13】.

The design and analysis of RCC structures rely heavily on Indian Standards such as IS 456 (2000) and IS 875 (1987, 2015), which provide comprehensive guidelines for load calculations, structural stability, and material usage. IS 875 (2015) specifically addresses wind loads, which are critical in the design of high-rise buildings like G+20 structures. These codes ensure that structures can withstand both static and dynamic loads while maintaining structural integrity and serviceability【5】【6】【7】【9】.

Bhavikatti's (2015) Structural Analysis II and Krishnaraju's Design of Reinforced Concrete Structures provide essential theoretical foundations for analyzing RCC structures, supplementing practical ETABS-based studies with essential analytical insights【10】【11】. Furthermore, Agarwal and Shrikhande's Earthquake Resistance Design of Structures serves as a key resource for understanding seismic design concepts, which are indispensable for performance evaluation of multi-story buildings under earthquake conditions【12】.

Maheedhar et al. (2018) investigated the effect of shear walls in a G+12 building with two basements, demonstrating the significant impact of shear walls in resisting lateral forces. Their research underscores the importance of incorporating such elements into the design of high-rise buildings to improve seismic performance and reduce drift under lateral loads. This case study is relevant to G+20 structures, where lateral stability becomes increasingly important with height【14】.

Table -1 Literature Review

Reference	**Title/Study Focus**	**Objective**	**Methodology**	**Key Findings**	**Relevance to Current Study**
[1] A. Pavan Kumar Reddy, R. Master Praveen Kumar (2017)**	Analysis of G+30 high-rise buildings using ETABS for various frame sections in Zone IV and V	Assess impact of different frame sections on high-rise building stability in seismic zones	ETABS software used to analyze static and seismic performance in Zones IV & V	Seismic zones significantly influence building stability, requiring optimized structural systems	Useful for understanding structural behavior of G+20 buildings under different seismic intensities
[2] K. Naga Sai Gopal, N. Lingeshwaran (2017)**	Analysis and design of G+5 residential building using ETABS	Design and analyze a small-scale building considering static loads	ETABS modeling for dead and live load analysis, with load combinations	Proper load distribution is essential for structural safety and stability	Provides insights into load combinations relevant for multi-story design

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[3] M. Mallkarjun, Dr. P.V. Surya Prakash (2016)**	Economic design of multi-storied (UNG-2+G+10) building using optimized column method	Optimize material usage through column design techniques	ETABS software used with cost-effective column placement	Optimization reduces costs while maintaining safety	Highlights the need for material efficiency in G+20 structures
[4] R. Bhandarkar, U.M. Ratanpara, M. Qureshi (2016)**	Seismic analysis of multi-story buildings using ETABS	Analyze seismic performance of buildings	Seismic load simulations based on IS 1893 (2002)	Shear walls improve seismic resistance and reduce drift	Reinforces the importance of seismic evaluation in high-rise RCC buildings
[5] IS 456 (2000)**	Code of practice for plain and reinforced concrete	Provide guidelines for RCC design	Prescriptive codes for material strength, stability, and durability	Ensures structural integrity under static conditions	Forms the basis for RCC design
[6] IS 875 - Part 1 (1987)**	Code for design loads – Dead loads	Specify dead load values for structural design	Prescriptive standards for load calculations	Accurate dead load assessment is critical for stability	Forms part of the load combinations required in ETABS
[7] IS 875 - Part 2 (1987)**	Code for design loads – Imposed loads	Specify imposed load values	Guidelines for live load considerations	Accurate live load prediction ensures safety	Used for load combinations in ETABS analysis
[8] IS 1893 - Part 1 (2002)**	Criteria for earthquake-resistant design	Provide seismic load guidelines for structures	Prescriptive seismic design criteria	Essential for designing earthquake-resistant buildings	Critical for G+20 structures in seismic regions
[9] IS 875 - Part 3 (2015)**	Code for design loads – Wind loads	Provide wind load guidelines	Wind load calculation methods	Wind load becomes significant with height	Relevant for stability of tall G+20 structures
[10] S.S. Bhavikatti (2015)**	Structural Analysis II	Provide analytical methods for	Analytical models and case studies	Improves understandin	Supports theoretical background

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		structural analysis		g of load behavior	for ETABS analysis
[11] N. Krishnaraju	Design of Reinforced Concrete Structures	Provide design methods for RCC structures	Design principles and examples	Supports practical application of RCC design	Complements ETABS modeling with theoretical design
[12] P. Agarwal, M. Shrikhande	Earthquake Resistance Design of Structures	Provide insights into seismic design	Seismic load theories and design practices	Helps enhance seismic resistance of buildings	Guides earthquake-resistant design in ETABS
[13] P. Srikanth Reddy et al.	Blast-resistant design using ETABS	Analyze blast resistance of multi-story buildings	Blast simulations using ETABS	ETABS is effective in simulating extreme loads	Highlights ETABS's flexibility in various loading scenarios
[14] Maheedhar et al. (2018)**	Effect of shear walls in G+12 building with two basements	Investigate the impact of shear walls	Seismic analysis using ETABS	Shear walls significantly reduce lateral displacements	Supports use of shear walls in high-rise structures

3. METHODOLOGY

The methodology adopted for this research is systematic and structured, ensuring comprehensive coverage of both static and seismic analysis.

3.1 Structural Modeling

The initial phase of the research involved developing an accurate model of the G+20 RCC framed structure using ETABS software. The process included:
Plan Development: An architectural plan of the structure was developed using AutoCAD. This plan detailed the layout of the building, including the dimensions of the columns, beams, slabs, and other structural elements. The AutoCAD plan was then imported into ETABS to facilitate accurate modeling.

3.2 Material Definition

The properties of the materials used in the structure were defined according to the relevant Indian Standards (IS). The concrete was defined with a specific grade, considering its compressive strength, while the steel reinforcement was defined based on its yield strength. The material properties were critical in determining the structure's behavior under various loads.

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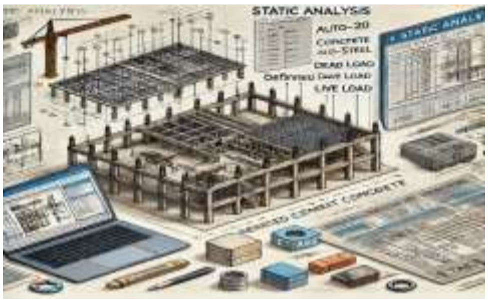

4.2 Load Application

To simulate real-world conditions, both static and seismic loads were applied to the structure.

Static Loads:
Dead Load: This included the self-weight of the structure, the weight of the walls, partitions, and other permanent components. The dead load was calculated as per IS 456:2000, ensuring that all permanent fixtures were accounted for in the analysis.
Live Load: Live loads were applied based on the intended use of the building. These loads represented the temporary forces exerted by occupants, furniture, and movable objects. The live load values were also determined according to IS 875.

Seismic Loads:
Seismic Forces: The structure was analyzed for seismic forces considering its location in a high-risk seismic zone. The seismic loads were applied based on the guidelines provided in IS 1893:2002. The response spectrum method was used to analyze the structure's response to seismic activity, considering various factors such as soil type, building height, and the structure's natural frequency.

3.3 Analysis Process
The analysis was carried out in two distinct phases, each focusing on different aspects of the structure's performance.
Phase 1 - Static Analysis: The first phase of the analysis involved evaluating the structure under static loads. The static analysis focused on:
Bending Moment: The bending moment distribution was assessed to understand how the structure would respond to the static loads applied.
Shear Force: The shear force distribution across the structure was analyzed to identify critical sections that may require additional reinforcement.
Displacement: The displacement of the structure, particularly at the top stories, was measured to ensure it remained within permissible limits.
Phase 2 - Seismic Analysis: In the second phase, the structure was subjected to seismic loads. The seismic analysis aimed to assess:
Base Shear: The total shear force at the base of the structure, which is critical in determining the building's stability during an earthquake.
Lateral Drift: The lateral displacement or drift of the structure under seismic loads, which is essential in ensuring the building's serviceability and safety.

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Natural Frequency: The natural frequency of the structure was analyzed to avoid resonance during seismic events, which could lead to catastrophic failure.

4. RESULTS AND DISCUSSION

Result

The analysis provided comprehensive insights into the structural performance under both static and seismic loads.

4.1 Static Analysis Results

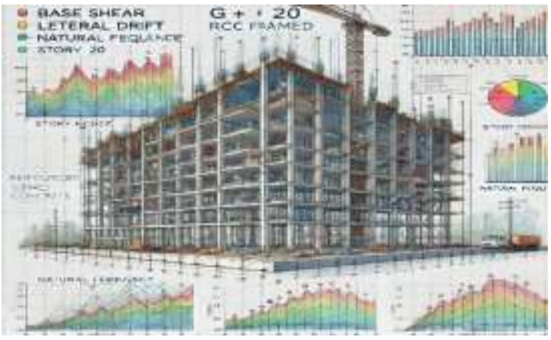
Bending Moment: The analysis revealed that the maximum bending moment occurred at the lower stories of the structure, gradually decreasing towards the upper stories. This pattern is typical in high-rise buildings, where the lower sections bear the majority of the load. The bending moments were within acceptable limits as per IS standards, indicating that the structure was well-designed to handle the static loads.

Shear Force: The shear force distribution followed a similar pattern to the bending moment, with the highest forces observed at the base of the structure. The analysis suggested that additional reinforcement might be necessary in the lower stories to enhance the structure's resilience against shear forces.

Displacement: The maximum displacement was observed at the top story, as expected in tall buildings. However, the displacement values were within the permissible limits, ensuring that the structure would remain stable and functional under the applied static loads.

4.2 Seismic Analysis Results

Base Shear: The seismic analysis revealed that the base shear values were significantly higher than those observed in the static analysis. The increased shear forces were a direct result of the seismic activity, highlighting the importance of reinforcing the base of the structure to withstand such dynamic forces.



Lateral Drift: The lateral drift values were within the permissible limits as per IS 1893:2002, indicating that the structure was capable of resisting the lateral forces induced by an earthquake. The analysis also showed that the structure's design was effective in minimizing drift, which is crucial for maintaining the building's integrity during seismic events.

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Natural Frequency: The analysis of the structure's natural frequency indicated that there was no significant risk of resonance during seismic activity. However, the study recommended further analysis using dynamic time-history methods to ensure the structure's resilience against more complex seismic forces.

Discussion

The results of the analysis underscore the importance of a dual approach to structural design, where both static and seismic loads are carefully considered.

4.3 Implications for Structural Design

The static analysis confirmed that the structure was well-designed to handle the everyday loads it would encounter. However, the seismic analysis revealed potential vulnerabilities, particularly in the lower stories and base of the structure, where shear forces were highest. These findings suggest that while the structure is safe under normal conditions, additional reinforcement and design modifications are necessary to ensure its resilience against seismic events.

4.4 Recommendations for Future Work

This research highlights several areas for future study:

Dynamic Analysis: A more detailed dynamic analysis, including time-history analysis, could provide deeper insights into the structure's performance under various seismic scenarios.

Material Alternatives: Exploring the use of alternative materials, such as high-performance concrete or fiber-reinforced polymers, could enhance the structure's resilience against both static and dynamic loads.

Seismic Retrofitting: For existing structures, the findings of this study could inform seismic retrofitting strategies, particularly in high-risk seismic zones.

5. CONCLUSION

The study successfully demonstrated the use of ETABS software for conducting both static and seismic analysis of a G+20 RCC framed structure. The results highlighted the structure's capability to withstand static loads while identifying areas that require reinforcement to improve its seismic performance. By integrating seismic considerations into the design process, engineers can ensure that high-rise buildings are not only functional but also resilient against natural disasters. This research contributes to the ongoing efforts to enhance the safety and sustainability of urban infrastructure.

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