



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

 [ijirset@gmail.com](mailto:ijirset@gmail.com)

 [www.ijirset.com](http://www.ijirset.com)

# Analysis and Design of High-Rise Buildings in Seismic Zones

Suryawanshi Rohankumar Prakashrao, Prof. Sushant M. Gajbhiye

P.G. Student, Department of Civil Engineering, Guru Nanak Institute of Engineering and Technology, Nagpur,  
Maharashtra, India

Associate Professor, Department of Civil Engineering, Guru Nanak Institute of Engineering and Technology, Nagpur,  
Maharashtra, India

**ABSTRACT:** Reinforced Concrete Frames are the most commonly adopted buildings construction practices in India. With growing economy, urbanization and unavailability of horizontal space increasing cost of land and need for agricultural land, high-rise sprawling structures have become highly preferable in Indian buildings scenario, especially in urban. With high-rise structures, not only the building has to take up gravity loads, but as well as lateral forces. Many important Indian cities fall under high risk seismic zones, hence strengthening of buildings for lateral forces is a prerequisite. In this study the aim is to analyze the response of a high-rise structure to ground motion using Response Spectrum Analysis. Different models, that is, bare frame, brace frame and shear wall frame are considered in Staad Pro. and change in the time period, stiffness, base shear, storey drifts and top-storey deflection of the building is observed and compared.

**KEYWORDS:** Reinforced Concrete frame, Shear Wall, response spectrum

## I. INTRODUCTION

The devastation caused by earthquakes is indeed a sobering reminder of nature's power and our vulnerability to it. The recent earthquake in Nepal serves as a poignant example of how unpredictable and destructive seismic events can be. It underscores the importance of advancing our understanding of seismic forces and developing techniques to mitigate their impact on structures and human lives.

The unpredictability of earthquakes and the random ground motions they generate make it essential to design structures capable of withstanding a variety of forces and directions. Horizontal ground shaking, in particular, poses a significant threat to buildings and infrastructure. Structures must be engineered to absorb and dissipate the inertial forces generated during ground vibration.

One critical aspect of seismic design is the ability of structures to withstand the reversal of stresses induced by earthquakes. As seismic waves change direction, they can subject structural components to alternating tension and compression forces. Failure to adequately account for these stress reversals can lead to structural damage and collapse. The high stresses generated during earthquakes can cause yielding and large deformations in buildings, rendering them non-functional and unsafe for occupancy. Large storey drifts, where different parts of the building move relative to each other, can further compromise structural integrity and pose a danger to occupants.

To address these challenges, ongoing research and development efforts worldwide are focused on enhancing seismic resilience in building design. This includes the development of innovative materials, structural systems, and construction techniques aimed at improving the performance of buildings during earthquakes. While seismic-resistant construction may entail higher costs, the investment is crucial for safeguarding lives and property against the devastating effects of seismic events.

Ultimately, the goal of seismic design is to create structures that can withstand the forces unleashed by earthquakes and provide a safe environment for occupants. By integrating advanced techniques and technologies into building design and construction practices, we can better prepare ourselves for the inevitable seismic events that will continue to shape our world.

## II. METHODOLOGY

### DATA COLLECTION

Obtaining Indian standard codes from the Department of Civil Engineering at NIT Rourkela and earthquake data from [peer.berkeley.edu](http://peer.berkeley.edu) demonstrates a meticulous approach to gathering the necessary resources for research. Here's how each source contributes to project:

1. Indian Standard Codes from NIT Rourkela: Indian standard codes are essential for ensuring compliance with regulatory requirements and industry best practices in structural engineering and seismic design. By obtaining these codes from a reputable institution like NIT Rourkela, can be confident in the accuracy and reliability of the information used in analysis. These codes serve as a foundational reference for structural design, material specifications, and seismic analysis methodologies specific to the Indian context.

2. Earthquake Data from [peer.berkeley.edu](http://peer.berkeley.edu): Accessing earthquake data from [peer.berkeley.edu](http://peer.berkeley.edu) provides valuable seismic records for analysis. The website is known for providing reliable and comprehensive datasets of ground motion recordings from various seismic events worldwide. By leveraging this data source, can incorporate real-world seismic inputs into analysis, including time history records of ground motion corresponding to earthquakes such as those from IS 1893:2002 (Part-I), Imperial Valley, and San Francisco. This ensures that seismic analysis is based on authentic and relevant seismic events, enhancing the accuracy and reliability of findings.

Overall, by leveraging these resources, have equipped self with the necessary tools and data to conduct a robust analysis of seismic performance in high-rise structures. This demonstrates a proactive approach to research and ensures that project is founded on credible information and methodologies.

### METHODOLOGY ADOPTED

Dividing the work into three distinct parts as outlined helps to streamline the analysis process and allows for a systematic examination of the structural response under different seismic conditions and lateral stiffness systems. Here's how each part contributes to the overall scope of the work:

1. Analysis of Bare Frame in Different Ground Motions: The first part focuses on analysing the performance of the bare frame structure under various ground motion scenarios, including IS 1893:2002 (Part-I), Imperial Valley, and San Francisco earthquakes. This analysis provides baseline data on the structural response without any additional lateral stiffness systems, offering insights into the inherent behaviour of the building under seismic loading.

2. Analysis of Braced Frames: The second part involves analysing the performance of the building with braced frames. Bracing systems are introduced to enhance the lateral stiffness of the structure and mitigate the effects of seismic forces. By comparing the responses of braced frames to those of bare frames, researchers can evaluate the effectiveness of bracing systems in improving the seismic performance of the structure.

3. Analysis of Frames with Shear Walls: The third part focuses on analysing the building with shear walls. Shear walls are another common lateral stiffness system used to resist lateral loads and enhance structural stability during earthquakes. By conducting analysis on frames with shear walls, researchers can assess the impact of shear wall configuration on the overall seismic response of the building and compare it with the responses of bare frames and braced frames.

By dividing the work into these three parts, researchers can systematically investigate the influence of different lateral stiffness systems on the seismic behaviour of high-rise structures. This approach facilitates a comprehensive understanding of the structural response under various seismic conditions and enables informed decision-making regarding the design and retrofitting of buildings for enhanced seismic performance.

#### 1. Building Description:

The building is a theoretical 12-story structure modeled in Staad Pro as a space frame.

The building is unsymmetrical, with greater span along the Z direction than the X direction.

It rises to a height of 42m along the Y direction and spans 15m along the X direction and 20m along the Z direction. The building does not represent any real existing structure but serves as a hypothetical case study for analysis purposes.

## 2. Analysis Methodology:

Response Spectrum Analysis is chosen as the analysis method.

Dynamic Analysis is adopted over static analysis for better results, considering the dynamic nature of seismic loading.

## 3. Frame Specifications:

The specifications of the frame are provided in Table 1, which likely includes details such as material properties, member sizes, and connection details.

## 4. Coordinate System:

The X and Z axes are taken as the horizontal axes, while the Y axis is taken as the vertical axis throughout the coursework.

## 5. Visual Representations:

The plan of the building is shown in Fig. 4, providing a graphical representation of the layout and dimensions.

The model of the building in Staad Pro is depicted in Fig. 5, offering a visual depiction of the structural geometry within the analysis software.

## III. RESULT AND DISCUSSION

### COMPARISON OF TIME PERIOD

The finding that the fundamental time period of the bare frame is longer than that of the braced frame and frames with shear walls aligns with expectations and established principles in structural engineering. Here's an explanation of this observation:

#### 1. Effect of Lateral Stiffness Systems:

- Braced frames and shear walls are introduced to the building structure to enhance its lateral stiffness and resistance to lateral loads, such as those induced by seismic forces.
- The presence of bracings and shear walls effectively increases the overall stiffness of the structure, leading to shorter fundamental time periods compared to the bare frame.
- Braces and shear walls act as additional structural elements that contribute to restraining lateral movement and reducing the building's natural vibration period.

#### 2. Impact on Dynamic Characteristics:

- In a dynamic analysis, shorter fundamental time periods indicate higher stiffness and faster response of the structure to dynamic loads.
- The gradual decrease in time period from the bare frame to the braced frame to the frame with shear walls reflects the increasing effectiveness of the lateral stiffness systems in reducing the building's flexibility and enhancing its dynamic behavior.
- This observation underscores the importance of incorporating appropriate lateral stiffness systems in structural design to achieve desired seismic performance objectives.

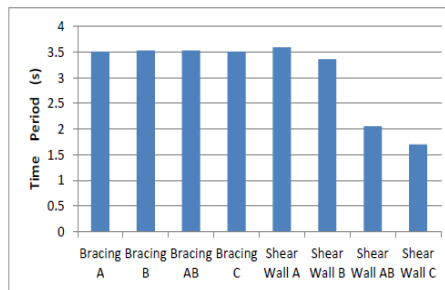
#### 3. Design Implications:

- The finding that braced frames and shear walls result in shorter fundamental time periods implies that these lateral stiffness systems are effective in improving the seismic performance of the building.
- Designers and engineers can use this information to optimize the selection and placement of lateral stiffness systems in high-rise structures to meet specific performance criteria and regulatory requirements.
- Additionally, the observed differences in time periods between different frame configurations can inform decisions related to structural design, retrofitting, and seismic risk mitigation strategies.

Overall, the finding of a gradual decrease in fundamental time period from the bare frame to the braced frame to the frame with shear walls highlights the importance of incorporating appropriate lateral stiffness systems to enhance the seismic resilience of high-rise structures.

**Table 1. Variation of time period**

Cases	Time Period
Bare frame	3.51224
Bracing A	3.51208
Bracing B	3.53179
Bracing AB	3.53164
Bracing C	3.5124
Shear wall A	3.59052
Shear wall B	3.36548
Shear wall AB	2.05164
Shear wall C	1.70323



**Fig.1 Variation of time periods**

Overall, the findings underscore the critical role of bracing and shear wall systems in reducing inter-storey drifts and ensuring compliance with safety limits under the Imperial Valley ground motion. By strategically designing and implementing these lateral stiffness systems, engineers can enhance the seismic resilience and safety of high-rise structures.

Table 22 shows the base shear for ground motion in X-direction for all the cases and Fig 15. Shows the variation of the base shear

**Table 2. Inter-Storey Drift for ground motion in X- direction**

Storey	Bare Frame	Bracing A	Bracing B	Bracing AB	Bracing C	Shear Wall A	Shear Wall B	Shear Wall AB	Shear Wall C
1	0	0	0	0	0	0	0	0	0
2	9.942	7.914	9.915	7.901	6.598	2.875	9.232	2.961	1.934
3	17.173	12.79	17.147	12.77	10.488	5.157	17.164	6.085	3.798
4	18.271	13.491	18.275	13.472	11.159	6.288	19.184	7.554	4.673
5	17.806	13.338	17.83	13.328	11.172	6.964	19.117	8.334	5.237
6	16.8	12.84	16.818	12.832	10.907	7.46	18.145	8.777	5.649
7	15.506	12.125	15.508	12.117	10.465	7.812	16.718	9.015	5.945
8	13.99	11.231	13.986	11.223	9.871	8.005	15.007	9.069	6.118
9	12.275	10.164	12.276	10.156	9.119	8.008	13.073	8.909	6.147
10	10.364	8.912	10.373	8.905	8.185	7.784	10.943	8.485	6.007
11	8.267	7.465	8.274	7.458	7.048	7.291	8.656	7.771	5.674
12	6.025	5.834	6.022	5.828	5.704	6.515	6.313	6.809	5.136
13	3.856	4.077	3.847	4.073	4.245	5.441	4.162	5.659	4.41

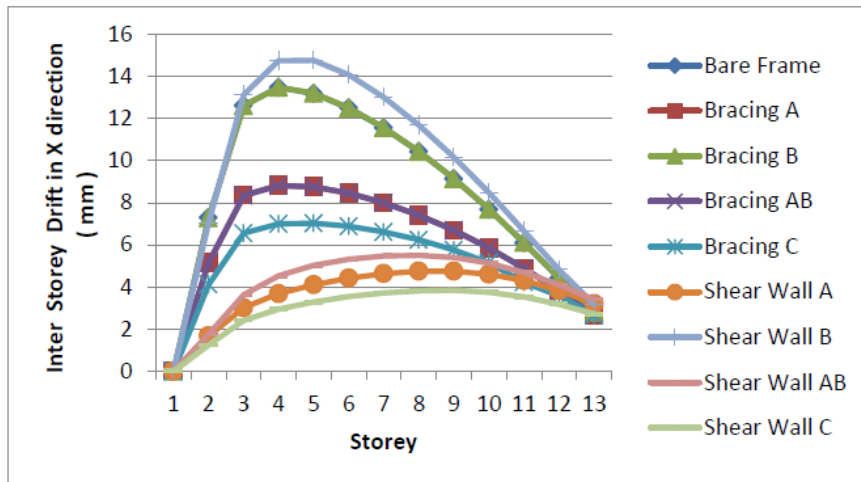
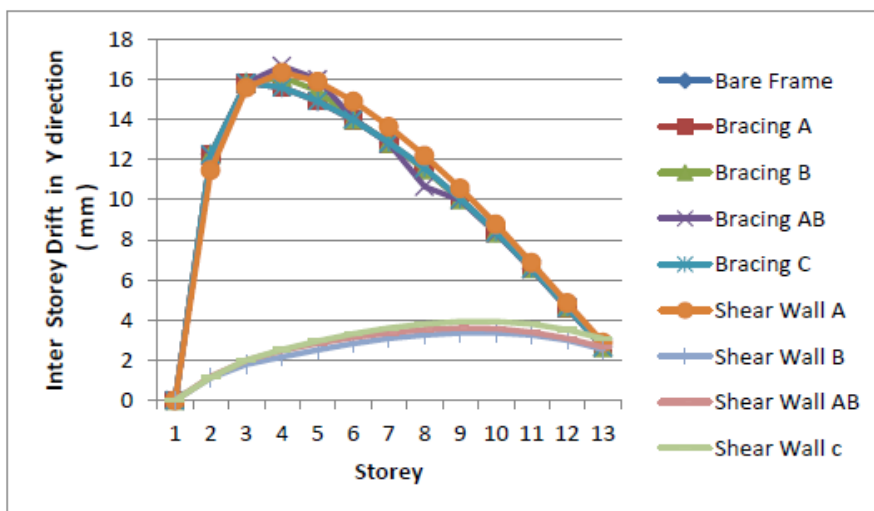


Fig 2. Variation of Inter-Storey Drift for ground motion in X direction



Variation of Inter-Storey Drift for ground motion in Z direction

#### IV. RESULT AND DISCUSSION

- The incredibly important and relevant, especially considering the seismic activity in India and the prevalence of reinforced concrete (RC) frame structures. Earthquakes pose significant risks to life and property, making it crucial to implement effective seismic retrofit strategies to enhance the resilience of buildings.
- By investigating the impact of introducing bracing or shear walls into RC frame structures, these structural elements can mitigate the effects of earthquakes. Even small additions or modifications to existing buildings can have a significant impact on their ability to withstand seismic forces and protect occupants.
- Moreover, the effectiveness and role of these structural elements highlights their importance in safeguarding lives and properties during earthquakes. Through project, the potential benefits of seismic retrofitting and encouraging stakeholders, such as building owners, engineers, and policymakers, to prioritize the implementation of such measures.
- In a country like India, where seismic activity is frequent, efforts can contribute to building safer and more resilient communities. By emphasizing the importance of proactive measures like introducing bracing or shear walls to reduce the vulnerability of buildings to earthquakes and ultimately save lives.

## REFERENCES

- [1] Google images for Steel Bracing in RC building.
- [2] Google images for Steel Bracing in RC building.
- [3] Google images for Shear Wall.
- [4] IS 1893 (Part 1) : 2002 Indian Standard Criteria for Earthquake Resistant Design of Structures, Part 1 General Provisions and Buildings, (Fifth Revision).
- [5] Anil K. Chopra [2003] "Dynamics of Structures, Theory and Applications to
- [6] Earthquake Engineering" (Prentice Hall of India Private Limited).
- [7] Chandurkar P. P, Dr. Pajgade P. S. (2013). "Seismic Analysis of RCC Building with and Without Shear Wall." , International Journal of Modern Engineering Research (IJMER) (2249-6645).
- [8] Chavan Krishnaraj R. ,Jadhav H.S. (2014). "Seismic Response of RC Building With Different Arrangement of Steel Bracing System." , International Journal of engineering Research and Applications (2248-9622).
- [9] Esmaili O. et al. (2008). "Study of Structural RC Shear Wall System in a 56- Storey RC Tall Building." , The 14th World Conference on Earthquake Engineering October 12-17, 2008 , Beijing, China.
- [10] Akbari R.et al. (2014). "Seismic Fragility Assessment of Steel X-Braced and Chevron- Braced RC Frames." , Asian Journal of Civil Engineering (BHRC), VOL-16 No.1 .
- [11] Kappos Andreas J., Manafpour Alireza (2000). "Seismic Design of R/C Buildings with the aid of advanced analytical techniques." Engineering Structures 23 (2001) 319-332.
- [12] Yamada M. et al. " Multistorey Bracing Systems of Reinforced Concrete and Steel –Rigid Frames Subjected To Horizontal Loads- Proposition of Total Evaluation on the Aseismic Capacity for Design."
- [13] Viswanath K.G. et al.(2010). "Seismic Analysis of Steel Braced Reinforced Concrete Frames." International Journal of Civil & Structural Engineering (0976-4399).
- [14] International Journal of Scientific & Technology Research Volume 4, Issue 09, September 2015 Effect of
- [15] Shape And Plan Configuration On Seismic Response of structure Milind V. Mohod (Assistant Professor,
- [16] Department of Civil Engineering, PRMIT & R,Badnera)
- [17] Earthquake Analysis of Multi Storied Residential Building - A Case Study E. Pavan Kumar<sup>1</sup>, A. Naresh<sup>2</sup>, M. Nagajyothi<sup>3</sup>, M. Rajasekhar<sup>4</sup>
- [18] Comparison on the effect of earthquake and wind loads on the performance of reinforced concrete buildings.



INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details