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Comparative Seismic Analysis and Design of G+6 RCC Buildings in Different Seismic Zones of India Using STAAD-PRO

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ABSTRACT

Earthquakes are among the most destructive natural disasters, posing a significant threat to life and infrastructure. Ensuring structural safety in seismic-prone regions requires proper analysis, design, and implementation of earthquake-resistant techniques. This study focuses on the comparative seismic analysis and design of a G+6 reinforced concrete (RCC) building in two different seismic zones of India: Zone II (Hyderabad) and Zone III (Vijayawada). The primary objective is to evaluate the structural performance of a multi-story residential building under seismic forces and determine the impact of varying seismic intensities on its stability and safety. In this study, STAAD-PRO software is used for modeling and analyzing the building under different loading conditions, including dead load, live load, wind load, and seismic load. The analysis is performed using the Equivalent Static Lateral Force Method, which helps in understanding the structural response to earthquake forces. The study emphasizes the importance of ductile detailing in beams and columns to enhance the overall earthquake resistance of the structure. A comparative assessment is carried out between the two seismic zones, focusing on parameters such as base shear, story drift, lateral displacement, and overall structural stability. The results of this research provide valuable insights into how buildings behave in different seismic zones and highlight the necessary design modifications required for improved safety and performance. The findings will assist structural engineers in optimizing the design of multi-story buildings to withstand seismic forces effectively. By integrating advanced analysis tools and earthquake-resistant design principles, this study aims to contribute to the development of safer and more resilient structures in seismic-prone regions of India.

Keywords: Seismic Analysis, RCC Building, STAAD-PRO, Earthquake Resistance, Equivalent Static Lateral Force Method, Structural Stability.

1. INTRODUCTION

Day-by-day increase in population growth in cities of India for several acceptable reasons and deficiency of land area so that there is a requirement of design and seismic analysis of multistoried building before construction work starts. Multistoried buildings are designed for the basic need of people. These buildings are the shelter for all the human beings and help grown up the infrastructure to the city. So, we need a residential building to serve the people. The main object of the project is to modify the general design of multi storied building with seismic effect. Seismology is the study of vibration of earth mainly caused by earthquakes and seismic waves that move through and around the earth.

A seismic wave causes the sudden breaking of rock within the earth or an explosion. They are the energy in the form of waves that travels through the beneath of earth and is recorded on seismographs. The study of these waves by various techniques, understanding there nature and various physical processes that generate there from the major part of the seismology. A seismic design of high-rise building has assumed considerable important in recent times. In traditional method adopted based on fundamental mode of the structure and distribution of earthquake forces as static forces at various stories may be adequate for structure of small height subjected to earthquake of very low intensity but as the number of the stories increases the seismic design demand more rigorous.

2. LITRATURE REVIEW

Akshay R. Kohli, Prof. N.G. Gore, “Analysis and design of an earthquake resistance using STAAD Pro.” In this paper, they study that, the main purpose of this letter is to make and earthquake resistant by the structure of the seismic study structure of the static equivalent method analyse and complete the analysis and design of building using STAAD. The structural safety of building is ensured by calculating all the acting load on it structure, which includes lateral load due to ventilated load and seismic stimulation, they the conclusion is that, as a result, inter-story dript should be obtained within the specified limit. For minimum specified lateral force with partial safety factor of 1.0, the inter-story drift should be under 0.04 x Hs, where (Hs) is the story height (Clause 7.11.1, IS 1893:2002 (part 1)). For 3300 mm floor height, inter-story drift = 0.04 x 3300 = 13.2 mm. The actual relative displacement between every story in the structure is below the inter-story drift limit and hence safe. It undergoes static as well as dynamic analysis of the structure and gives accurate results.

Anoop Singh, VikasSrivastava, N.N. Harry, “seismic analysis an design of building structures in STAAD Pro. In this paper, they study that seismic reaction of structures is examined earthquake stimulation was expressed in the form of joint displacement, member forces, story drift and support feedback. Reaction for G+10 building structure is examined design software using STAAD Pro. They see a decrease in the reaction of the case common moment resist frame. In this case we have taken earthquake area II, feedback factor 3. resisting the frame and importance factor 1 for the normal moment. This paper, main the conclusion is that, (i) design calculate by IS 1893:2002 according to calculation made by STAAD Pro. (ii) According to Indian standard the displacement of the beam comes in building is limited. (iii) According to IS 1893:2002, the maximum drift in the building is safe. i.e 2.077 cm. (iv) the allowable displacement is 12 mm and maximum beam displacement of 3 m span is 0.044 mm.

Chandurkar, Pajgade (2013) evaluated the response of a 10 storey building with seismic shear wall using Staad Pro V8i Main focus was to compare the change in response by changing the location of shear wall in the multi-storey building. Four models were studied- one being a bare frame structural system and rest three were of dual type structural system. The results were excellent for shear wall in short span at corners. Larger dimension of shear wall was found to be ineffective in 10 or below 10 stories. Shear wall is an effective and economical option for high-rise structures. It was observed that changing positions of shear wall was found to attract forces, hence proper positioning of shear wall is vital. Major amount of horizontal forces were taken by shear wall when the dimension is large. It was also observed that shear walls at substantial locations reduced displacements due to earthquake.

Viswanath K.G (2010) investigated the seismic performance of reinforced concrete buildings using concentric steel bracing. Analysis of a four, eight, twelve and sixteen storied building in seismic zone IV was done using Staad Pro software, as per IS 1893: 2002 (Part-I). The bracing was provided for peripheral columns, and the effectiveness of steel bracing distribution along the height of the building, on the seismic performance of the building was studied. It was found that lateral displacements of the buildings reduced after using X-type bracings. Steel bracings were found to reduce flexure and shear demand on the beams and columns and transfer lateral load by axial load mechanism. Building frames with X- type bracing were found to have minimum bending as compared to other types of bracing. Steel bracing system was found to be a better alternative for seismic retrofitting as they do not increase the total weight of the building significantly.

Chavan, Jadhav (2014) studied seismic analysis of reinforced concrete with different bracing arrangements by equivalent static method using Staad Pro. Software. The arrangements considered were diagonal, V-type, inverted V-type and X-type. It was observed that lateral displacement reduced by 50% to 60% and maximum displacement reduced by using X-type bracing. Base shear of the building was also found to increase from the bare frame, by use of X-type bracing, indicating increase in stiffness.

Esmaili et al. (2008) studied the structural aspect of a 56 stories high tower, located in a high seismic zone in Tehran. Seismic evaluation of the building was done by nonlinear dynamic analysis. The existing building had main walls and its side walls as shear walls, connected to the main wall by coupling of beams. The conclusion was to consider the time-dependency of concrete. Steel bracing system should be provided for energy absorption for ductility, but axial load can have adverse effect on their performance. It is both conceptually and economically unacceptable to use shear wall as both gravity and bracing system. Confinement of concrete in shear walls is good option for providing ductility and stability.

Akbari et al. (2015) assessed seismic vulnerability of steel X-braced and chevronbraced Reinforced Concrete by developing analytical fragility curve. Investigation of various parameters like height of the frame, the p-delta effect and the fraction of base shear for the bracing system was done. For a specific designed base shear, steel-braced RC dual systems have low damage probability and larger capacity than unbraced system. Combination of stronger bracing and weaker frame reduces the damage probability on the entire system. Irrespective of height of the frame, Chevron braces are more effective than X-type bracing. In case of X-type bracing system, it is better to distribute base shear evenly between the braces and the RC frame, whereas in case of Chevron braced system it is appropriate to allocate higher value of share of base shear to the braces. Including p-delta effect increases damage probability by 20% for shorter dual system and by 100% for taller dual systems. The p-delta effect is more dominant for smaller PGA values.

3. PROPOSED SYSTEM

The proposed system aims to analyze and design a G+6 RCC hospital building subjected to seismic forces in different earthquake zones of India using STAAD.Pro software. The system will evaluate the structural performance of the building under static and dynamic loads and provide optimized design recommendations for enhanced seismic resistance.

1. **Building Modeling & Structural Design**
   - A G+6 hospital building will be modeled in STAAD.Pro with appropriate dimensions and material properties.
   - Structural elements such as beams, columns, slabs, and foundations will be designed as per IS 456:2000 and seismic provisions from IS 1893:2016 and IS 13920:2016.
2. **Load Considerations & Analysis**
   - The structure will be subjected to various loads, including dead load (IS 875: Part 1), live load (IS 875: Part 2), wind load (IS 875: Part 3), and seismic load (IS 1893:2016).
   - Both static and dynamic analysis will be conducted to compare the structural behavior in Zone II (Hyderabad) and Zone III (Vijayawada).
3. **Seismic Analysis**
   - The Equivalent Static Lateral Force Method will be used to determine seismic forces acting on the structure.
   - Structural response parameters such as base shear, story drift, lateral displacement, bending moment, and shear force will be evaluated for both seismic zones.
4. **Optimization & Safety Measures**
   - To improve earthquake resistance, necessary modifications will be suggested, such as increasing reinforcement percentage, improving ductility, and optimizing member dimensions.
   - Deflection and shear tests will be conducted to ensure the structural members remain within permissible limits.
5. **Result Evaluation & Conclusion**
   - Comparative results between Zone II and Zone III will be presented to determine the impact of increasing seismic intensity on structural stability.
   - The study will provide recommendations for safer and more economical hospital building designs in seismic-prone areas.

4. RESULTS AND DISCUSSIONS

4.1 GEOMETRY

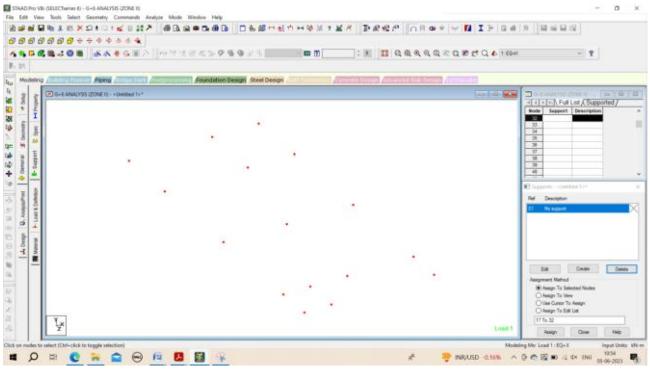

Fig 4.1: Geometry (import plan in terms of nodes)

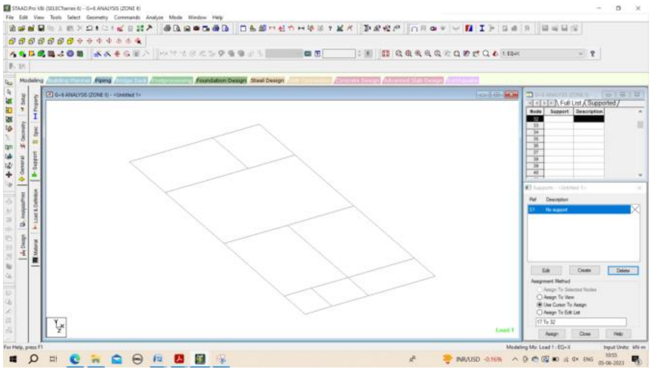

Fig 4.2: Add beams by point to point

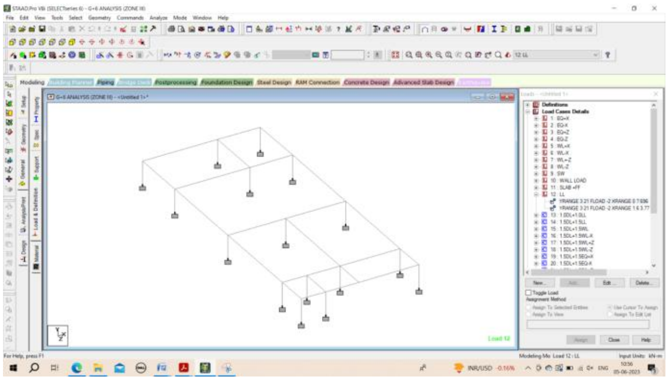

Fig 4.3: Plinth level generation

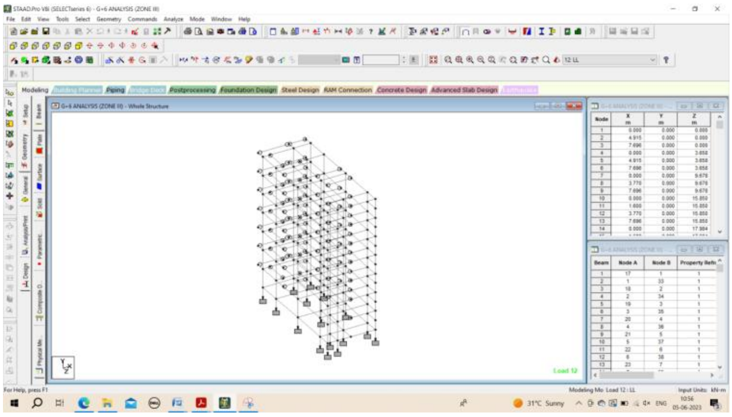

Fig 4.4: Generation of G+6

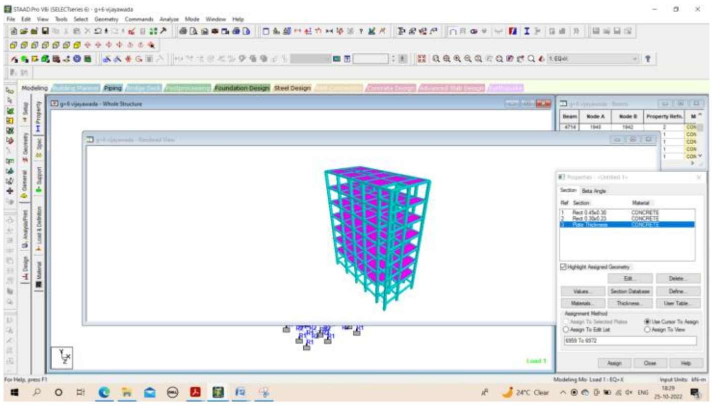

Fig 4.5: 3-d view

4.2 GENERATION OF MEMBER PROPERTY

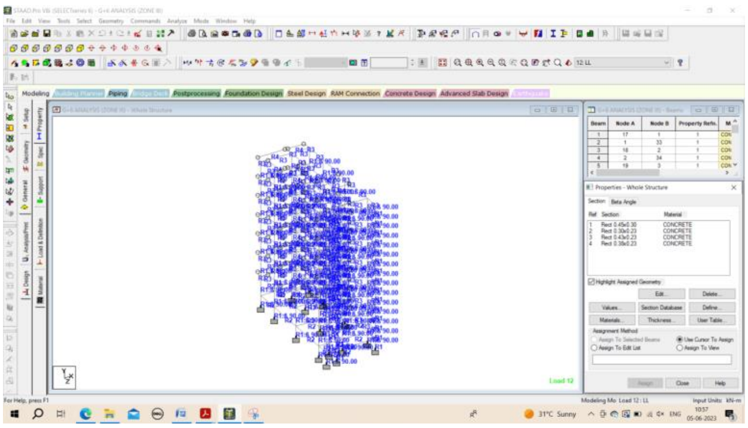

Fig 4.5: Generation of member property

Generation of member property can be done in STAAD.Pro by using the window as shown above. The member selection is selected and the dimension have been specified.

4.3 SPECIFICATION

Releasing end moments to the secondary beams both at starting and end of the beams.

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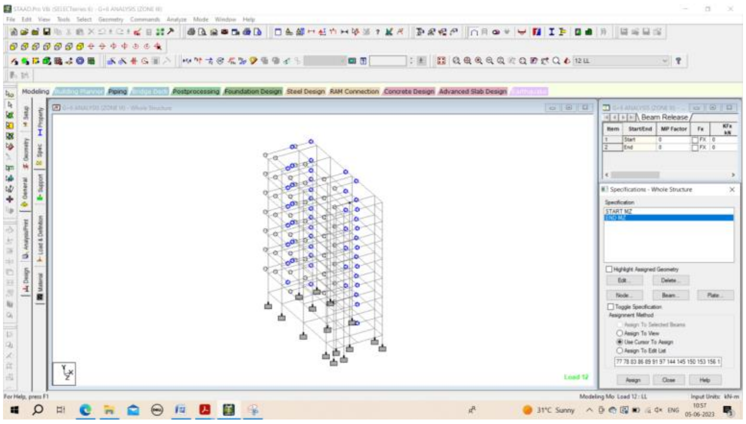

Fig 4.6: Releasing end movements

4.4 SUPPORT

The base support of the structure was assigned as Fixed. The support was generated using the STAAD.Pro support generator

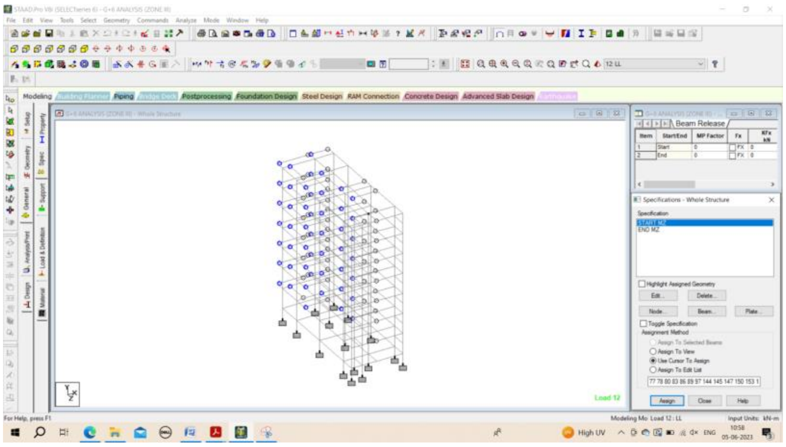

Fig 4.7: Releasing End moments with supports

4.5 RESULTS

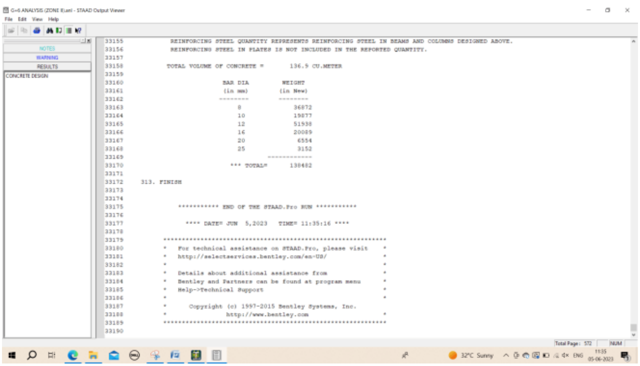

Fig 4.8: Staad output quantities Zone II

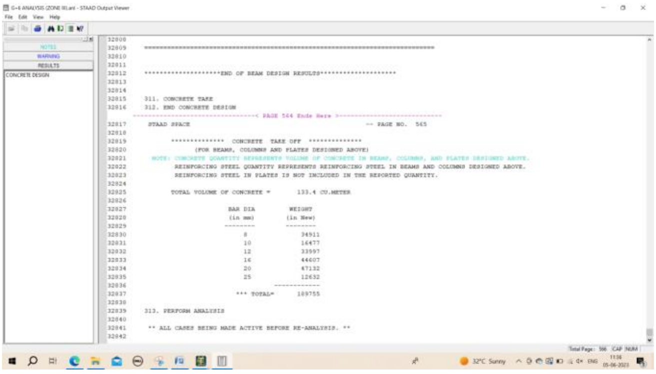

Fig 4.9: Staad output quantities Zone III

5. CONCLUSION

This analysis involves various studies carried out on planning, designing, and analyzing a structure using different software. Based on the studies reviewed, STAAD.Pro is recommended over other software for building structure analysis due to its flexibility and provision for economic sections in terms of both steel and concrete. Therefore, STAAD.Pro is adopted for further analysis in this study. The analysis and design focus on a hospital building, where various structural parameters such as bending moment, shear force, torsion, and stresses are examined. The analysis and design are conducted according to standard specifications using STAAD.Pro, considering both static and dynamic loads. Structural member dimensions are specified, and loads such as dead load, live load, and wind load are applied. Additionally, deflection and shear tests are performed on beams, columns, and slabs, ensuring that the structure remains safe. Both theoretical and practical aspects have been explored, and it is concluded that practical work provides deeper insights compared to theoretical studies. Key observations from this study indicate that to enhance structural safety against seismic loading, the percentage of steel reinforcement must be increased. It is also observed that deflection and shear bending values are approximately 37% higher in Zone III compared to Zone II, highlighting the significant impact of seismic zones on structural behavior. Furthermore, as the severity of earthquake zones increases, the deflection values also increase, emphasizing the need for careful design considerations in higher seismic zones.

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