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Research Paper

SEISMIC RESPONSE INVESTIGATION OF MULTI STORED BUILDING BY USING STAAD PRO

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ABSTRACT

Earthquake forces pose a significant threat to the safety and stability of multistoried structures, especially in developing urban regions where high-rise buildings are increasingly common. This project focuses on the seismic analysis and design of a G+10 reinforced cement concrete (RCC) residential building using STAAD.Pro software in accordance with Indian Standard codes such as IS 1893:2002 and IS 456:2000. The study evaluates the structural behavior of the building under various loading conditions, including dead load, live load, wind load, and seismic load. Two different seismic zones of India, Zone II (Vishakhapatnam) and Zone III (Vijayawada), are considered to understand the variation in structural response due to changes in seismic intensity. The methodology involves structural planning, modeling using coordinate systems, load assignment, and analysis through equivalent static and dynamic methods. STAAD.Pro is utilized for generating accurate results related to bending moments, shear forces, deflections, and reinforcement requirements. The building is modeled as a three-dimensional space frame with fixed supports, and load combinations are applied as per code provisions. The results indicate that seismic forces significantly influence the design parameters, especially in higher seismic zones, leading to increased reinforcement and structural demands. A comparative study between Zone II and Zone III reveals that higher seismic zones result in increased base shear, displacement, and internal forces. The findings highlight the importance of incorporating seismic considerations in the design process to ensure structural safety, serviceability, and durability. The study also emphasizes that proper detailing and ductile design practices can enhance the performance of structures during earthquake events. Overall, the project demonstrates the effectiveness of STAAD.Pro in analyzing complex structural systems and provides valuable insights into earthquake-resistant design of multistoried buildings.

Keywords: Seismic Analysis, RCC Building, STAAD.Pro, Earthquake Resistant Design, G+10 Structure, IS 1893, Structural Analysis, Load Combinations, Dynamic Analysis, Multistoried Building

I. INTRODUCTION

The rapid urbanization and continuous increase in population have created a strong demand for multistoried buildings in modern cities. Due to limited land availability, vertical construction has become a practical solution to accommodate residential and commercial requirements. However, as the height of buildings increases, their vulnerability to external forces, particularly earthquakes, also increases significantly. Earthquakes are natural phenomena that generate dynamic forces capable of causing severe structural damage and even collapse if buildings are not properly designed. Therefore, ensuring the safety and stability of such structures under seismic conditions has become a major concern in structural engineering. This project focuses on the seismic analysis and design of a G+10 reinforced cement concrete building using advanced tools and standard design procedures. The study aims to evaluate how the structure behaves under different types of loads, including dead load, live load, wind load, and earthquake load. By understanding these effects, engineers can design buildings that are both safe and economical. The project also highlights the importance of following codal provisions such as IS 1893 and IS 456, which provide guidelines for earthquake-resistant design. Proper implementation of these standards helps in

minimizing damage and ensuring the safety of occupants. Overall, this study contributes to developing reliable structural systems that can withstand seismic forces effectively in urban environments.

In recent years, seismic design has become an essential part of structural engineering due to the increasing awareness of earthquake risks and their impact on infrastructure. Conventional design methods that consider only static loads are insufficient for analyzing the behavior of structures subjected to dynamic forces such as earthquakes. Seismic forces act laterally and vary with time, making their analysis more complex compared to static loads. To address this, modern engineering practices include both linear static and dynamic analysis methods for accurate prediction of structural response. In this project, the equivalent static method and response-based analysis are used to evaluate the performance of a G+10 building. The study considers two different seismic zones, Zone II and Zone III, to understand how variations in seismic intensity influence the design parameters. Factors such as base shear, storey drift, displacement, and internal forces are analyzed and compared. This comparison helps in identifying critical structural elements that require special attention during design. Additionally, the concept of ductility is emphasized, which allows structures to absorb

and dissipate energy during seismic events without sudden failure. The project also examines the role of proper load combinations and structural configurations in improving seismic performance. By integrating these concepts, the study ensures that the building can resist earthquake forces effectively while maintaining structural integrity and serviceability throughout its lifespan.

The advancement of computational tools has significantly improved the accuracy and efficiency of structural analysis and design processes. STAAD.Pro is one of the most widely used software applications for analyzing and designing structures under various loading conditions. It provides a user-friendly interface and powerful analytical capabilities, enabling engineers to model complex structures and obtain precise results. In this project, STAAD.Pro is used to develop a three-dimensional model of the G+10 building, define material properties, assign loads, and perform analysis as per relevant Indian Standard codes. The software helps in calculating important structural responses such as bending moments, shear forces, axial forces, and deflections. These results are then used to design structural members like beams, columns, and slabs to ensure safety and efficiency. The project also demonstrates how software-based analysis can reduce manual effort and minimize errors in calculations. Furthermore, the use of STAAD.Pro allows for quick modifications in design, making it easier to evaluate different scenarios and

optimize the structure. The findings of this study highlight the importance of integrating modern software tools with engineering principles to achieve reliable and cost-effective designs. Ultimately, this project aims to provide a comprehensive understanding of seismic analysis and contribute to the development of earthquake-resistant multistoried buildings in India.

II. LITRATURE REVIEW

1. Analysis and Design of Earthquake Resistant Structures using STAAD.Pro : Akshay R. Kohli and Prof. N. G. Gore conducted a study on the seismic analysis and design of structures using STAAD.Pro software. Their research focused on evaluating building performance under earthquake loads using the equivalent static method. The study emphasized the importance of calculating all acting loads, including seismic and wind loads, to ensure structural safety. One of the key findings was related to inter-storey drift, which must remain within permissible limits as specified by IS 1893:2002. The authors demonstrated that proper modeling and analysis using STAAD.Pro can produce accurate results for displacement, forces, and stresses. They concluded that combining static and dynamic analysis methods enhances the reliability of the design. Their work highlights that maintaining drift limits and ensuring adequate stiffness are essential for earthquake-resistant structures, making STAAD.Pro a valuable tool in modern structural engineering practices.

2. Seismic Analysis of G+5 Residential Building

K. Aparna Srivastava presented a detailed study on seismic analysis and design of a G+5 residential building using STAAD.Pro. The research considered multiple load combinations including dead load, live load, wind load, and earthquake load as per IS 1893:2002. The study identified critical load combinations that govern structural design and highlighted the increase in steel reinforcement due to seismic effects. It was observed that seismic loads dominate wind loads in moderate seismic zones. The research also showed that storey drift values remained within safe limits, indicating structural stability. Additionally, the study concluded that proper load combination selection plays a vital role in safe design. The findings emphasize that seismic analysis leads to more conservative and safer designs compared to conventional methods. This work provides valuable insights into the importance of considering seismic forces in multistoried building design.

3. Seismic Performance of Buildings with Shear Walls

: Chandurkar and Pajgade studied the effect of shear wall positioning in multistoried buildings using STAAD.Pro software. Their research compared different structural models, including bare frames and structures with shear walls placed at various locations. The results showed that shear walls significantly improve the seismic performance of buildings by reducing lateral displacement and increasing stiffness. It was observed that placing shear walls at corners

or along shorter spans provides better resistance against earthquake forces. The study also highlighted that improper placement of shear walls can lead to inefficient load distribution. The authors concluded that shear walls are an economical and effective solution for enhancing structural stability in high-rise buildings. Their research supports the importance of structural configuration in seismic design and provides guidance for optimizing building performance under earthquake conditions.

4. Use of Steel Bracing in Seismic Design

Viswanath K.G. investigated the effectiveness of steel bracing systems in improving the seismic performance of reinforced concrete buildings. The study analyzed buildings of varying heights in seismic zone IV using STAAD.Pro software. Different types of bracing systems, such as X-type bracing, were evaluated for their efficiency in reducing lateral displacement. The results indicated that steel bracing significantly enhances structural stiffness and reduces bending and shear forces in beams and columns. The study also found that X-type bracing provides better performance compared to other configurations. Additionally, steel bracing does not add excessive weight to the structure, making it a suitable option for seismic retrofitting. The research concluded that incorporating bracing systems can improve the overall safety and performance of buildings during earthquakes. This study highlights the importance of alternative structural systems in seismic design.

5. **Comparative Study of Static and Dynamic Analysis Methods** Siva Kiran Kollimarla and Chadalawada Jagan Mohan conducted a comparative study of static and dynamic analysis methods for multistoried buildings. The research focused on evaluating the differences between equivalent static analysis and response spectrum analysis using STAAD.Pro. The study revealed that dynamic analysis provides more accurate results as it considers higher modes of vibration and time-dependent effects. In contrast, static analysis is simpler but less precise for taller structures. The authors observed that structures analyzed using dynamic methods showed different force distribution patterns compared to static methods. The study concluded that response spectrum analysis is more suitable for high-rise buildings subjected to seismic forces. This research emphasizes the need for adopting advanced analysis techniques in modern structural design to ensure safety and accuracy.

6. **Nonlinear Seismic Analysis and Structural Performance** Kappos and Manafpour proposed a methodology for seismic design based on nonlinear analysis techniques, including pushover and time history analysis. Their study focused on evaluating the inelastic behavior of reinforced concrete structures under earthquake loads. The research demonstrated that nonlinear analysis provides a more realistic representation of structural performance compared to linear methods. It allows engineers to assess deformation capacity, ductility, and potential

failure mechanisms. The authors highlighted that performance-based design approaches can improve structural safety by considering different limit states such as serviceability and life safety. The study also showed that nonlinear methods are effective in identifying critical structural components that may fail during strong earthquakes. Their work emphasizes the importance of advanced analysis techniques in achieving reliable and resilient structural designs, especially for high-rise buildings in seismic regions.

III. WORKING METHODOLOGY

1. **Structural Planning and Modeling :** The working methodology of this project begins with the structural planning and modeling of a G+10 reinforced cement concrete (RCC) building. Initially, the architectural layout is prepared using AutoCAD, where the plan, elevation, and sectional details are developed with proper dimensions. The drawing includes the positioning of beams, columns, slabs, doors, and windows to ensure functional and structural efficiency. After preparing the layout, the structural model is generated in STAAD.Pro using a coordinate system. Nodes are created at specific points, and these nodes are connected using beam elements to form the structural framework. The modeling process also includes assigning appropriate support conditions, typically fixed supports at the base, to simulate real-life conditions. Material properties such as grade of concrete (M30) and

steel (Fe 415) are defined according to IS codes. Member properties like beam and column dimensions are assigned based on preliminary design considerations. The structure is modeled as a three-dimensional space frame to accurately capture its behavior under various loading conditions. Proper layer management and verification of geometry are carried out to avoid modeling errors. This stage ensures that the structural model is ready for further analysis and represents the actual building configuration accurately. The accuracy of modeling plays a crucial role in obtaining reliable results in later stages of analysis and design.

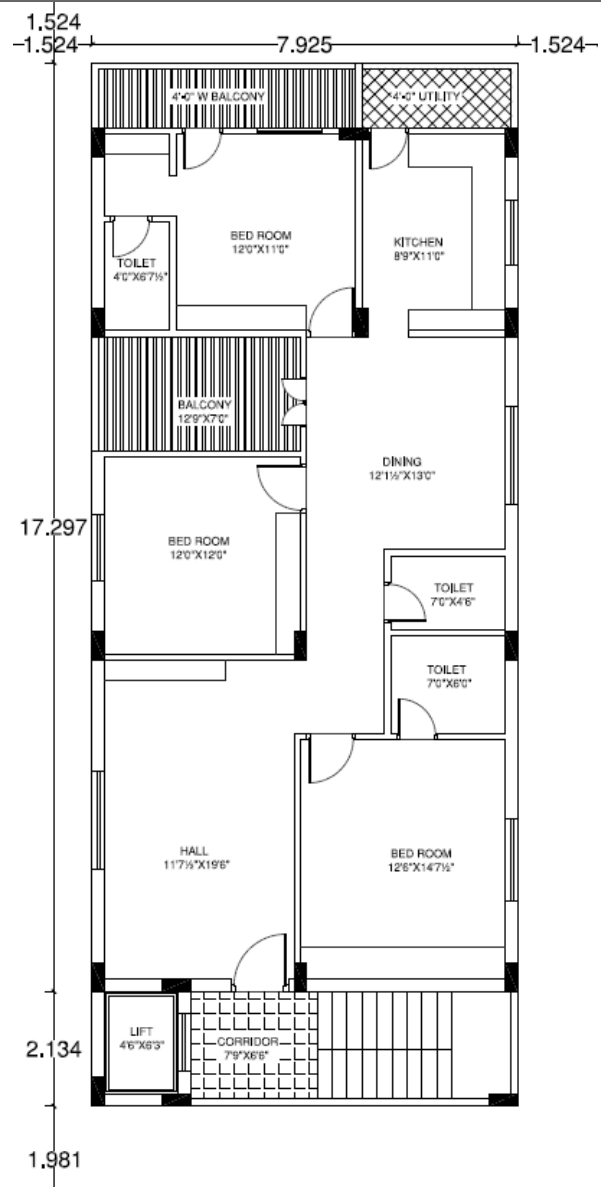


Fig 1 : AutoCAD plan

2. Load Calculation and Structural Analysis

After completing the structural model, the next step involves the calculation and application of loads on the building. Various types of loads such as dead load, live load, wind load, and seismic load are considered in accordance with IS 875 and IS 1893 provisions. Dead loads include the self-weight of structural components, wall loads, floor finishes, and other permanent

loads. Live loads are applied as per usage requirements of the building. Wind loads are calculated based on parameters such as basic wind speed, terrain category, and height factors. Seismic loads are defined using zone factors, importance factors, response reduction factors, and soil conditions for Zone II and Zone III. These loads are assigned to the structure in different directions (X and Z axes) to simulate realistic conditions.

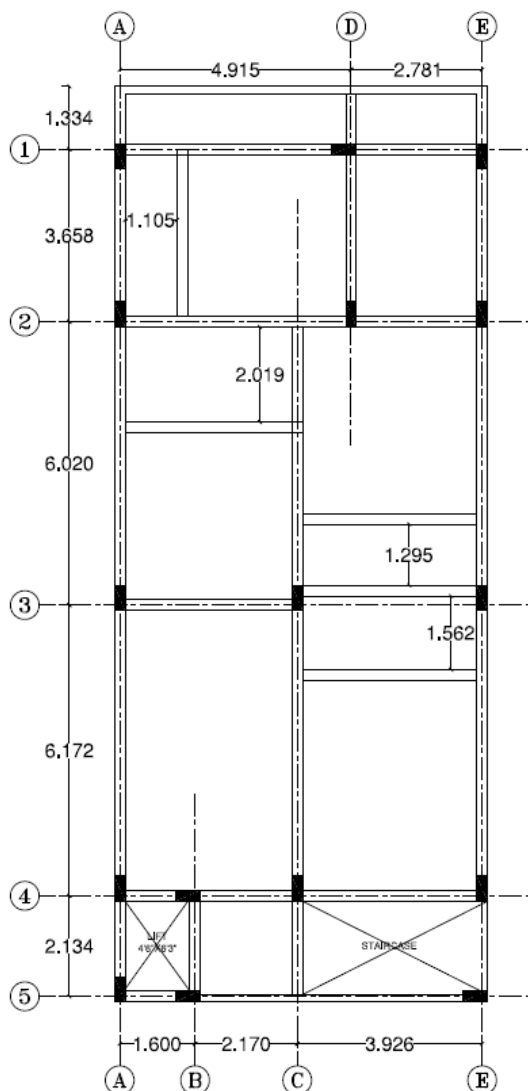


Fig : 2 Centre line diagram of plan AutoCAD plan

Load combinations are then generated as per IS 456:2000 to evaluate the structure under various critical scenarios. Once all loads are applied, the analysis is performed using STAAD.Pro. The software calculates structural responses such as bending moments, shear forces, axial forces, and displacements. Both equivalent static and dynamic analysis methods are used to assess the behavior of the structure under seismic conditions. The results obtained from the analysis help in identifying critical sections and load cases that govern the design. This step is essential to ensure that the structure can safely withstand all applied loads.

3. Design, Evaluation, and Comparison

The final stage of the methodology involves the design and evaluation of structural components based on the analysis results. Using STAAD.Pro, beams, columns, and slabs are designed in accordance with IS 456:2000 and IS 13920 guidelines. The design process considers factors such as bending moments, shear forces, torsion, and axial loads to determine the required reinforcement for each structural member. Special attention is given to ductile detailing to improve the seismic performance of the structure. The software automatically checks for design adequacy and provides reinforcement details for beams and columns. Deflection limits and drift criteria are also verified to ensure serviceability and stability of the building. After completing the design, a comparative analysis is carried out

between Zone II and Zone III to evaluate the effect of seismic intensity on the structure. Parameters such as base shear, displacement, and material requirements are compared. The results indicate that higher seismic zones require more reinforcement and exhibit greater structural responses. This comparison helps in understanding the importance of seismic considerations in design. Finally, the overall performance of the structure is assessed to ensure safety, economy, and compliance with design standards. The methodology concludes with validating that the designed structure can effectively resist seismic forces while maintaining structural integrity.

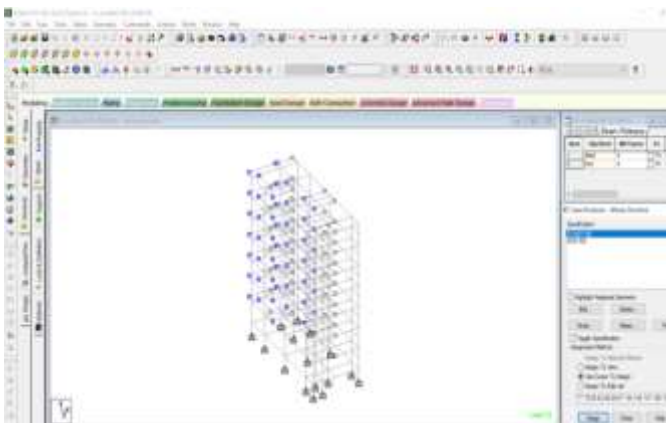


Fig 3: Releasing End moments with supports

IV. CONCLUSION

The present project focused on the seismic analysis and design of a G+10 reinforced cement concrete (RCC) building using STAAD.Pro software in accordance with Indian Standard codes such as IS 1893:2002 and IS 456:2000. The study successfully demonstrated how different types of loads, including dead load, live

load, wind load, and seismic load, influence the behavior of multistoried structures. By modeling the structure as a three-dimensional space frame and applying appropriate load combinations, the analysis provided detailed insights into structural responses such as bending moments, shear forces, axial forces, and deflections. The use of STAAD.Pro ensured accurate and efficient computation, reducing manual effort and improving reliability of results.

A comparative analysis between seismic Zone II and Zone III highlighted the significant impact of seismic intensity on structural performance. It was observed that parameters such as base shear, displacement, and internal forces increase with higher seismic zone factors. Consequently, the requirement for reinforcement and material strength also increases to maintain safety and stability. The study confirmed that structures in higher seismic zones demand more careful design considerations, including ductile detailing and proper load distribution. Additionally, the results verified that all structural components satisfied the permissible limits for deflection and drift as specified by IS codes, ensuring serviceability and safety under seismic conditions.

Overall, the project emphasizes the importance of incorporating seismic analysis in the design of multistoried buildings. It highlights that modern software tools like STAAD.Pro play a crucial role in achieving safe, economical, and efficient structural designs. The findings reinforce that

adherence to codal provisions, proper structural planning, and advanced analysis methods are essential for developing earthquake-resistant structures. This study provides a practical understanding of seismic design and contributes to improving the resilience of buildings against earthquake forces.

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