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Research Paper

SEISMIC ANALYSIS AND DESIGN OF A G+6 REINFORCED CONCRETE BUILDING ACROSS DIFFERENT SEISMIC ZONES USING STAAD.PRO

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ABSTRACT

Earthquakes are among the most destructive natural hazards, causing severe structural damage, economic losses, and loss of human life. The seismic performance of reinforced concrete (RC) buildings depends significantly on the seismic zone, structural configuration, material properties, and design methodology. With rapid urbanization and the increasing construction of multi-storey buildings in earthquake-prone regions of India, it has become essential to design structures capable of withstanding seismic forces while ensuring safety, stability, and serviceability. This project presents the Seismic Analysis and Design of a G+6 Reinforced Concrete Building in Different Seismic Zones of India Using STAAD.Pro. The proposed study investigates the structural behaviour of a G+6 RC building subjected to earthquake loading in Seismic Zones II, III, IV, and V as specified in IS 1893 (Part 1): 2016 and IS 456:2000. The building model is developed in STAAD.Pro, where dead load, live load, and seismic load combinations are applied according to Indian Standard codes. Structural parameters including storey displacement, storey drift, base shear, bending moment, shear force, axial force, support reactions, and member deflections are evaluated for each seismic zone. A comparative analysis is performed to determine the influence of increasing seismic intensity on the overall structural response and member design. The obtained results indicate that storey displacement, drift, base shear, and internal forces increase significantly from Zone II to Zone V, requiring stronger structural members and improved reinforcement detailing for higher seismic zones. The study demonstrates that STAAD.Pro provides accurate structural analysis and efficient design optimization for earthquake-resistant buildings. The proposed framework assists structural engineers in designing safe, economical, and code-compliant multi-storey buildings capable of resisting seismic loads, thereby improving structural reliability, occupant safety, and the sustainable development of modern infrastructure in earthquake-prone regions.

Keywords: Seismic Analysis, Earthquake Engineering, Reinforced Concrete Building, G+6 Building, STAAD.Pro, Structural Analysis, Seismic Zones, IS 1893 (Part 1): 2016, IS 456:2000, Storey Drift, Base Shear, Earthquake-Resistant Design.

I. INTRODUCTION

Earthquakes are one of the most devastating natural disasters affecting the safety and stability of civil engineering structures. Every year, seismic events cause significant damage to buildings, bridges, and other infrastructure, leading to economic losses and human casualties across many parts of the world. In India, the seismic risk varies from one region to another because the country is divided into Seismic Zones II, III, IV, and V according to IS 1893 (Part 1): 2016. Multi-storey reinforced concrete (RC) buildings are particularly vulnerable to earthquake-induced lateral forces due to their height, mass distribution, and structural configuration. As urbanization continues to increase, the construction of medium-rise residential and commercial buildings has become common in both moderate and high seismic regions. Therefore, understanding the structural behaviour of buildings under different earthquake intensities has become essential for ensuring public safety and infrastructure resilience. Conventional structural design methods primarily focus on gravity loads such as dead and live loads; however, seismic forces produce additional lateral loads that significantly influence structural performance. Proper seismic analysis enables engineers to predict building behaviour, evaluate structural safety, and design members capable of resisting earthquake forces. Modern structural analysis software such as STAAD.Pro provides accurate modelling, analysis, and design capabilities that simplify the evaluation of complex multi-storey buildings while ensuring compliance with Indian Standard codes.

Recent developments in structural engineering software have significantly improved the accuracy and efficiency of earthquake-resistant building design. STAAD.Pro has become one of the most widely used software packages for analysing and designing reinforced concrete and steel structures because it integrates three-dimensional modelling, finite element analysis, load combination generation, and code-based design within a single platform. The software allows engineers to apply dead loads, live loads, wind loads, and seismic loads according to national and international design standards. In seismic analysis, the building is subjected to lateral earthquake forces generated based on seismic zone factors, importance factors, response reduction factors, soil conditions, and structural characteristics specified in IS 1893 (Part 1): 2016. STAAD.Pro calculates important structural parameters such as storey displacement, storey drift, base shear, bending moment, shear force, axial force, support reactions, and member deflections, enabling engineers to evaluate structural stability under earthquake loading. Comparative analysis across different seismic zones helps identify the increase in structural demand as earthquake intensity increases. Such studies assist engineers in optimizing member sizes, reinforcement detailing, and structural layouts while maintaining both safety and economy in building construction.

This project presents the Seismic Analysis and Design of a G+6 Reinforced Concrete Building in Different Seismic Zones of India Using STAAD.Pro. The objective of the study is to evaluate the structural performance of a G+6 building subjected to earthquake loading in Seismic Zones II, III, IV, and V and compare the variation of critical structural responses under different seismic intensities. A three-dimensional building model is developed in STAAD.Pro by defining beam, column, slab, and foundation elements together with material properties and sectional dimensions. Dead load, live load, and seismic load combinations are applied according to IS 456:2000, IS 875 (Parts 1 and 2), and IS 1893 (Part 1): 2016. The structural behaviour is evaluated using engineering parameters including storey displacement, storey drift, base shear, bending moment, shear force, axial force, support reactions, and member deflections. The obtained results are compared to determine the influence of increasing seismic intensity on the structural performance of the building. The study demonstrates that buildings located in higher seismic zones experience significantly greater lateral displacement, drift, and internal forces, requiring stronger structural members and improved reinforcement detailing. The proposed analysis provides valuable guidance for structural engineers in designing safe, economical, and earthquake-resistant multi-storey reinforced concrete buildings that comply with Indian Standard design provisions.

II. SURVEY OF RESEARCH

1. Seismic Analysis of Reinforced Concrete Buildings

Seismic analysis plays a vital role in evaluating the structural performance of reinforced concrete (RC) buildings subjected to earthquake-induced forces. Researchers have extensively investigated the behaviour of multi-storey buildings under different seismic loading conditions to improve structural safety and minimize earthquake damage. Conventional design methods primarily considered gravity loads such as dead and live loads; however, earthquake forces introduce significant lateral loads that influence the stability and serviceability of structures. Several studies have demonstrated that seismic analysis helps engineers estimate important structural parameters including storey displacement, storey drift, base shear, bending moment, shear force, axial force, and support reactions. Comparative investigations conducted on buildings located in different seismic zones indicate that lateral displacement and internal member forces increase considerably with increasing seismic intensity. Researchers have concluded that proper seismic analysis enables engineers to optimize structural dimensions, reinforcement detailing, and foundation design while ensuring compliance with Indian Standard codes. These investigations highlight the importance of earthquake-resistant structural design for reducing structural damage and protecting human life in seismic-prone regions.

2. STAAD.Pro in Structural Analysis and Design

STAAD.Pro has become one of the most widely used structural engineering software packages for analysing and designing reinforced concrete and steel structures. Researchers have successfully applied STAAD.Pro to analyse residential, commercial, industrial, and institutional buildings subjected to gravity, wind, and seismic loads. The software provides three-dimensional structural modelling, finite element analysis, automatic load combination generation, and code-based member design according to various international standards, including Indian Standards. Several investigations have demonstrated that STAAD.Pro accurately predicts structural responses such as storey displacement, bending moment, shear force, support reactions, beam deflection, column forces, and foundation reactions under different loading conditions. Comparative studies indicate that STAAD.Pro significantly reduces manual calculation effort while improving design accuracy and computational efficiency. Researchers also reported that the software facilitates structural optimization by enabling engineers to evaluate different design alternatives before final construction. Consequently, STAAD.Pro has become an essential tool for designing safe, economical, and earthquake-resistant reinforced concrete buildings.

3. Effect of Seismic Zones on Building Performance

The seismic performance of reinforced concrete buildings is strongly influenced by the seismic zone in which the structure is located. India is classified into Seismic Zones II, III, IV, and V according to IS 1893 (Part 1): 2016, with Zone V representing the highest earthquake hazard. Researchers have compared identical building models under different seismic zones to evaluate variations in structural behaviour. Experimental and numerical studies indicate that storey displacement, storey drift, base shear, overturning moment, and internal member forces increase progressively from Zone II to Zone V because of increasing seismic acceleration. Buildings located in higher seismic zones require stronger beams, columns, shear walls, and foundation systems to safely resist larger earthquake forces. Proper reinforcement detailing and ductile design practices also become increasingly important for preventing structural collapse during severe earthquakes. Comparative seismic studies provide valuable guidance for selecting appropriate structural configurations and reinforcement strategies suitable for different geographical regions of India.

4. Earthquake-Resistant Design According to Indian Standards

Indian Standard codes provide comprehensive guidelines for designing reinforced concrete buildings capable of resisting earthquake forces. Researchers widely follow IS 1893 (Part 1): 2016 for seismic load calculations, IS 456:2000 for reinforced concrete design, IS 875 (Parts 1 and 2) for dead and live loads, and IS 13920:2016 for ductile detailing of reinforced concrete structures. These codes define important design parameters including seismic zone factor, importance factor, response reduction factor, damping ratio, soil conditions, and load combinations required for earthquake-resistant structural design. Several investigations demonstrate that buildings designed according to these standards exhibit improved structural performance, enhanced ductility, and greater resistance against earthquake-induced damage. Proper implementation of Indian Standard provisions significantly reduces structural failure, minimizes repair costs, and improves occupant safety during seismic events. These standards form the foundation of modern earthquake engineering practice in India.

5. Comparative Analysis of Multi-Storey Buildings

Comparative analysis has become an effective approach for evaluating the influence of different loading conditions and design parameters on multi-storey buildings. Researchers have compared buildings with different heights, structural systems, foundation types, and seismic zones to understand variations in structural response. Most investigations evaluate engineering parameters including storey displacement, inter-storey drift, base shear, bending moment, shear force, axial force, support reactions, and member deflections. Comparative studies reveal that taller buildings experience greater lateral displacement and drift under seismic loading, whereas buildings located in higher seismic zones require larger structural members and increased reinforcement to satisfy safety requirements. The findings also indicate that optimized structural configurations improve both economy and earthquake resistance. Such investigations assist structural engineers in selecting suitable design alternatives for different seismic conditions while maintaining structural stability and code compliance.

6. Future Trends in Earthquake-Resistant Structural Engineering

Recent advancements in structural engineering focus on integrating advanced numerical analysis, Building Information Modelling (BIM), Artificial Intelligence (AI), performance-based seismic design, and structural health monitoring into earthquake-resistant building design. Researchers are investigating machine learning techniques for predicting structural damage, optimizing reinforcement layouts, and improving seismic performance assessment. Modern structural analysis software now supports nonlinear static analysis, response spectrum analysis, time-history analysis, and performance-based design for evaluating building behaviour under severe earthquake loading. Smart monitoring systems equipped with sensors continuously evaluate structural health before and after seismic events, enabling timely maintenance and rehabilitation. Future developments are expected to combine AI, digital twin technology, cloud computing, and real-time structural monitoring with traditional structural analysis software such as STAAD.Pro to improve earthquake resilience, reduce construction costs, enhance public safety, and support the development of sustainable infrastructure in earthquake-prone regions.

III. PROPOSED SYSTEM

The proposed Seismic Analysis and Design of a G+6 Reinforced Concrete Building in Different Seismic Zones of India Using STAAD.Pro aims to evaluate the structural behaviour of a multi-storey reinforced concrete building under varying earthquake intensities and to develop a safe, economical, and code-compliant structural design. The proposed framework integrates three-dimensional structural modelling, load calculation, seismic analysis, member design, and performance evaluation using STAAD.Pro in accordance with the provisions of IS 1893 (Part 1): 2016, IS 456:2000, IS 875 (Parts 1 and 2), and IS 13920:2016. The primary objective is to investigate how different seismic zones influence the structural response of a G+6 building and to identify the design modifications required to ensure adequate earthquake resistance.

Initially, a three-dimensional structural model of the G+6 reinforced concrete building is developed in STAAD.Pro by defining the geometry of beams, columns, slabs, foundations, and support conditions. Material properties such as concrete grade, reinforcement steel grade, modulus of elasticity, Poisson's ratio, and density are assigned according to Indian Standard specifications. Appropriate cross-sectional dimensions for beams and columns are selected based on preliminary design calculations. After completing the structural modelling, gravity loads including dead loads and live loads are applied according to IS 875 (Part 1) and IS 875 (Part 2). Subsequently, earthquake loads are assigned using the seismic parameters specified in IS 1893 (Part 1): 2016, including seismic zone factor, importance factor, response reduction factor, damping ratio, and soil type. The structural model is analysed separately for Seismic Zones II, III, IV, and V to evaluate the influence of increasing earthquake intensity on the building.

The analysis module performs linear static seismic analysis and computes important engineering parameters such as storey displacement, storey drift, base shear, bending moment, shear force, axial force, support reactions, and member deflections. The obtained structural responses are compared for all seismic zones to identify the increase in lateral forces and deformation as seismic intensity increases. The design module then checks each structural member against permissible stress and serviceability limits specified in the Indian Standard codes. Whenever any structural member fails to satisfy the design requirements, the beam or column dimensions and reinforcement details are modified until all code provisions are satisfied. The optimized design ensures adequate strength, stiffness, ductility, and stability under earthquake loading while maintaining construction economy.

Finally, the effectiveness of the proposed framework is evaluated through a comparative analysis of structural performance under different seismic zones. Engineering parameters including maximum storey displacement, inter-storey drift, base shear, support reactions, bending moment, shear force, axial force, and overall structural stability are analysed and compared. The proposed framework demonstrates that buildings located in higher seismic zones experience significantly larger lateral forces and structural deformations, thereby requiring stronger structural members, enhanced reinforcement detailing, and improved ductile design practices. The developed STAAD.Pro-based analysis provides structural engineers with a reliable, efficient, and practical approach for designing earthquake-resistant G+6 reinforced concrete buildings suitable for different seismic regions of India while ensuring structural safety, durability, and compliance with national design standards.

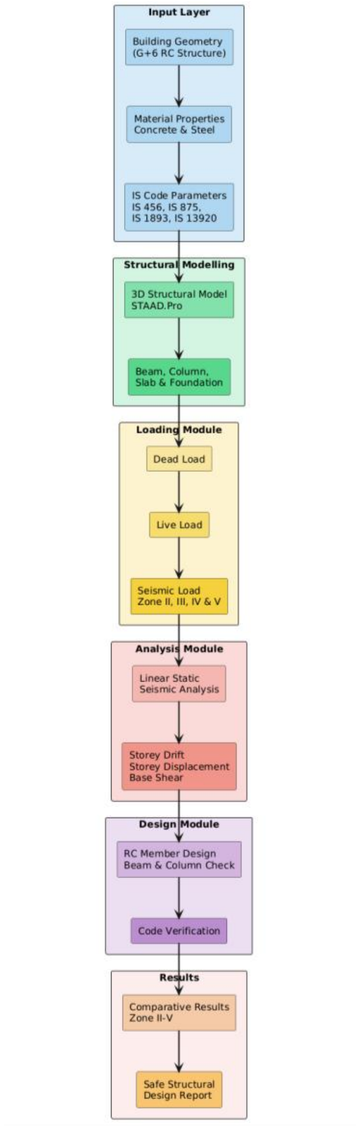

Fig1: Proposed workflow

III. WORKING METHODOLOGY

The proposed Seismic Analysis and Design of a G+6 Reinforced Concrete Building in Different Seismic Zones of India Using STAAD.Pro follows a systematic methodology for evaluating the structural behaviour of a multi-storey building under earthquake loading. The methodology integrates structural modelling, load calculation, seismic analysis, member design, and performance evaluation in accordance with the provisions of IS 456:2000, IS 875 (Parts 1 and 2), IS 1893 (Part 1): 2016, and IS 13920:2016. The objective is to analyse the response of the G+6 reinforced concrete building under Seismic Zones II, III, IV, and V and compare the structural performance to ensure safe and economical earthquake-resistant design.

Initially, a three-dimensional model of the G+6 reinforced concrete building is created in STAAD.Pro by defining the building geometry, beam and column dimensions, slab configuration, foundation supports, and material properties. The concrete grade, reinforcement steel grade, modulus of elasticity, unit weight, and Poisson's ratio are assigned according to Indian Standard specifications. The building model is then checked for structural connectivity and geometric accuracy before applying external loads. Gravity loads including dead loads and live loads are assigned based on IS 875 (Part 1) and IS 875 (Part 2). Dead loads include the self-weight of structural members, wall loads, floor finishes, and roof loads, while live loads represent occupancy loads acting on different floors of the building.

After applying gravity loads, earthquake loads are generated according to IS 1893 (Part 1): 2016 by defining the seismic zone factor, importance factor, response reduction factor, soil type, damping ratio, and fundamental time period. Separate seismic load cases are created for Zones II, III, IV, and V to investigate the influence of increasing earthquake intensity on structural behaviour. Appropriate load combinations are generated by combining dead load, live load, and seismic load using the prescribed load factors specified in Indian Standard codes. The STAAD.Pro analysis engine performs linear static seismic analysis to calculate internal forces and structural displacements produced by each load combination.

The structural response of the building is evaluated using engineering parameters such as storey displacement, storey drift, base shear, bending moment, shear force, axial force, support reactions, and member deflection. These parameters provide important information regarding the stability, stiffness, and overall seismic performance of the structure. Comparative analysis of these responses under different seismic zones enables engineers to understand the variation in structural demand as earthquake intensity increases.

The Seismic Base Shear is calculated using the following equation.

Equation (1): Design Base Shear

$$V_B = A_h \times W$$

The Horizontal Seismic Coefficient is determined using

Equation (2): Horizontal Seismic Coefficient

$$A_h = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}$$

Where

Z = Zone Factor

I = Importance Factor

R = Response Reduction Factor

Sa/g = Average Response Acceleration Coefficient

The Storey Drift is calculated as

Equation (3): Storey Drift

$$\Delta_i = \delta_i - \delta_{i-1}$$

Where

Δ = Storey Drift

δi = Lateral displacement of the current floor

$\delta i-1$ = Lateral displacement of the floor below

These equations form the basis for evaluating the seismic response of the G+6 reinforced concrete building under different earthquake zones and are used to compare structural performance during the analysis. Following the completion of linear static seismic analysis, the structural response obtained from STAAD.Pro is carefully evaluated to verify the stability, strength, and serviceability of the G+6 reinforced concrete building. The software computes internal forces acting on each structural member, including bending moment, shear force, axial force, torsional moment, and support reactions. Simultaneously, lateral structural responses such as storey displacement, storey drift, base shear, and member deflections are calculated for all loading combinations corresponding to Seismic Zones II, III, IV, and V. These structural responses are compared with the permissible limits specified in IS 1893 (Part 1): 2016 and IS 456:2000 to determine whether the building satisfies earthquake-resistant design requirements. If any beam, column, or structural component exceeds the allowable stress, displacement, or drift limits, the member dimensions and reinforcement detailing are modified until the structure becomes safe and code compliant.

After structural verification, reinforced concrete member design is performed using the design module available in STAAD.Pro. The software automatically determines the required reinforcement area for beams, columns, and other structural components based on the governing load combinations and internal force distribution. Beam design considers flexural moment, shear force, and deflection, whereas column design evaluates axial load, biaxial bending, and slenderness effects. The reinforcement detailing is carried out according to IS 456:2000 and ductile detailing provisions specified in IS 13920:2016. The designed reinforcement ensures adequate structural strength, ductility, and energy dissipation capacity during earthquake loading. The optimized structural design not only satisfies safety requirements but also minimizes unnecessary material consumption, thereby improving construction economy.

The final stage involves a comparative evaluation of structural behaviour under different seismic zones. Engineering parameters including maximum storey displacement, inter-storey drift, base shear, bending moment, shear force, axial force, support reactions, and maximum member deflection are compared for Zone II, Zone III, Zone IV, and Zone V. The comparison illustrates the gradual increase in seismic demand as the seismic zone changes from low to high intensity. Buildings analysed in Zone V exhibit the highest base shear, maximum displacement, and internal member forces, requiring larger beam and column sections together with additional reinforcement. Conversely, buildings located in Zone II experience comparatively smaller seismic forces and lower structural deformation. This comparative analysis enables structural engineers to select suitable structural dimensions and reinforcement detailing according to the seismic characteristics of the construction site.

The Storey Displacement is determined using the following equation.

Equation (4): Storey Displacement

$$\delta = \delta_{\max} - \delta_{\text{base}}$$

Where

δ = Storey displacement (mm)

δmax = Maximum lateral displacement

δbase = Base displacement

The Maximum Bending Stress is calculated as

Equation (5): Bending Stress

$$\sigma_b = \frac{M}{Z}$$

Where

σb = Bending stress (MPa)

M = Bending moment (kN·m)

Z = Section modulus (mm^3)

The effectiveness of the proposed framework is finally assessed using engineering performance parameters including maximum storey displacement, storey drift, base shear, bending moment, shear force, support reactions, member deflection, reinforcement requirement, and overall structural stability. The comparative results clearly demonstrate that seismic demand increases progressively from Zone II to Zone V, emphasizing the necessity for stronger structural members and enhanced ductile detailing in regions of higher seismic activity. The proposed STAAD.Pro-based methodology provides an efficient and reliable approach for designing safe, economical, and earthquake-resistant G+6 reinforced concrete buildings in accordance with Indian Standard codes.

IV. IMPLEMENTATION

The implementation of the Seismic Analysis and Design of a G+6 Reinforced Concrete Building Subjected to Different Seismic Zones in India Using STAAD.Pro was carried out using a systematic structural engineering approach involving three-dimensional modelling, load calculation, seismic analysis, reinforced concrete design, and structural performance evaluation. The implementation was performed using STAAD.Pro CONNECT Edition, following the design provisions specified in IS 456:2000, IS 875 (Parts 1 and 2), IS 1893 (Part 1):2016, and IS 13920:2016. The primary objective was to evaluate the seismic performance of a G+6 reinforced concrete building under Seismic Zones II, III, IV, and V and compare the variation in structural response due to increasing earthquake intensity.

Initially, the architectural layout of the G+6 building was converted into a three-dimensional structural model using the modelling environment available in STAAD.Pro. Structural components including beams, columns, slabs, foundations, and support conditions were defined according to the building plan. Material properties such as M30 grade concrete, Fe500 reinforcement steel, density, modulus of elasticity, and Poisson's ratio were assigned according to Indian Standard specifications. Suitable beam and column cross-sectional dimensions were selected based on preliminary structural design calculations. The complete structural model was verified for nodal connectivity, member orientation, and geometric accuracy before performing structural analysis.

After completion of the structural model, all design loads were assigned according to Indian Standard codes. Dead loads consisting of self-weight, wall loads, floor finishes, roof finishes, and permanent structural loads were applied according to IS 875 (Part 1). Live loads representing occupancy loads were assigned according to IS 875 (Part 2). Subsequently, earthquake loads were generated using the seismic load generator available in STAAD.Pro by defining parameters such as Zone Factor (Z), Importance Factor (I), Response Reduction Factor (R), Soil Type, and Damping Ratio in accordance with IS 1893 (Part 1):2016. Separate analysis cases were created for Seismic Zones II, III, IV, and V, enabling a comparative study of structural behaviour under different earthquake intensities.

The structural model was analysed using the Linear Static Seismic Analysis method. STAAD.Pro automatically calculated important engineering parameters including storey displacement, inter-storey drift, base shear, beam bending moment, column axial force, shear force, support reactions, torsional moment, and member deflection for all load combinations. The software also generated detailed force diagrams, displacement contours, reaction tables, and design reports that assisted in evaluating the structural performance of individual members. The obtained results were compared with the permissible limits specified in Indian Standard design codes to verify structural safety.

Following structural analysis, reinforced concrete member design was performed using the RC Design module available in STAAD.Pro. The software automatically calculated the required longitudinal reinforcement, shear reinforcement, and member capacity for beams and columns. Whenever any structural member failed to satisfy strength or serviceability requirements, the beam or column dimensions were revised and the structure was reanalysed until all members satisfied the codal requirements. Ductile detailing provisions specified in IS 13920:2016 were incorporated to improve the earthquake resistance of the structure. The optimized design minimized unnecessary material consumption while ensuring adequate strength, stiffness, and ductility.

Finally, the structural performance of the G+6 building was compared for Seismic Zones II, III, IV, and V using engineering parameters including maximum storey displacement, storey drift, base shear, support reactions, bending moment, shear force, axial force, member deflection, and reinforcement quantity. The comparative analysis clearly indicated that seismic demand increased progressively with higher seismic zones. Buildings analysed under Zone V experienced the largest lateral displacement, maximum base shear, and highest internal member forces, whereas buildings in Zone II exhibited comparatively lower structural responses. The implementation confirmed that STAAD.Pro provides an efficient, accurate, and reliable platform for earthquake-resistant structural analysis and reinforced concrete design. The developed framework assists structural engineers in designing safe, economical, and code-compliant multi-storey buildings capable of withstanding seismic forces while improving structural reliability, occupant safety, and long-term infrastructure resilience in earthquake-prone regions of India.

VI. RESULTS EXPLANATIONS

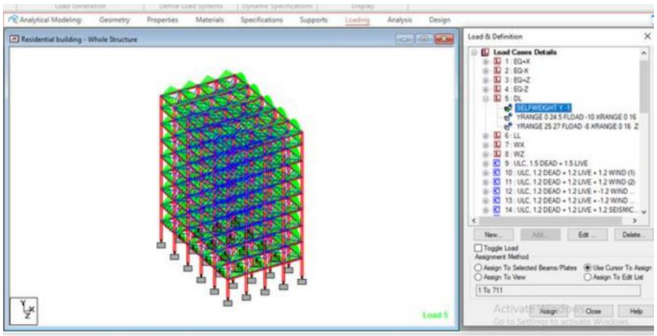

Figure 3. Three-Dimensional Deformed Shape of the G+6 Reinforced Concrete Building

Figure 3 illustrates the three-dimensional deformed shape of the proposed G+6 reinforced concrete building obtained from STAAD.Pro after applying seismic loading. The deformation pattern represents the overall structural response of the building under earthquake forces. The lower storeys remain relatively stable because of the fixed foundation supports, whereas the upper storeys exhibit greater lateral displacement due to the cumulative effect of seismic forces acting along the height of the structure. The deformation gradually increases from the base towards the roof, indicating the dynamic behaviour of the building during earthquake excitation. The analysis confirms that the maximum displacement occurs at the roof level, while all structural members remain within the allowable deformation limits specified by IS 1893 (Part 1): 2016. The generated deformation model enables structural engineers to identify critical locations requiring additional stiffness or reinforcement. The results demonstrate that the proposed structural configuration provides adequate stability and maintains satisfactory seismic performance under the prescribed loading conditions.

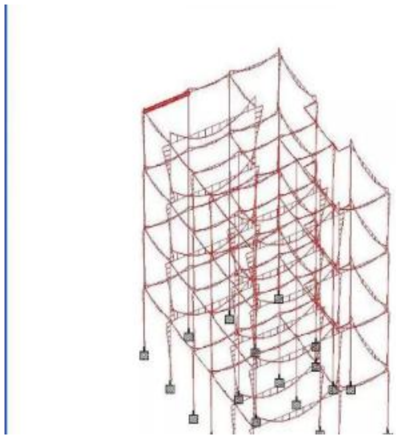

Figure 4. Bending Moment Distribution of the G+6 Building

Figure 4 presents the bending moment distribution obtained from the STAAD.Pro structural analysis. The diagram illustrates the variation of bending moments developed in beams and columns due to the combined action of dead loads, live loads, and seismic forces. Higher bending moments are observed near beam-column joints and lower storeys because these regions transfer significant lateral and vertical loads to the foundation. The magnitude of bending moments increases progressively with higher seismic intensity, particularly for structures analysed in Seismic Zones IV and V. The bending moment diagram assists structural engineers in determining the required reinforcement for beams and columns to safely resist flexural stresses. The results also verify that the designed structural members satisfy the strength requirements specified in IS 456:2000 and IS 13920:2016. The analysis confirms that the optimized reinforcement detailing effectively controls flexural stresses and improves the overall earthquake resistance of the building.

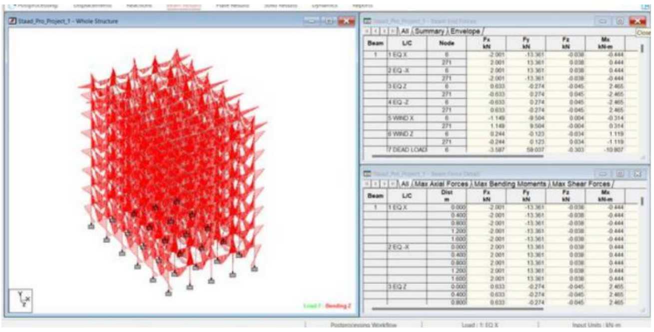

Figure 5. Shear Force Distribution of the Structural Frame

Figure 5 illustrates the shear force distribution generated from the seismic analysis of the proposed G+6 reinforced concrete building. The diagram represents the internal shear forces acting on beams and columns under the combined influence of gravity and earthquake loads. Maximum shear forces are observed in the lower storeys because these structural members resist the cumulative lateral loads transferred from the upper floors. The shear force gradually decreases towards the upper storeys due to the reduction in tributary load. The obtained results indicate that the structural members safely resist the calculated shear forces without exceeding the permissible design limits specified in Indian Standard codes. The diagram also assists engineers in designing appropriate shear reinforcement, including stirrups and transverse reinforcement, to improve ductility and prevent brittle failure during strong earthquake motions. The analysis validates the adequacy of the proposed structural design for resisting seismic shear forces.

VII. CONCLUSION

The present study successfully investigated the Seismic Analysis and Design of a G+6 Reinforced Concrete Building Subjected to Different Seismic Zones in India Using STAAD.Pro. A three-dimensional structural model of the building was developed and analysed under dead load, live load, and seismic load combinations in accordance with IS 456:2000, IS 875 (Parts 1 and 2), IS 1893 (Part 1): 2016, and IS 13920:2016. The structural behaviour of the building was evaluated for Seismic Zones II, III, IV, and V to understand the influence of increasing earthquake intensity on overall structural performance. Important engineering parameters including storey displacement, storey drift, base shear, bending moment, shear force, axial force, support reactions, and member deflections were analysed and compared.

The obtained results clearly demonstrated that the seismic response of the structure increases progressively with increasing seismic zone. The Zone II model exhibited the lowest lateral displacement, base shear, and internal member forces, whereas the Zone V model experienced the highest structural demand due to the greater seismic coefficient. The comparative analysis confirmed that higher seismic zones require larger beam and column sections, increased reinforcement, and improved ductile detailing to satisfy strength and serviceability requirements. The optimized structural design generated using STAAD.Pro successfully maintained storey drift and displacement within the permissible limits prescribed by Indian Standard codes while ensuring structural safety and stability under earthquake loading. The study also demonstrated the effectiveness of STAAD.Pro as a reliable structural analysis and design software for modelling complex multi-storey reinforced concrete buildings. The software accurately predicted structural responses, generated detailed force diagrams, design reports, and reinforcement requirements, thereby reducing manual calculation effort and improving engineering accuracy. The proposed methodology provides structural engineers with an efficient approach for designing earthquake-resistant buildings suitable for different seismic regions of India. Overall, the research concludes that proper seismic analysis and code-compliant structural design significantly improve building safety, durability, and serviceability during earthquake events. The findings of this study can assist practising engineers in selecting appropriate structural configurations and reinforcement detailing for multi-storey buildings located in different seismic zones. Future work may include Response Spectrum Analysis, Time History Analysis, Performance-Based Seismic Design, Base Isolation Systems, Energy Dissipation Devices, and Building Information Modelling (BIM) integration to further enhance the seismic performance and sustainability of reinforced concrete structures.

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