

Dynamic Seismic Analysis of G+14 High-Rise RC Building Using Response Spectrum Method in STAAD.Pro

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Abstract - The rapid growth of urban areas has led to increased construction of high-rise buildings. These structures are highly sensitive to seismic forces due to their height and flexibility. Dynamic analysis is therefore essential to evaluate the structural response during earthquakes. In this study, a G+14 reinforced concrete building is analyzed using the response spectrum method. The structural model was developed using STAAD.Pro software and analyzed according to IS 1893 (Part 1): 2016 and IS 456:2000 provisions. Important parameters such as storey displacement, storey drift, base shear, and natural time period were evaluated. The results show that response spectrum analysis provides accurate prediction of seismic response and helps ensure safe design of high-rise RC structures.

Key Words: High Rise Building, Dynamic Analysis, Response Spectrum Method, Seismic Analysis, STAAD.Pro, Storey Drift.

1. INTRODUCTION

High-rise reinforced concrete buildings are increasingly constructed in urban regions due to limited land availability. However, these structures are more vulnerable to lateral loads such as earthquakes. Seismic forces cause vibrations in structures which may lead to excessive displacement or structural failure.

Dynamic analysis is an important tool used to understand the response of structures during earthquakes. The response spectrum method considers the dynamic characteristics of the structure such as natural frequency and mode shapes. The objective of this research is to analyze the seismic performance of a G+14 reinforced concrete building using response spectrum analysis

1.1 Objectives of Study

- To perform dynamic analysis of a G+14 RC building.
- To determine storey displacement and storey drift.
- To evaluate base shear generated during seismic loading.
- To study structural behavior using response spectrum analysis.

2. LITERATURE REVIEW

Anil K. Chopra (2012), stated that dynamic analysis plays a crucial role in understanding the behavior of structures subjected to earthquake excitation. His work on structural dynamics explains that the response spectrum method provides an efficient approach for estimating maximum structural response without performing detailed time history analysis. The method considers natural frequencies and mode shapes of structures, which significantly influence seismic behavior.

S. K. Duggal (2013), emphasized that earthquake-resistant design must consider lateral forces, structural stiffness, and energy dissipation capacity of buildings. His research explains that reinforced concrete moment-resisting frames are commonly used in seismic regions due to their ability to resist lateral loads effectively.

C. S. Agarwal and B. K. Agarwal (2015), investigated earthquake-resistant design of buildings and highlighted the importance of considering dynamic characteristics of structures during analysis. Their research demonstrated that buildings with greater height tend to exhibit larger displacements and require careful design to ensure stability and serviceability.

Clotaire Michel et al. (2007), conducted full-scale dynamic testing of reinforced concrete buildings under weak seismic motions and ambient vibrations. Their research showed that modal parameters obtained from field measurements can help validate analytical models and improve accuracy of seismic analysis.

Hassan Moniri (2017), studied the seismic performance of reinforced concrete buildings subjected to near-field earthquakes and found that dynamic analysis methods provide better prediction of structural response compared to simplified static approaches. The study also highlighted that high-rise buildings are more sensitive to earthquake-induced vibrations due to their flexibility.

V. D. Pawar and R. S. Patil (2019), compared equivalent static analysis with response spectrum analysis for multi-storey buildings. They performed response spectrum analysis of reinforced concrete structures and found that dynamic analysis methods provide more accurate estimation of storey drift and displacement.

Kislay Kashyap and M. P. Verma (2019), studied dynamic analysis of high-rise buildings using response spectrum method and concluded that displacement increases with height while drift values remain within permissible limits when structures are properly designed according to seismic codes.

A. Surwase et al. (2018), performed seismic analysis of multi-storey buildings using structural analysis software. His study confirmed that dynamic analysis methods such as response spectrum analysis provide reliable results for evaluating seismic behavior of structures.

R. Ghosh and R. Debbarma (2017), evaluated the seismic performance of setback buildings with open ground storey and observed that irregularities in building configuration significantly influence seismic response. Their study highlighted the importance of proper structural modeling in earthquake analysis.

From the literature review, it is evident that dynamic analysis plays a crucial role in the design of high-rise reinforced concrete buildings located in earthquake-prone regions. Most researchers recommend using response spectrum analysis for buildings with more than ten storeys to accurately evaluate structural response under seismic loading.

Therefore, the present study focuses on performing seismic analysis of a G+14 reinforced concrete residential building using the response spectrum method. The building model is developed using STAAD.Pro and analyzed according to Indian seismic design provisions specified in IS 1893 (Part 1): 2016.

The objective of this research is to evaluate key seismic parameters such as storey displacement, storey drift, base shear, and natural time period in order to assess the structural performance of the building under earthquake loading.

3. METHODOLOGY

The objective of this research is to evaluate the seismic performance of a G+14 reinforced concrete residential building subjected to earthquake forces. The structural model was developed and analyzed using STAAD.Pro structural analysis software. The analysis was carried out according to Indian Standard codes including IS 1893 (Part 1): 2016 for earthquake resistant design and IS 456:2000 for reinforced concrete design.

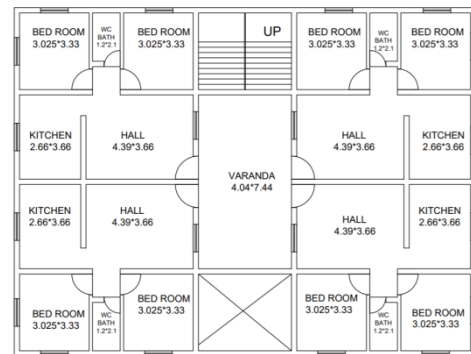


Figure 1. Building Plan

3.1 Building Description:-

The building considered in this study is a multi-storey reinforced concrete residential structure consisting of ground floor plus fourteen upper storeys (G+14). The plan of the building is symmetrical, which helps in reducing torsional irregularities during seismic loading.

Table 1. Building Description

Parameter	Value
Building Type	Residential
Storeys	G+14
Storey Height	3 m
Total Height	45 m
Column Size	400 mm × 600 mm
Beam Size	230 mm × 500 mm
Slab Thickness	150 mm
Concrete Grade	M30
Steel Grade	Fe500
Seismic Zone	Zone V
Soil Type	Medium

The building was modeled and analyzed using STAAD.Pro.

3.2 Load Considerations:-

The loads applied to the building were determined according to Indian Standard codes. Dead loads were calculated based on the self-weight of structural elements and floor finishes

according to IS 875 (Part 1): 1987. Live loads were applied according to IS 875 (Part 2): 1987.

Typical loads considered in the analysis include:

Table 2. Load Considerations

Parameter	Value
Building Type	Residential
Storeys	G+14
Storey Height	3 m
Total Height	45 m

3.3 Seismic Parameters :-

Table 3. Seismic Parameters

Parameter	Value
Zone Factor (Z)	0.36
Importance Factor (I)	1.0
Response Reduction Factor (R)	5
Damping	5%

These parameters were used to generate the response spectrum curve used in dynamic analysis.

3.4 Structural Modeling :-

The structural model of the building was created in STAAD.Pro using the following steps:

- Creation of three-dimensional geometry of the building.
- Assignment of beam and column properties.
- Definition of material properties for concrete and steel.
- Application of dead load and live load.
- Definition of seismic load cases.
- Generation of load combinations.
- Execution of structural analysis.

3.5 Analysis Methods:-

Two seismic analysis methods were used in this study.

- Equivalent Static Analysis** - In this method, earthquake forces are calculated based on the total seismic weight of the building and distributed along the height according to code provisions.

- Response Spectrum Analysis** - Response spectrum analysis is a dynamic analysis technique that considers multiple vibration modes of the structure. The maximum response of each mode is combined to determine the overall structural response.

4. RESULTS AND DISCUSSION

The results obtained from the analysis include storey displacement, storey drift, base shear, and natural time period of the structure.

4.1 Story Displacement:-

Storey displacement refers to the lateral movement of each floor due to earthquake forces. The results show that displacement increases with building height.

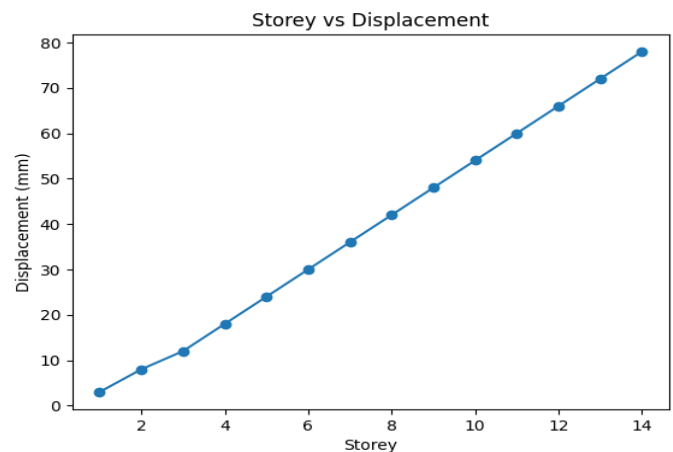


Chart 1. Storey vs Displacement

Table 4. Storey vs Displacement

Storey	Displacement (mm)
14	78
13	72
12	66
11	60
10	54
9	48
8	42
7	36
6	30
5	24
4	18
3	12
2	8
1	3

The maximum displacement occurs at the top storey, which is expected because the cumulative flexibility increases with height.

4.2 Storey Drift :-

Storey drift represents the relative displacement between two consecutive storeys.

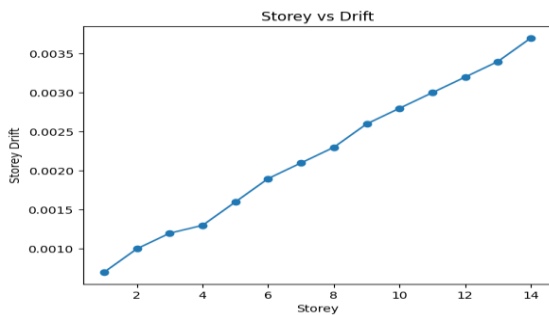


Chart 2. Storey vs Drift

Table 5. Storey vs Drift

Storey	Drift
14	0.0037
12	0.0032
10	0.0028
8	0.0023
6	0.0019
4	0.0013
2	0.0007

The permissible drift limit according to IS 1893 (Part 1):

2016 is: $0.004 \times \text{storey height}$

The obtained drift values are within allowable limits, indicating satisfactory seismic performance.

4.3 Base Shear :-

Base shear represents the total lateral force acting at the base of the structure during an earthquake.

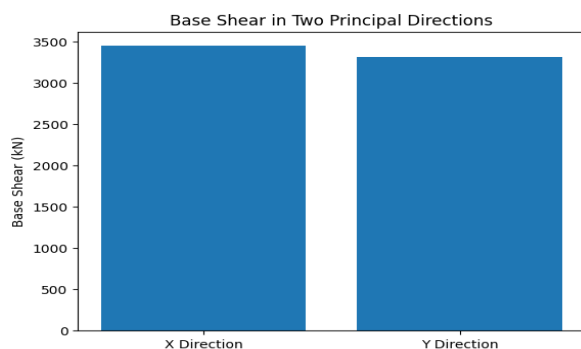


Chart 3. Base Shear

Table 6. Base Shear

Direction	Base Shear (kN)
X Direction	3450
Y Direction	3320

The base shear values obtained from response spectrum analysis are distributed along the building height according to mass participation.

4.4 Natural Time Period:-

The fundamental natural time period of the building was obtained from modal analysis.

Fundamental Time Period = 1.45 seconds

This value indicates that the building behaves as a flexible structure, which is typical for high-rise reinforced concrete buildings.

5. CONCLUSION

The present study investigated the seismic behavior of a G+14 reinforced concrete residential building using dynamic analysis methods.

The following conclusions can be drawn from the study:

1. Storey displacement increases gradually with building height, with maximum displacement occurring at the top storey.
2. Storey drift values obtained from analysis are within the permissible limits specified in IS 1893 (Part 1): 2016.
3. The base shear values indicate the magnitude of seismic forces acting on the structure in different directions.
4. The response spectrum method provides a more realistic estimation of seismic forces compared to equivalent static analysis.
5. The structural model developed in STAAD.Pro effectively simulates the dynamic behavior of the building.

Therefore, dynamic analysis techniques should be adopted for the design of high-rise buildings located in earthquake-prone regions.

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