iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** VIII **Month of publication:** August 2025

DOI: https://doi.org/10.22214/ijraset.2025.73766

Analysis and Design of Multistoried Building By Using Software For Different Earthquake Zones: A Review

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Abstract: This study synthesizes findings from various research on the seismic analysis of multi-story buildings. It highlights the crucial role of software tools like ETABS and STAAD-Pro in conducting static and dynamic analyses across different seismic zones and soil conditions. A key finding across multiple studies is the significant improvement in seismic performance achieved through the incorporation of shear walls, which effectively reduce storey drift and enhance base shear resistance in both regular and irregular building configurations. The analysis also underscores the vulnerability of irregular building plans to increased deformation and torsional effects during seismic events, advocating for symmetrical designs in high-risk zones. Furthermore, the importance of employing dynamic analysis methods, such as response spectrum and time history analysis, is emphasized for a comprehensive understanding of structural behavior under seismic loads. The influence of building height on seismic response parameters is also noted. Finally, the necessity of adhering to relevant seismic design codes from India (IS) and Bangladesh (BNBC) is highlighted to ensure the safety and stability of multi-story structures in earthquake-prone regions.
Keywords: Seismic analysis, Multi-story buildings, Shear walls, Irregular structures, Dynamic analysis, Seismic codes.

I. INTRODUCTION

In modern urban environments, the demand for housing, commercial spaces, and infrastructure has grown exponentially due to rapid urbanization and population growth. With limited availability of horizontal space, vertical expansion through multi-story buildings has become a practical and necessary solution. These structures, ranging from medium-rise residential apartments to high-rise skyscrapers, play a pivotal role in addressing space constraints while accommodating various functionalities such as offices, residences, and mixed-use developments.

A. Key Considerations in Multi-Story Building Design

The design of multi-story buildings requires a comprehensive understanding of several factors to ensure their safety, durability, and usability. These include:

Structural Integrity: Ensuring the building's ability to carry vertical and horizontal loads, including dead loads (self-weight), live loads (occupants and furniture), and environmental loads such as wind and seismic forces.

Safety: Protecting occupants from potential hazards, particularly in regions prone to earthquakes or extreme weather conditions. This involves integrating features like reinforced concrete frames, shear walls, and bracing systems.

Functionality: Designing layouts that maximize usable space while maintaining structural efficiency. This includes appropriate placement of columns, beams, and walls to meet architectural and operational requirements.

B. Seismic Considerations in Multi-Story Design

In seismically active regions, designing multi-story buildings poses unique challenges. Earthquakes induce dynamic forces that can cause significant structural damage if not adequately addressed. Incorporating earthquake-resistant features into building design is essential to prevent collapse and minimize damage. Key elements include:

Flexibility and Ductility: Allowing the structure to absorb and dissipate seismic energy without sudden failure.

Base Isolation and Dampers: Reducing the impact of ground motion on the building by isolating the foundation or dissipating energy.

Load Path Continuity: Ensuring that seismic forces are effectively transferred from the roof to the foundation.

C. Role of Software Tools in Design

Modern software tools, such as STAAD-PRO, ETABS, and SAP2000, have become indispensable in the design of multi-story buildings. These tools enable engineers to:

Model Complex Geometries: Accurately represent the structural components of the building, including irregular shapes and layouts.

Perform Dynamic Analysis: Simulate the building's response to seismic forces, identifying potential weaknesses and optimizing the design accordingly.

Optimize Material Usage: Achieve a balance between structural safety and cost-efficiency by selecting appropriate materials and configurations.

Streamline Workflow: Reduce design time by automating calculations and generating detailed reports, drawings, and specifications.

Incorporating advanced software in the design process ensures that multi-story buildings are not only efficient and economical but also capable of withstanding the challenges posed by seismic forces, making them integral to sustainable urban development.

D. Importance of Earthquake-Resistant Design

Earthquakes are among the most destructive natural disasters, capable of causing widespread devastation to infrastructure, significant economic losses, and tragic loss of life. The unpredictability of seismic events and the forces they generate necessitate robust design practices to ensure the safety and longevity of buildings, particularly in seismically active regions.

II. LITERATURE REVIEW

The design and analysis of earthquake-resistant structures have been extensively studied to mitigate the risks posed by seismic activities. This chapter reviews existing research on the seismic behavior of multi-story buildings, focusing on both regular and irregular configurations. It highlights key findings related to static and dynamic analyses, the impact of different soil types, and the influence of seismic zones. Additionally, the chapter discusses various methodologies, tools, and design approaches used to evaluate and enhance the structural performance of buildings under seismic loads. This review serves as the foundation for identifying gaps and establishing the scope of the current study.

Mahesh, S., & Rao, M. D. B. P. (2014) [1] has studied the behaviour of G+11 multi story building of regular and irregular configuration under earth quake is complex and it varies of wind loads are assumed to act simultaneously with earth quake loads. In this paper a residential of G+11 multi story building is studied for earth quake and wind load using ETABS and STAAS PRO V8i .Assuming that material property is linear static and dynamic analysis are performed. These analysis are carried out by considering different seismic zones and for each zone the behaviour is assessed by taking three different types of soils namely Hard , Medium and Soft .Different response like story drift, displacements base shear are plotted for different zones and different types of soils.

Kumar, E. P., et al (2014) [2] observed that earthquake occurred in multistoried building shows that if the structures are not well designed and constructed with and adequate strength it leads to the complete collapse of the structures. To ensure safety against seismic forces of multi-storied building hence, there is need to study of seismic analysis to design earthquake resistance structures. In seismic analysis the response reduction was considered for two cases both Ordinary moment resisting frame and Special moment resisting frame. The main objective this paper is to study the seismic analysis of structure for static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis are the methods used in structural seismic analysis. We considered the residential building of G+ 15 storied structure for the seismic analysis and it is located in zone II.

Ahamad, S. A., & Pratap, K. V. (2021) [3] found that the Multi storied building with G + 20 is analyzed for storey drift, base shear, maximum allowable displacement and torsional irregularity. The analysis and modeling for the whole structure is done by using prominent FEM integrated software named Etabs 2015 in all the seismic zones of India prescribed by IS 1893 (Part-1) −2016. In this project the dynamic analysis is carried out on type -III (i.e., soft soil) for a irregular structure in plan in all the zones as specified and it is concluded that the structure with shear walls (i.e., Case C) placed symmetrically will show better results in terms of all the seismic parameters when compared with the structures without shear wall (i.e., Case A) and with shear wall at one end (i.e., Case B).

Sharma, M., & Maru, D. S. (2014) [4] studied that reinforced concrete (RC) frame buildings are most common type of constructions in urban India, which are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to the wind and earthquake. Here the present works (problem taken) are on a G+30 storied regular building. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of

STAAD-Pro software using the parameters for the design as per the IS-1893- 2002-Part-1 for the zones- 2 and 3 and the post processing result obtained has summarized.

Rathod, P., & Chandrashekar, R. (2017) [5] observed that storey shear inversely varies with respect to number of storeys. Storey stiffness increases with increase in storey height. But this case is satisfied only till 6th storey level. The value of shear stiffness is maximum for all the shape. But after 6th storey, the stiffness goes on decreasing. Joint displacement is directly proportional to the storey levels or no of storey. The values are maximum for Lshaped structure suggesting maximum deformation in that particular shape. It is lowest in rectangular shaped structure due to similarity of the structure. Centre of mass displacement is directly proportional to number of storeys. It is observed that maximum value of Centre of mass displacement is in T-shaped structure followed by I-shaped structure. L-shaped structure has the lowest value amongst the 4 shapes. It is observed that asymmetrical plans undergo more deformation than symmetrical plans and therefore while constructing a new structure in high seismic zone, it is most likely to construct a structure which is symmetric in shape so as to provide better stability.

Haque, M., et al (2016) [6] found that seismic performance analysis is highly recommended to ensure safe and sound building structures for this region. To get better performance from reinforced concrete (RCC) structure, new seismic design provisions require structural engineers to perform both static and dynamic analysis for the design of structures. The objective of the this study is to carry out static and dynamic analysis i.e. equivalent static analysis, response spectrum analysis (RSA) and time history analysis (THA) over different regular and irregular shaped RCC building frame considering the equal span of each frame as per Bangladesh National Building Code (BNBC)- 2006. In this study, four different shaped (W-shape, L-shape, Rectangle, Square) ten storied RCC building frames are analysed using ETABS v9.7.1 and SAP 2000 v14.0.0 for seismic zone 3 (Sylhet) in Bangladesh. Comparative study on the maximum displacement of different shaped buildings due to static loading and dynamic response spectrum has been explored. From the analyzed results it has been found that, for static load analysis, effects of earthquake force approximately same to all models except model-1(W-shape).

Sarath, C. S., et al (2022) [7] found that the results of analysis are used to verify the structure stability for use. Computer aided software is also being used for calculation of forces, bending moment, stress, strain vs deformation or deflection of a complex structural system. The aim of this project is the comparative study on design and analysis of high-rise multistorey building by using STAAD. Pro software. STAAD. Pro is one of the most commonly used software for fast and efficient construction of high-rise buildings. In this project we analyze a multistorey building by considering the building components (such as beams, columns & slabs) to develop the economic design. The total structure was completely analyzed by computer using STAAD. Pro software.

Kalsait, V. S., & Varghese, V. (2015) [8] concluded that the structure should withstand the moderate earthquakes, which may be expected to occur during the service life of structure with damage within acceptable limits. Such earthquakes are characterized as Design Basis Earthquakes (DBE). The building is modeled as a 3D space frame with six degrees of freedom at each node using the software STAAD- PRO. Building (G+15) is analyzed using Response Spectrum method on 0°, 7.5°, 15°, 22° slope ground. The Response Spectrum as per IS 1893 (Part 1):2002 for medium soil is used. Comparison of results for (G+15) building is done for different slope and same soil condition. Analysis is performed for various load cases and combinations and the worst case is considered for the design of beams and columns. Reinforced concrete design is carried out as Per IS 456: 2000 and ductile detailing is done as per IS 13920: 1993. Various static checks are applied on the results.

Giberson, M. F. (1967) [9] found that the dynamic responses of a 20-story nonlinear structural frame representative of a modern high rise building are analyzed with the aid of a digital computer. Related analytical studies of continuous systems are carried out. Quantitative information is provided on the importance of a wide range of modes to the various responses of a multistory structure during an earthquake. The effect of yielding on the response is observed. The magnitude of the structural responses are compared with common measurements of earthquake strength. At the ends of each girder and column of the structural frame are yield hinges which have bilinear bending moment-rotation hysteretic characteristics. Two beam models having such characteristics are studied; one of these models can treat curvilinear hysteretic behavior. Three definitions of ductility factor are discussed, one of which is applicable to both bilinear and curvilinear hysteresis loops.

Gottala, A., et al (2015) [10] studied a multi-storied framed structure of (G+9) pattern is selected. Linear seismic analysis is done for the building by static method (Seismic Coefficient Method) and dynamic method (Response Spectrum Method) using STAAD-Pro as per the IS-1893-2002-Part-1. A comparison is done between the static and dynamic analysis, the results such as Bending moment, Nodal Displacements, Mode shapes are observed, compared and summarized for Beams, Columns and Structure as a whole during both the analysis.

Farqaleet, A. (2016) [11] found that the important objective of earthquake engineers is to design and build a structure in such a way that damage to the structure and its structural component during the earthquake is minimize. This report aims towards the dynamic analysis of a multistorey RCC building with symmetrical configuration. For the analysis purpose model of ten storey RCC with symmetrical floor plan is consider. The analysis is by carried by using finite element based software. Various response parameters such as lateral force, base shear , story drift , story shear can be determined. For dynamic analysis time history method or response spectra method can be used .Time-history analysis is a step-by-step analysis of the dynamical response of a structure to a specified loading that may vary with time.

Atif, M., et al (2015) [12] focuses on comparison of seismic analysis of G+19 building stiffened with bracings and shear wall. The performance of the building is analyzed in Zone II, Zone III, Zone IV, Zone V. The study includes understanding the main consideration factor that leads the structure to perform poorly during earthquake in order to achieve their appropriate behavior under future earthquakes. The analyzed structure is symmetrical, G+19, Ordinary RC moment-resting frame (OMRF). Modelling of the structure is done as per staad pro. V8i software. Time period of the structure in both the direction is retrieve from the software and as per IS 1893(part 1):2002 seismic analysis has undergone. The Lateral seismic forces of RC frame is carried out using linear static method as per IS 1893(part 1) : 2002 for different earthquake zones.

III. CONCLUSIONS

Studies emphasize the importance of seismic analysis for multi-story buildings, highlighting the use of software like ETABS and STAAD-Pro for static and dynamic analysis across different seismic zones and soil types. Shear walls are consistently shown to significantly improve seismic performance by reducing storey drift and increasing base shear resistance in irregular and regular buildings. Irregular building configurations tend to exhibit greater deformation and torsional irregularity compared to regular, symmetrical plans, suggesting symmetrical designs are preferable in high seismic zones. Dynamic analysis methods like response spectrum and time history analysis are crucial for understanding the structural response to earthquake forces and are often compared with equivalent static analysis. Building height and number of storeys influence seismic parameters like storey shear and displacement, with taller buildings potentially experiencing larger deformations. Design considerations based on Indian (IS) and Bangladesh (BNBC) seismic codes are essential for ensuring the safety and stability of structures in earthquake-prone regions.

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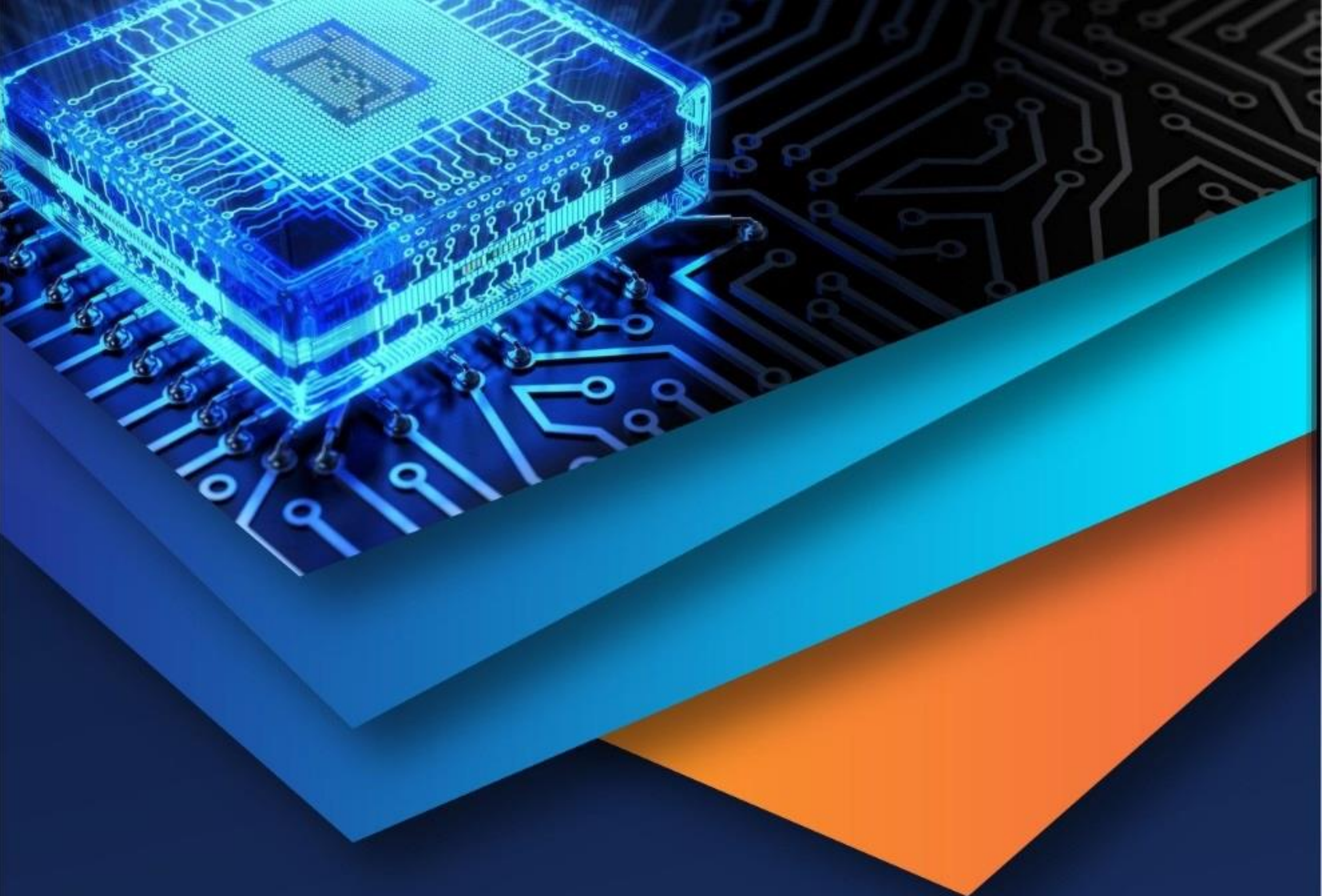

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