International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Seismic Performance Assessment of Buildings Using STAAD. Pro Software

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Abstract

This study explores the seismic behavior of high-rise buildings using STAAD.Pro, a structural engineering software. By simulating the dynamic performance of a G+10 reinforced concrete (RCC) building in seismic Zone IV of India, this research evaluates how such structures respond to earthquake-induced forces. The investigation considers two methods—Equivalent Static and Response Spectrum—aligned with IS 1893:2016 standards. Parameters like base shear, inter-storey drift, displacement, and fundamental period are analyzed. The outcome emphasizes STAAD.Pro's capability in simulating realistic seismic responses, offering practical insights for performance-based design.

Keywords: Seismic Design, STAAD.Pro, RCC Structures, Earthquake Loads, Structural Simulation, IS 1893:2016

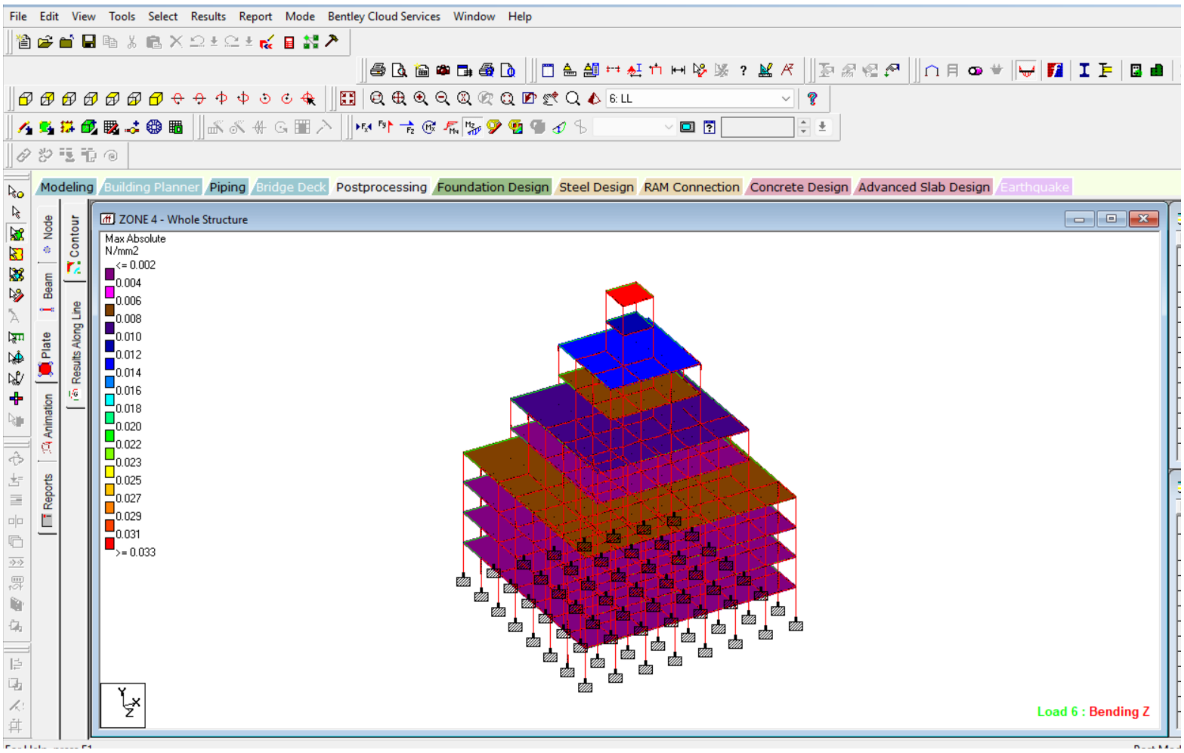
1. INTRODUCTION

1.1 Background

In regions prone to earthquakes, ensuring that buildings can resist seismic forces is essential to public safety. Modern engineering relies heavily on computational tools to perform complex structural analyses. Among these, STAAD.Pro has become a popular choice for modeling, analyzing, and designing buildings to withstand dynamic forces such as those generated by earthquakes.

1.2 Objectives

- Model a ten-story RCC structure in STAAD.Pro.
- Apply seismic loads according to IS 1893:2016.
- Perform analysis using both static and dynamic approaches.
- Compare critical performance indicators under different loading scenarios.



2. Methodology

2.1 Structure Details

- Configuration: G+10 RCC building
- Plan Dimensions: 21m x 21m
- Story Height: 3m
- Total Height: 33m
- Seismic Zone: IV (as per Indian standards)
- Importance Factor: 1.0
- Soil Classification: Medium (Type II)

2.2 Tools and Codes Used

The model was developed in STAAD.Pro CONNECT Edition. Design provisions were followed from IS 456:2000, and seismic forces were assigned as per IS 1893:2016 (Part 1).

2.3 Loading Considerations

- Dead Loads: Self-weight of structural elements
- Imposed Loads: 3 kN/m² live load
- Earthquake Loads: Based on code-defined parameters
- Load Combinations: As prescribed in IS 875 (Part 5)

2.4 Analytical Approach

- The Equivalent Static Method provides a simplified representation of lateral forces.
- The Response Spectrum Method captures the dynamic characteristics of the structure under seismic excitation.

3. Literature Review

3.1 Method of flexibility coefficient

The analysis method involves simplifying a statically indeterminate (hyperstatic) structure into a determinate form by eliminating redundant supports or inserting appropriate cuts or hinges.

Limitation:

This approach is generally not suitable for structures with a redundancy degree greater than three.

3.2 Slope displacement equations

This method is particularly effective when the number of kinematic (displacement-related) unknowns is less than the number of static unknowns. Originally introduced by Axel Bendixsen in 1914, the technique is grounded in the principles of equilibrium and compatibility. It is called the slope-displacement method because it explicitly calculates joint rotations (slopes) and lateral displacements. These values are used to formulate a system of simultaneous equations, which are then solved to determine the internal moments at the joints of structural members.

Limitations:

Solving these equations manually can be time-consuming, especially for large structures. Therefore, this method is generally not preferred for frames with more than two ways or more than two stories.

4. Structural Modeling in STAAD.Pro

4.1 Frame Definition

The structure was modeled using concrete frame elements. Beams were sized at 300mm x 450mm, while columns measured 450mm x 600mm. The model incorporates rigid floor diaphragms to distribute lateral forces uniformly.

4.2 Material Specifications

Concrete: M30

Steel: Fe500

4.3 Support Conditions

Base supports were considered fixed. No soil-structure interaction was modeled.

4.4 Seismic Design Inputs

- Zone Factor (Z): 0.24
- Importance Factor (I): 1.0
- Response Reduction Factor (R): 5 (SMRF)
- Soil Type: Medium

5. Results and Interpretation

5.1 Time Period

STAAD.Pro computed the fundamental natural period as 1.45 seconds, aligning closely with the empirical value of 1.44 seconds.

5.2 Displacement Analysis

Maximum lateral displacement was 42.5 mm at the roof, within the permissible limit of H/250 (132 mm).

5.3 Drift Values

Inter-story drift peaked at 0.0027, which is below the maximum threshold of 0.004 defined by IS 1893.

5.4 Base Shear Comparison

Base shear under static loading was 1800 kN, whereas dynamic analysis yielded 1520 kN—indicating reduced demand due to modal effects.

5.5 Modal Participation

The first three modes contributed over 90% of the mass participation, ensuring analytical accuracy.

6. Conclusion

The study confirms that STAAD.Pro is a reliable platform for conducting seismic evaluations. The RCC structure analyzed conforms to IS 1893:2016 design expectations under both static and dynamic analyses. The Response Spectrum Method offers more nuanced insights, particularly for taller structures. The results underscore the importance of dynamic analysis for realistic assessment of seismic performance.

7. Future Scope

- Analyze irregular structures with plan or elevation discontinuities.
- Incorporate Time History Analysis for near-field seismic effects.
- Investigate soil-structure interaction for foundation response.

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