SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 /https://doi.org/10.14445/23488352/IJCE-V9I3P104

Volume 9 Issue 3, 30-35, March 2022


*Original Article*

# Seismic Analysis of R-C Multi-Storey Building with Various Lateral Load Resisting Systems

Vaneeta Devi[1], Deepak Chauhan[2], Neeraj Kumar Tiwari[3], Sunil Kumar[4], Subir Kumar Sharma[5], Sanjeev Suman[6], Sandeep Gupta[7]

[1,2,3,4,5,6,7]*Civil Engineering Department, G.B. Pant University, Uttarakhand, India.*

Received: 09 February 2022 Revised: 23 March 2022 Accepted: 25 March 2022 Published: 30 March 2022

***Abstract*** *- Due to scarcity of space and the shifting of people from rural to urban areas, it is now essential to construct high rise buildings. Still, these buildings have drawbacks, such as lower resistance to wind and earthquake and large beams and columns leading to congested joints with poor workability and compaction. Thus, if constructed in high seismic areas, these buildings may be susceptible to severe damage, which further leads to loss of life. Along with gravity load, the structure has to withstand the lateral loads subjected to the building due to earthquakes; thus, different lateral load resisting techniques are used nowadays to make a tall structure stiff and stable. The present study focuses on the study of RC framed structures provided with two different conventional lateral load resisting systems, i.e., bracings and shear walls. A 3-D analysis of the G+14 storey building has been carried out using the STAAD. Pro V8i software. Different models have been drawn by adopting different locations of shear walls and bracings. A comparative study has been done on four parameters: storey displacement, storey drift, bending moment, and structure period between different frame RC models. Linear dynamic analysis (response spectrum analysis) has been performed for the study as per IS 1893 (Part l):2016.*

***Keywords*** *- Shear Wall, Storey Drift, Storey displacement, Bracings.*

## 1. Introduction

Buildings are physical structures that provide shelter and safety for people. Although reinforced concrete buildings are adequate to withstand vertical and lateral loads, in the prevailing situation and necessity of tall high-rise buildings, both residential and commercial, these simple framed buildings are inadequate under extreme lateral loading to sustain design requirements of strength and serviceability stability and human comfort. The lateral loads also decrease the structure's stability by creating a moment of sway and causing high stresses. In such a situation, the structure's stiffness is more important than the structure's strength to resist the lateral load. The lateral stability of the structure can be increased with the addition of bracing and shear walls.

### *1.1. Bracings*

In a frame structure, bracing is a highly effective and economical means for resisting horizontal forces. For most of the world's tallest buildings, bracing is used to support the structure laterally, as shown in fig.1. To provide stiffness and strength to the structure against horizontal shear, bracings are provided in the structure in which the diagonals are very effective as they work both in tension and compression. The lateral loads are resisted by the bracing action of the inclined members. The associated beams and columns stimulate forces such that the entire work is subjected to axial stress like a truss. This axial stress thus reduces the moment, which results in the reduced sections of the columns.

### *1.2. Shear Wall*

Several building codes recommend using shear walls to make buildings safer and secure, and learning about shear walls is an integral part of structural education. The shear wall acts as a partition wall. It serves as a load-bearing wall, thereby eliminating several columns and carrying a substantial portion of lateral force caused by the earthquake by vertue of the large stiffness of the walls in their planes. An effective shear wall is both stiff and strong and becomes economical as soon as the lateral force governs the design of structural components like beam and column. To resist horizontal or lateral forces, the shear wall transfers these forces to the following element of the building in the load path below them. In addition to this, they also provide roof or floor lateral firmness preventing them from unwarranted side swaying.

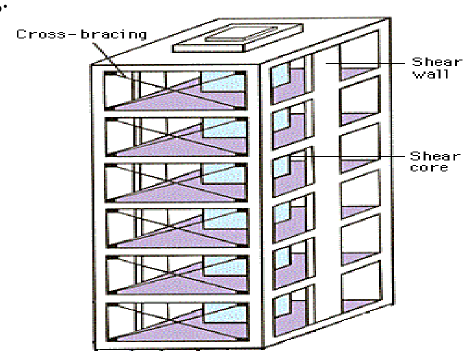


**Fig. 1 Building with bracing and shear wall**

## 2. Objectives of the Study

- To analyse the building model with a different arrangement of steel bracing System and shear wall using the response spectrum method.
- Comparative study of the parameters, i.e., Storey Drift, Storey Displacement, bending moment and Period of different models in seismic zone IV.
- To study the most efficient System with the best location in the RC framed structure for the seismic zone IV.

## 3. Methodology

The buildings' dynamic analysis (response spectrum analysis) was carried out by using three-dimensional modelling in STAAD.Pro software and earthquake loads were applied as per IS – 1893 (Part-I): 2016. Floors were assumed to act as rigid diaphragms. For the distribution of earthquake forces, the contribution of six interior frames without shear walls or braces was grouped, and the remaining forces were assumed to be taken by the two exterior frames with shear walls or braces. Related factors taken were; Zone factor 0.24, Response reduction factor 5, Importance factor 1, Damping 0.05 and foundation soil type as the medium. Dead load intensity at all floor and roof levels was taken as 3 kN/m2 and live load as 4 kN/m2 for the roof and 3 kN/m2 for other floors. The following load combinations are used-

- 1.5(DL+IL)
- 1.2(DL+IL±EL)
- 1.5(DL±EL)
- 0.9DL±1.5EL

## 4. Structural Configurations

Different models used are as follows:

**BF -** Bare RC frame structure
**BRX1-** RC frame structure with X Bracing in the mid-2-bays
**BRX2-** RC frame structure with X Bracing on the side bays
**BRV1-** RC frame structure with Inverted-V Bracing on the mid-2-bays
**BRV2-** RC frame structure with Inverted-V Bracing on the side bays
**SW1-** RC frame structure with the shear wall on the side bays (L-shape Shear Wall)
**SW2-** RC frame structure with the shear wall on the mid-2-bays (Rectangular shape Shear Wall).

**Table 1. General Description**

| | |
|---|---|
| No. of storeys | G+14 |
| Storey height | 3 m |
| Beam size | 450 x 450 mm |
| Column size | 600 x 600 mm |
| The thickness of the shear wall | 150 mm |
| Type of steel Bracing | ISMB 200 |

Fig.2 to Fig.9 shows the different configurations with plans and elevations.

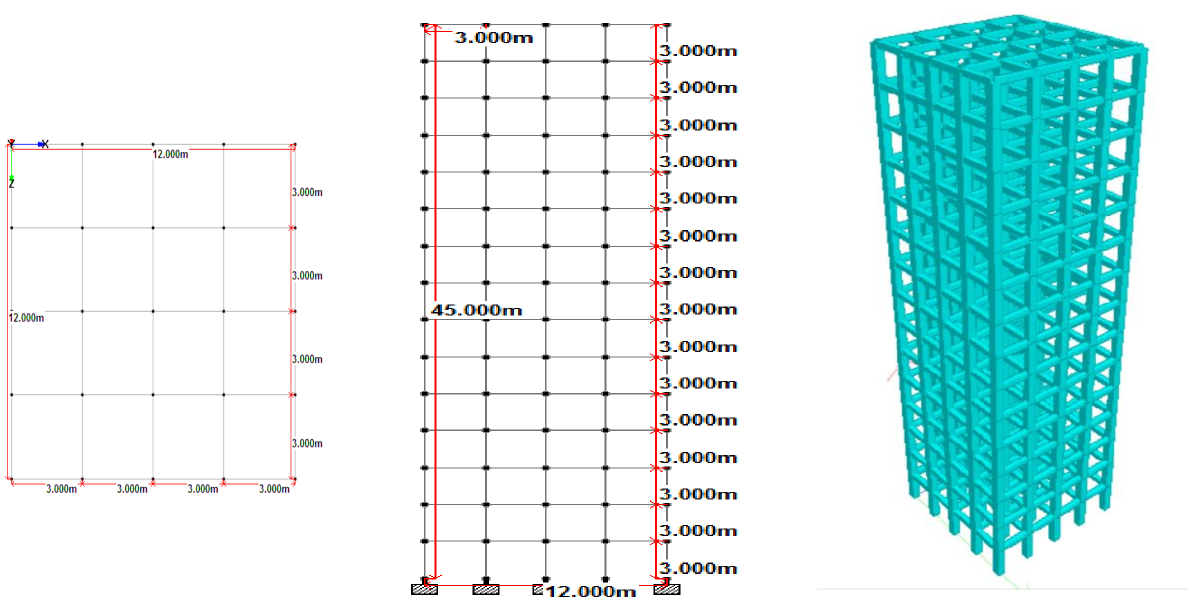


**Fig. 2 Structural Plan, Elevation and 3D Rendered view (BF) of RC Frame Model**

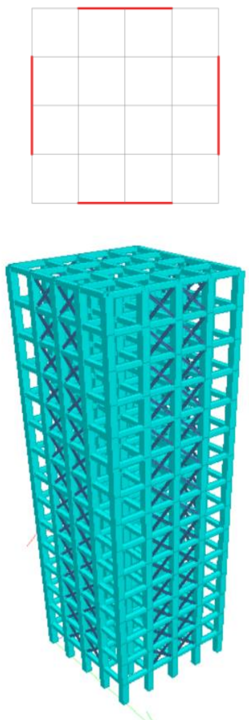

**Fig. 3 Frame with X-bracing at the mid bays (BRX1)**

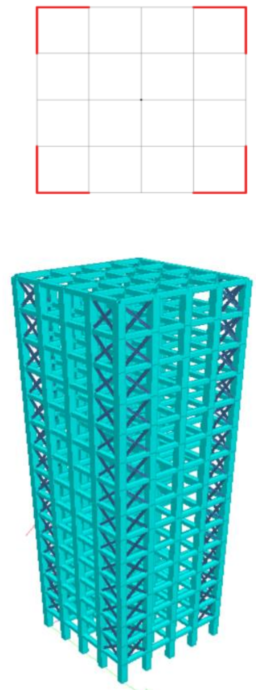

**Fig. 4 Frame with X-bracing at the side bays (BRX2)**

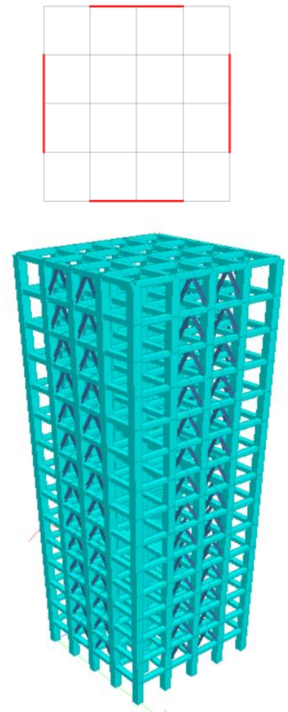

**Fig. 5 Frame with Inverted-V bracing at the mid bays (BRV1)**

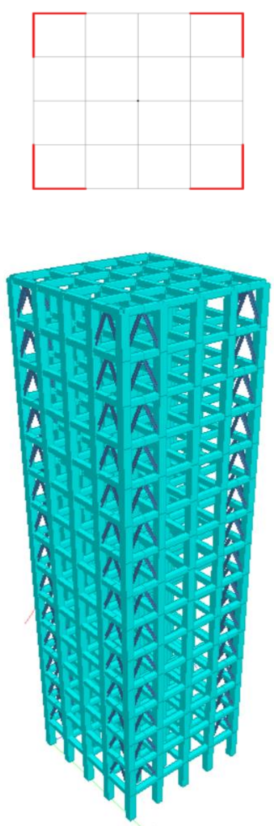

**Fig. 6 Frame with Inverted-V bracing at the side bays (BRV2)**

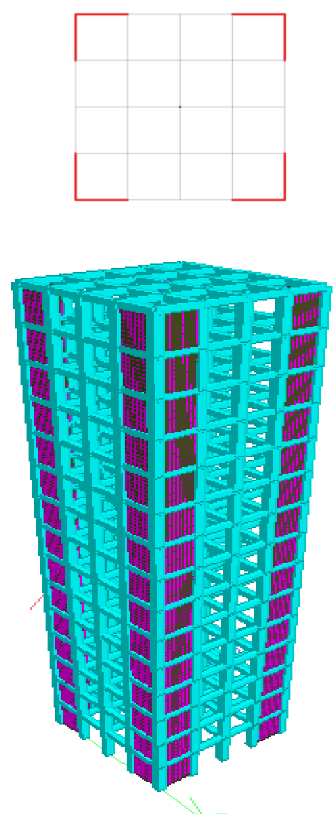

**Fig. 7 Frame with shear walls at the side bays (SW1)**

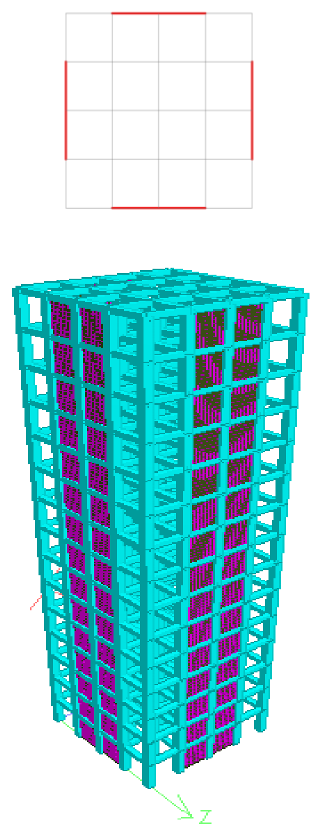

**Fig. 8 Frame with shear walls at the mid bays (SW2)**

## 5. Results and Discussion

### *5.1. Storey Drift*

Storey drift, also known as inter storey displacement, is the relative displacement between the floors above or below the storey under consideration. Although all curves in fig.9 show a similar pattern for the reduction in the storey drift value and building height for all models, there has been a large reduction in storey drift values in shear wall buildings and braced buildings compared to the bare building frame.

### *5.2. Storey Displacement*

Storey displacement measures the deflection or deviation of the structural element from its original/un-deflected position at each floor/roof level. Lateral displacement increases with the increase in the height of the building because with the increase in the height, the lateral stiffness of the building decreases. It can be observed from the lateral deflection plots (fig.10) that deflection along the height of the building got decreased in the shear wall system and bracing System concerning the bare.

Frame building. From the observation, it is found that the rectangular shear wall (SW2) building performed better than the other models.

### *5.3. Time Period*

It is the time taken by building in one complete oscillation. The time period of a building is its inherent property whose value gets affected by any change in the following; the mass of the building, building's stiffness, building height, column orientation in structure, infill walls with masonry only (i.e. without reinforcement) etc. Increased stiffness reduces the natural time period while increased mass increases it. It can be observed from the plotted chart (fig.11) that the time period values for shear wall and braced buildings have been decreased significantly concerning the bare frame building. The maximum reduction is observed in SW2, while the maximum value among the shear wall and braced systems is obtained for Inverted-V bracing provided at the side bays.

### *5.4. Time Period*

It is the time taken by building in one complete oscillation. The time period of a building is its inherent property whose value gets affected by any change in the following; the mass of the building, building's stiffness, building height, column orientation in structure, infill walls with masonry only (i.e. without reinforcement) etc. Increased stiffness reduces the natural time period while increased mass increases it. It can be observed from the plotted chart (fig.11) that the time period values for shear wall and braced buildings have been decreased significantly concerning the bare frame building. The maximum reduction is observed in SW2, while the maximum value among the shear wall and braced systems is obtained for Inverted-V bracing provided at the side bays.

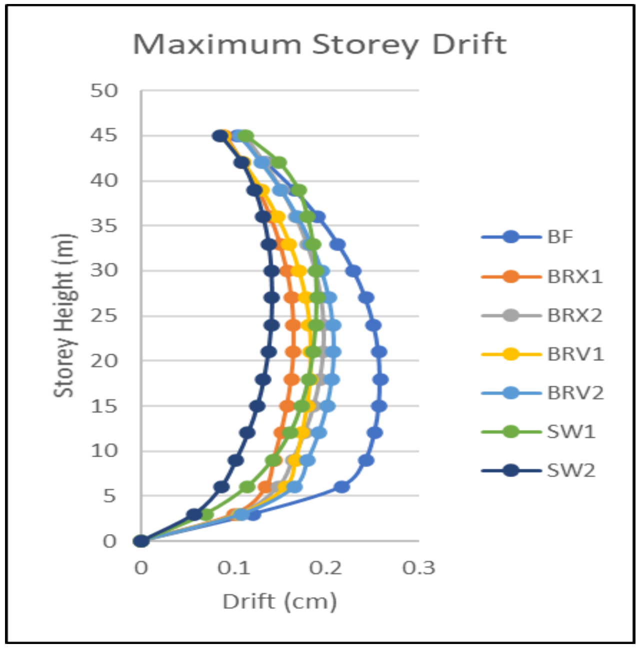


**Fig. 9 Storey Drift comparison**

### *5.5. Bending Moment*

As the transverse external force is applied to the columns, causing the element to bend from its original axis, the induced incident is called the bending moment. It has been observed from fig. 12 that the bending moment gets reduced when the shear wall system and bracing System is added to the RC frame building. The least value of bending moment has been observed in SW2, which contains a shear wall in its configuration.

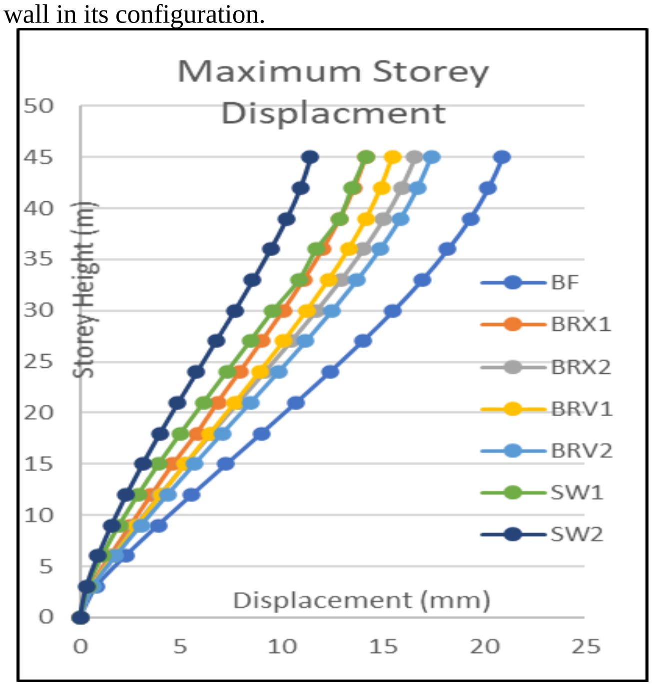


**Fig. 10 Storey Displacement comparison**

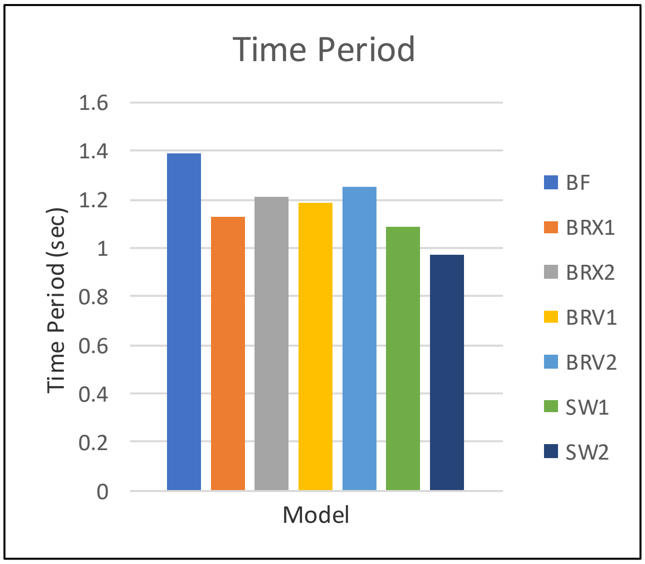


**Fig. 11 Time period comparison**

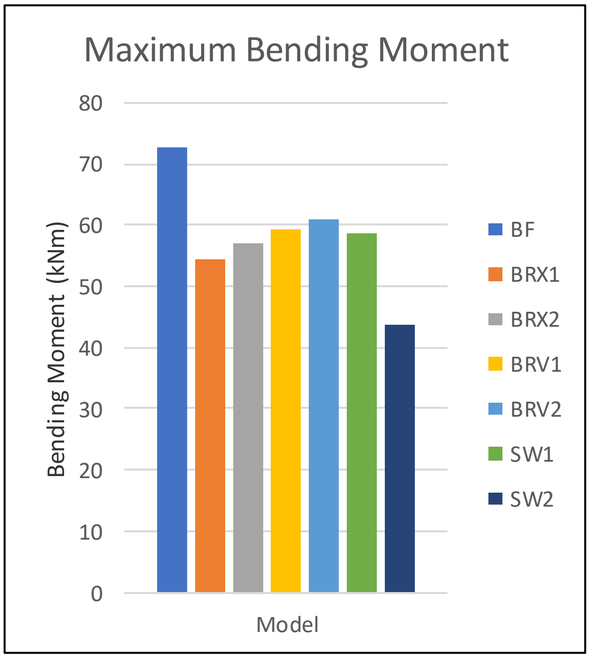


**Fig. 11 Bending moment comparison**

The performance ranking is shown in table 2. Thus the SW2, i.e. the RC framed structure with shear wall provided in the mid-2-bays, is ranked-1 based on its overall performance, and the least ranked model is BRV2, i.e. the RC framed structure with Inverted V-Bracing on the side bays.

**Table 2. Performance-based ranking of the different models**

| | **Performance-based ranking of the structural configurations investigated** | | | | | |
|---|---|---|---|---|---|---|
| **Model** | SW2 | BRX1 | SW1 | BRX2 | BRV1 | BRV2 |
| **Ranking** | 1 | 2 | 3 | 4 | 5 | 6 |

## 6. Conclusion

- A large percentage reduces the Storey drift values obtained for shear wall models compared to the bare RC frame and braced models. The rectangular shear wall shows a reduction in top storey drift of 91.83% for externally located shear walls.
- Time period decreases in models with shear wall and bracings compared to bare frame (BF). SW2 gives the lesser time period as it contains a shear wall at the mid bays and for bracing, X-type bracing shows the lesser time period compared with other braced models.
- Maximum bending moment values in columns of walled shear and braced structures get reduced vastly compared to the bare frame structure. SW2, i.e. rectangular-shape shear wall model, has the least value of maximum moment among all the models. The braced model, which consists of X-bracing at mid bays (BRX1), also shows less bending moment but more than SW2.
- Large reduction in lateral storey displacement occurs in all shear wall systems and bracing Systems with respect to the bare frame building. The model with a shear wall at the mid bays shows the largest reduction in the storey displacement, and in braced frames, X-bracing provided at the mid bays shows the best results.
- In the end, it is concluded that the shear wall provided at the mid bays of the structure shows the best overall performance compared to other models.

## References


[1] Abhyuday Titiksh, Dr. M.K. Gupta, "A Study of the Various Structural Framing Systems Subjected to Seismic Loads," *SSRG International Journal of Civil Engineering*, vol. 2, no. 4, pp. 21-28, 2015. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V2I4P105

[2] Adithya, M., Ramesh B.R, "Study on Effective Bracing System for High Rise Steel Structures," *SSRG International Journal of Civil Engineering (SSRG-IJCE)*, vol. 2, no. 2, pp. 19-20, 2015. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V2I2P103

[3] Akshay Agrawal, Vinita Gavanang, Shilpa Gaikwad, Shruti Patare, Pravina Mithe, Pallavi Sonavane, "Seismic Analysis of Multi Storied Building for SMRF and SMRF with Shear Wall by using Static and Dynamic Methods," *SSRG International Journal of Civil Engineering*, vol. 3, no. 5, pp. 15-17, 2016. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V3I5P133

[4] Aswathi P.M, Faisal Najeeb N.M, Fasna T, Mahmood, Muhammad Fayiz L, Sivakumar B, "Seismic Comparison of OMRF and SMRF Structural Systems on High Rise Building," *SSRG International Journal of Civil Engineering*, vol. 5, no. 5, pp. 45-52, 2018. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V5I5P109

[5] Chetan Raj, et al., "Seismic Analysis of Building with Mass and Vertical Geometric Irregularity by Response Spectrum and Seismic Coefficient Method in Zone V and III," *International Journal of Recent Research Aspects*, vol. 2, no. 2, pp. 204-211, 2015.

[6] Shachindra Kumar Chadhar and Dr. Abhay Sharma, "Seismic Behaviour of RC Building Frame with Steel Bracing System using Various Arrangements," *International Research Journal of Engineering and Technology*, vol. 2, no. 5, pp. 479-483, 2015.

[7] Chandurkar P.P and Pajgade P.S, "Seismic Analysis of RCC Building with and without Shear Wall," *International Journal of Modern Engineering Research (IJMER)*, vol. 3, no. 3, pp. 1805-1810, 2013.

[8] *Criteria for Earthquake Resistant Design of Structure Sixth Revision,* IS 1893 (Part 1): New Delhi, India, 2016.

[9] Dinesh Akshay Kumar R, Kalai Vani M, "Pounding Response of Buildings under Earthquake Motions," *SSRG International Journal of Civil Engineering*, vol. 4, no. 4, pp. 1-10, 2017. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V4I4P101

[10] Janakkumar M. Mehta, Hitesh K. Dhameliya, "Comparative Study on Lateral Load Resisting System in High-Rise Building using ETABS," *International Journal of Engineering Trends and Technology (IJETT),* vol. 47, no. 2, pp. 115-117, 2017. https://doi.org/10.14445/22315381/IJETT-V47P219

[11] Kevadkar M. D and Kodag P. B, "Lateral Load Analysis of RCC Building," *International Journal of Modern Engineering Research (IJMER)*, vol. 3, no. 3, pp. 1428-1434, 2013.

[12] Shahzeb Khan, Vishal Yadav, and Sandeep Singla, "Earthquake Resisting Techniques on a G+10 Storey Building with the help of Shear Wall and Bracings, Using Software," *International Journal of Innovative Technology and Exploring Engineering (IJITEE),* vol. 9, no. 2, 2019.

[13] Kulkarni J.G., Kore P. N.S. B. Tanawade, "Analysis of Multi-Storey Building Frames Subjected to Gravity and Seismic Loads with Varying Inertia," *International Journal of Engineering and Innovative Technology (IJEIT)*, vol. 2, no. 10, pp. 132, 2013.

[14] Mahdi Hosseini, Mohammed Farookh, Dr. Hadi Hosseini, "Earthquake Analysis of Multi-Storey Building with Effect of Shear Walls (Shear Walls at the Centre Core and Corners)," *International Journal of Innovative Research in Science, Engineering and Technology,* vol. 6, no. 6, 2017.

[15] Milind V. Mohod, "Effect of Shape and Plan Configuration on Seismic Response of Structure," *International Journal of Scientific & Technology Research*, vol. 4, no. 9, 2015.

[16] Nasratullah Zahir, Vivek Garg, "Static and Dynamic Analysis of RC Building Frame with Infill," *International Research Journal of Engineering and Technology (IRJET),* vol. 4, no. 7, pp. 13, 2017.

[17] Priya Chandurkar, Dr. P. S. Pajgade, "Seismic analysis of RCC building with and without the Shear Wall," *International Journal of Modern Engineering Research*, vol. 3, no. 3, pp. 1805-1810, 2013.

[18] Qureshi M. A, et al., "Earthquake Behaviour of Building using STAAD," *International Research Journal of Engineering and Technology,* vol. 5, no. 5, pp. 486-491, 2018.

[19] Rana Nishant, Rana Siddhant, "Structural Forms Systems for Tall Building Structures," *SSRG International Journal of Civil Engineering,* vol. 1, no. 4, pp. 33-36. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V1I4P106

[20] Rupak Banik, Kalai Vani M, "Analytical Study on Seismic Response with and Without Soft Storeys in Multi-Storey RC Building," *SSRG International Journal of Civil Engineering*, vol. 4, no. 4, pp. 16-24, 2017. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V4I4P104

[21] Shruti Badami, Suresh M.R, "A Study on Behaviour of Structural Systems for Tall Buildings Subjected to Lateral Loads," *International Journal of Engineering Research & Technology*, vol. 3, no. 7, pp. 989-994, 2014.

[22] Sruthi. P.V, Anita.S, "Seismic Performance and Retrofitting of Open Ground Storey Buildings with Floating Columns," *SSRG International Journal of Civil Engineering*, vol. 3, no. 8, pp. 23-26, 2016. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V3I8P105

[23] Umesh.R.Biradar, Shivaraj Mangalgi, "Seismic Response of Reinforced Concrete Structure by Using Different Bracing Systems," *International Journal of Research in Engineering and Technology*, vol. 3, no. 9, pp. 422-426, 2014.

[24] Varsha R. Harne, "Comparative Study of Strength of RC Shear Wall at Different Location on Multistoried Residential Building," *International Journal of Civil Engineering Research*, vol. 5, no. 4, pp. 391-400, 2014.

[25] Yadav P., and Khuswaha S. S., "Analysis of the Reinforced Concrete Building using Different Bracing System Under Earthquake Loading," *International Journal of Engineering Sciences and Research Technology*, vol. 5, no. 1, pp. 418-428, 2015.