RESPONSE SPECTRUM TECHNIQUE STUDY OF HIGH-RISE MULTISTORY STRUCTURE WITH AND WITHOUT SHEAR WALL

Dr. Sachin Balkrishna Mulay[1], Dr. Jyotiprakash G. Nayak[2], Mr. Rahul Tarachand Pardeshi[3]

Article History: Received: 12.12.2022 **Revised:** 29.01.2023 **Accepted:** 15.03.2023

Abstract

For high-rise structures to resist horizontal pressures brought on by wind and earthquakes, proper stiffness is crucial. Structural engineers are particularly interested in how a structure responds to horizontal forces. Shear walls are placed to the inside of the planned building in order to increase the structure's stiffness and protect it against horizontal pressures such lateral stresses brought on by earthquakes. The utilisation of with and without Shear walls at different locations in a G + 15 multistory residential building, as well as the kind of the structure exposed to earthquakes, are investigated in this paper using Response Spectrum Analysis. In a multi-story structure with G + 15, storey drift, storey displacement, storey pressures, storey response, storey shear, and storey stiffness are examined. In seismic zone 3 for a regular structure, the entire structure is analysed and modelled using the programme ETABs 2016, and it is determined that the structure with symmetrically positioned shear walls would perform better than the structures without shear walls in terms of all seismic characteristics.

Keywords: Shear wall, seismic analysis, response spectrum, and storey drift

[1]Associate Professor, Department of Civil Engineering, School of Engineering and Technology, Sandip University, Nashik, Maharashtra 422213
[2]Associate Professor, Department of Civil Engineering, Sandip Institute of Technology & Research Centre, Nashik, Maharashtra 422213
[3]Assistant Professor, Department of Civil Engineering, Sandip Institute of Engineering and Management, Nashik, Maharashtra 422213

Email: [1]sachin.mulay@sandipuniversity.edu.in, [2]jyotiprakash.nayak@sitrc.org, [3]rahul.pardeshi@siem.org.in

DOI: 10.31838/ecb/2023.12.s3.120

1. Introduction

An earthquake is a horrible natural disaster that happens when the earth's crust suddenly releases energy. It is regarded as one of the worst natural catastrophes since it causes the earth's surface, along with all man-made objects, living things, and non-living things on it, to tremble. Vibrations that result in fatalities and structural damage are induced by the energy released as well as by chemicals that are both internal and exterior to the surface.(Sharifi & Toopchi-Nezhad, 2018; Standard, 1993) It is crucial to consider the seismic behaviour of RC structures for various functions such as base shear, displacements, and so on since earthquakes can have a broad variety of intensities and magnitudes. To make a structure safe and understand its behaviour during earthquakes, a dynamic analysis should be performed to determine the maximum reaction to a base excitation. Shear walls are built to counteract the effects of lateral loads and to give the proper strength and stiffness when a building is subjected to earthquake shaking. Shear walls outperform all other lateral force resisting techniques, particularly in scenarios involving towering structures and lifts.(Sharifi & Toopchi-Nezhad, 2018)

2. Background of shear wall

Shear walls are used to lessen the impact of lateral loads acting on structures. Shear walls can be constructed as vertically oriented broad beams in a reinforced concrete framed structure. They are added to slabs, beams, and columns of a building and act as a case in addition to providing the necessary stiffness, especially in residential structures.(Sasmal, 2009) For the past 20 years, shear walls have been extensively employed in mid- and high-rise constructions. Since they are especially susceptible to lateral loads and seismic stresses, shear walls are very important in structures, especially tall ones.(Sasmal, 2009)

3. Research objective

1. To assess seismic zone 4 analytical results and the behaviour of multi-story structures with and without shear walls.
2. To establish the location of the shear wall so that it can effectively withstand lateral stresses.
3. By adjusting the stiffness of the building along its height in various seismic zones of India, dynamic analysis was used to analyse the structure in terms of base shear, displacements, drifts, storey stiffness, and storey forces.

4. Applied methodologies and parameters

The entire procedure is laid out in the flow chart. This study work takes into account regular form structures, which are depicted in figure 1 with and without shear walls. In this investigation, a high-rise structure with a length of 46.1 m called G+15 is employed. G+15 storeys, with a bottom height of 4.1 m and a normal storey height of 3 m. Support conditions of a certain type that are fixed in type are considered.(Bhaskar et al., 2020; Kumar, 2020)

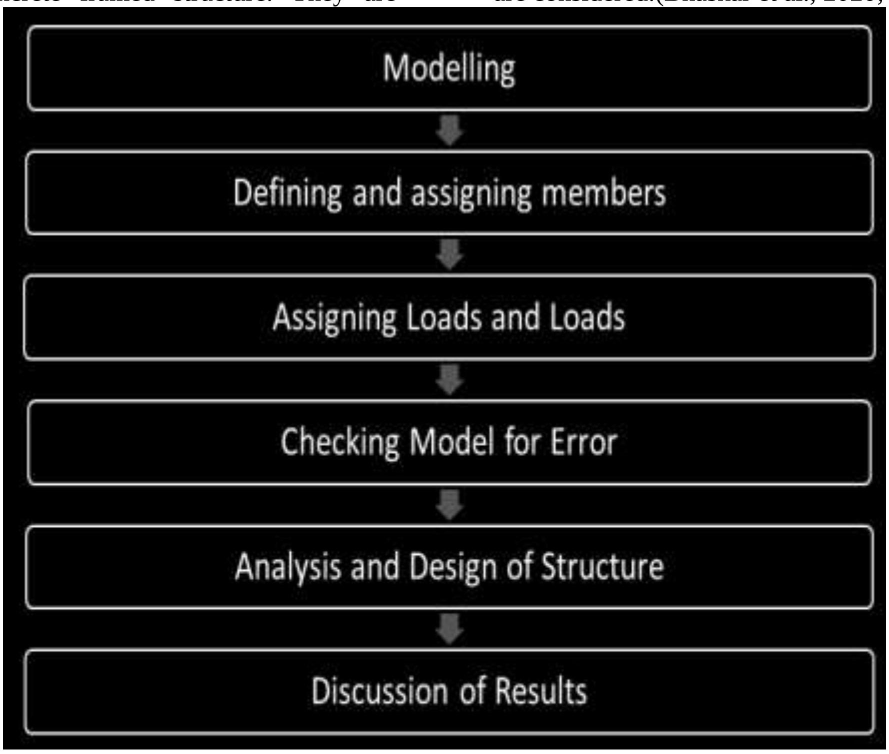

Figure 1: Flow of methodologies

Table 1: the dimensions and specifics of the multistory building model

Title	Specification
Beam Size	300*500 mm
Column Size	600*600 mm
Slab Thickness	150 mm
Thickness of Shear Wall	200 mm
Concrete Grade	M30
Steel And Rebar	HYSD415
Floor to Floor Height	3 m

Table 2: Load Calculation

Type of Load	Calculation
Wall Load	6.8 kN/m
Live Load	5 kN/m
Seismic Load	AS per IS 1893:2016

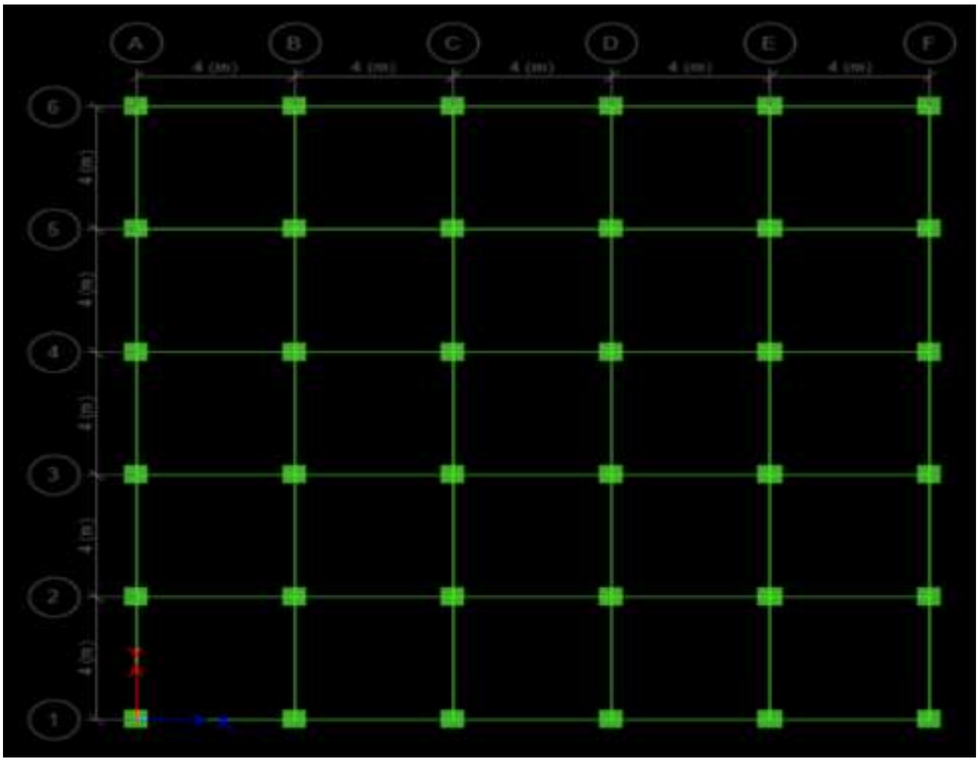

Figure 2: Construction without Shear Wall Floor Layout

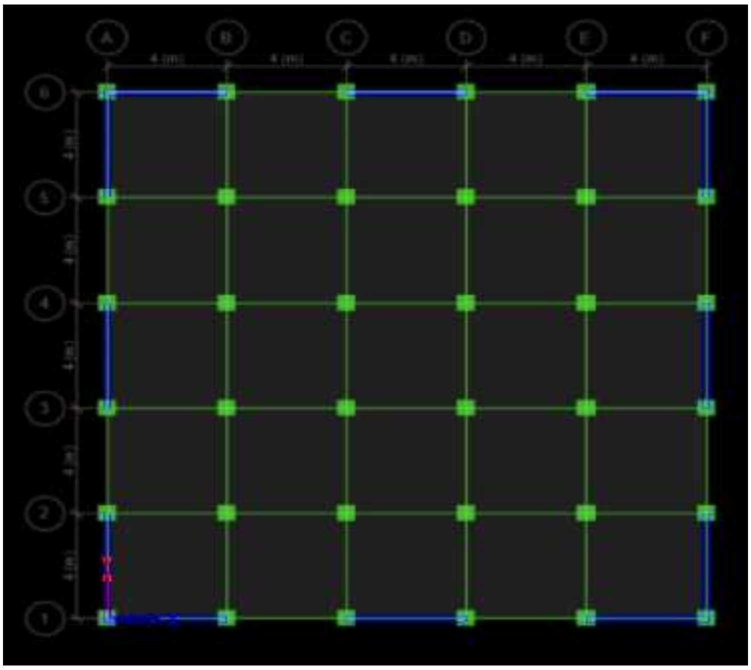

Figure 3: Building's Floor Layout with Shear Wall

5. System Modelling

The graphics below display a building's three-dimensional picture and floor layout. The entire structure is modelled and analysed using ETABS software.(Verma & Goliya, 2016) For gravity loads and lateral loads (Seismic and Wind) with different load combinations, all models are analysed. Indian standards are used to determine both the gravity and lateral loads.(Gupta & Bano, 2019; Verma & Goliya, 2016) Identification of property the initial definition used the material attribute. By providing the essential information while defining our structural components, we may add more materials to them (beams, Columns, and slabs.) After defining each property, we must now assign each property one by one.(Azad & Abd Gani, 2016; Pandey, 2021)

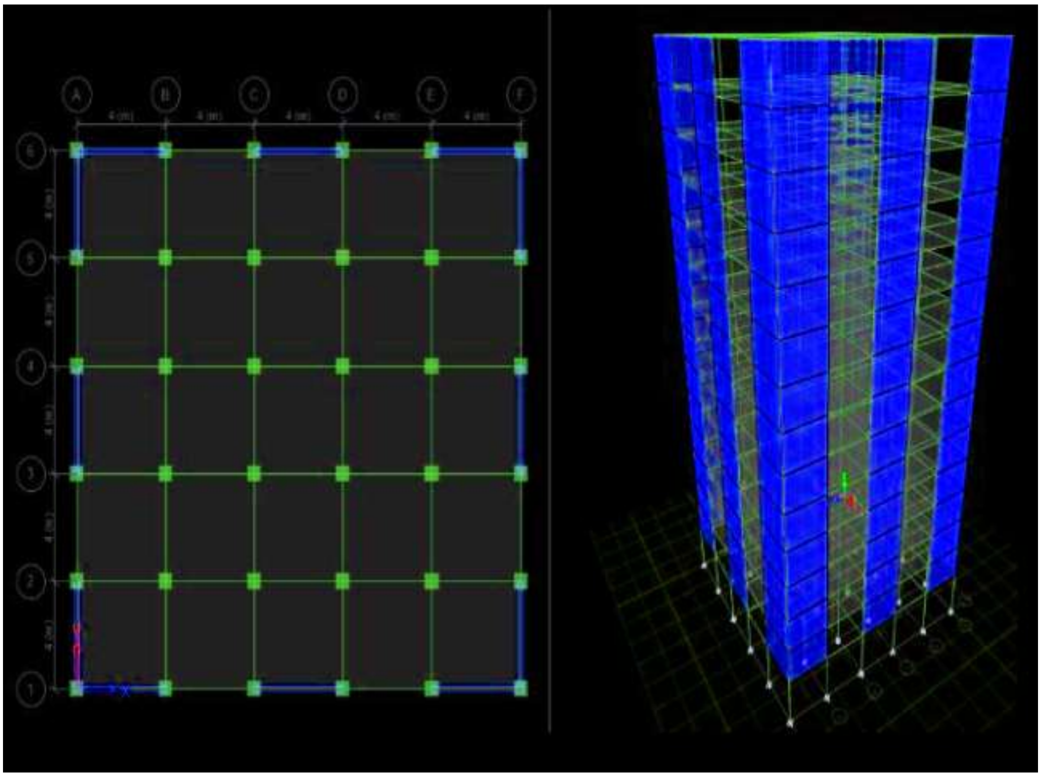

Figure 4: Floor plan and 3D building view

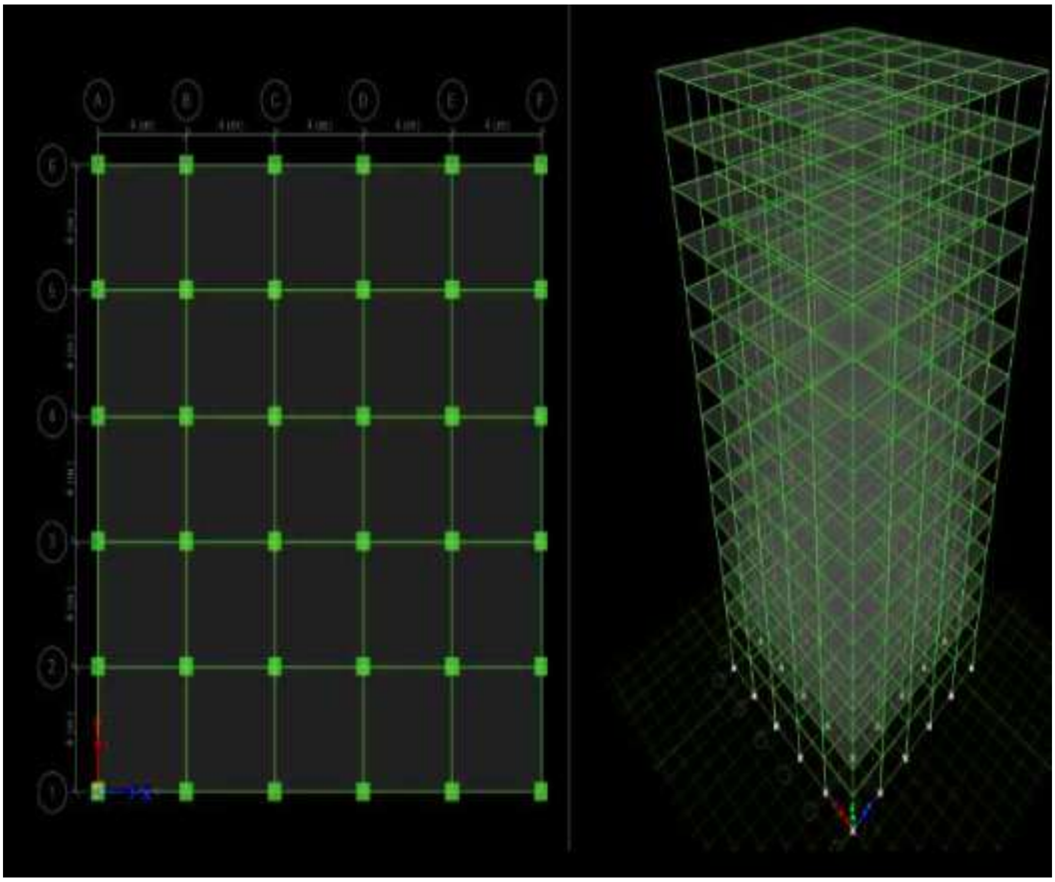

Figure 5: Floor plan and 3D building

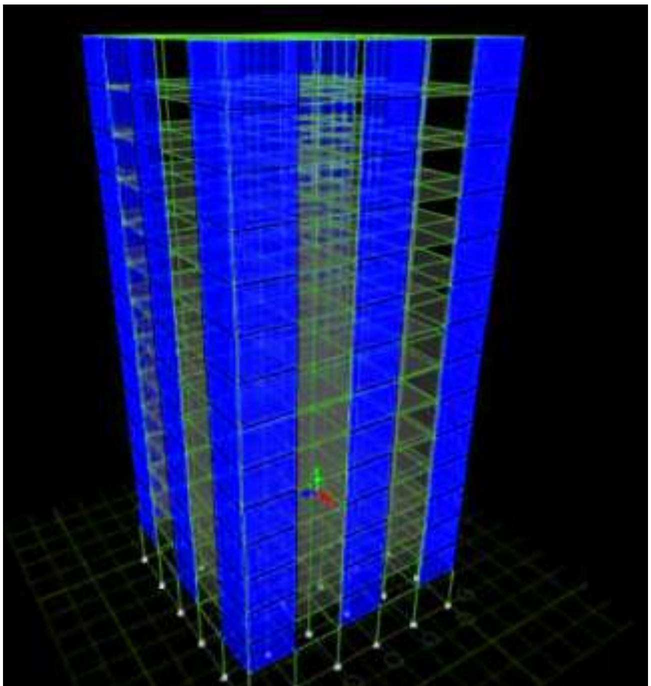

Figure 6: Construction using Shear Wall

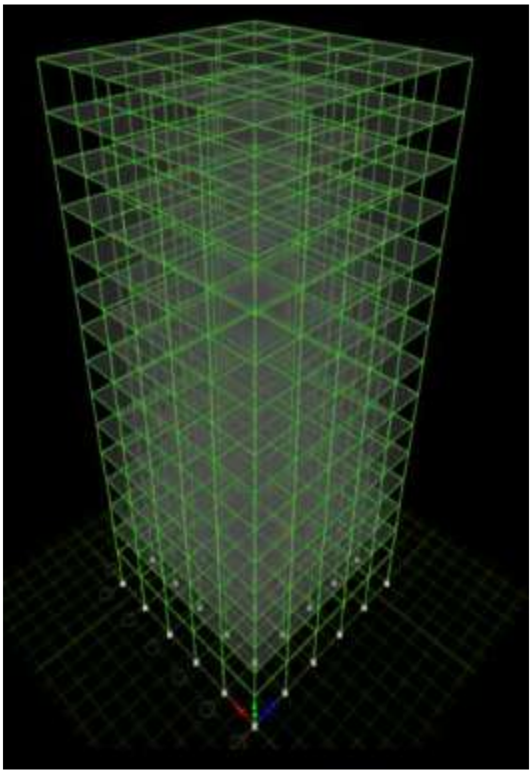

Figure 7: A structure lacking a shear wall

6. Review of Analysis and Design

After analysing all of the structures in the ETABS, the constraints are produced and displayed in the accompanying images. Out of all the load combinations analysed, the following four have been chosen as the load combinations: 1.2(DL + LL + EQX), 1.2(DL + LL + EQY), 1.2(DL+LL+WLX), and 1.2(DL+LL+WLY).(Dharanya et al., 2017)

7. The Findings and discussion

Buildings with and without shear walls are analysed in this article using ETAB's software. Every model is evaluated in seismic zone 4. Several graphs are created using the analysis results to compare with various parameters. The following findings are presented in this study.(Biswas et al., 2013; Dharanya et al., 2017)

7.1 Story Drift

This graph compares the compression experienced by buildings with and without shear walls during an earthquake in the X direction. WSW and WOSW in the paper stand for with shear wall and without shear wall, respectively.

The table below displays the change in storey drift with storey number during an earthquake in the X and Y directions for buildings with and without shear walls.(Sardar & Karadi, 2013)

Figure 8: Storey Drift for EQ in X Direction

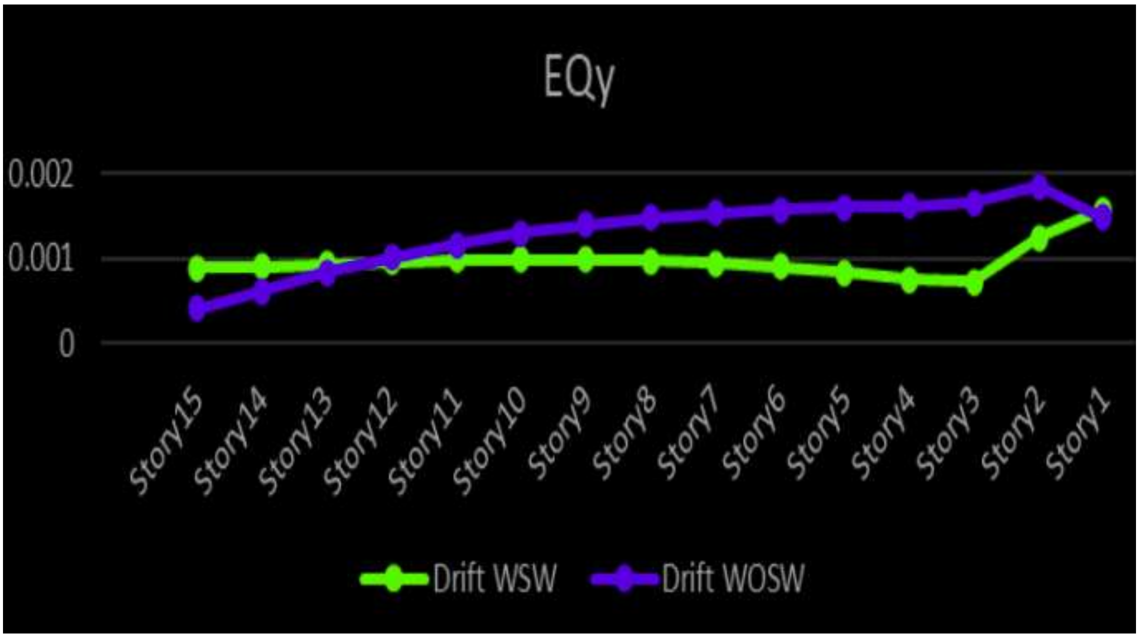

Figure 9: Storey Drift For EQ In The Y Direction

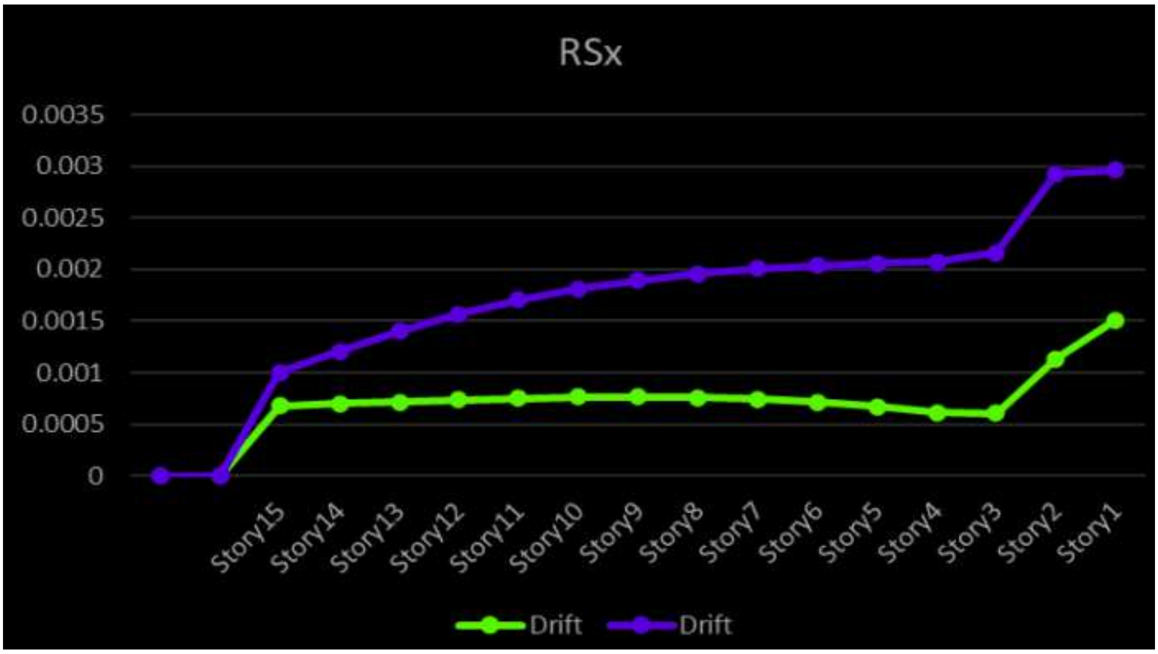

Figure 10: Response Spectrum In X Direction

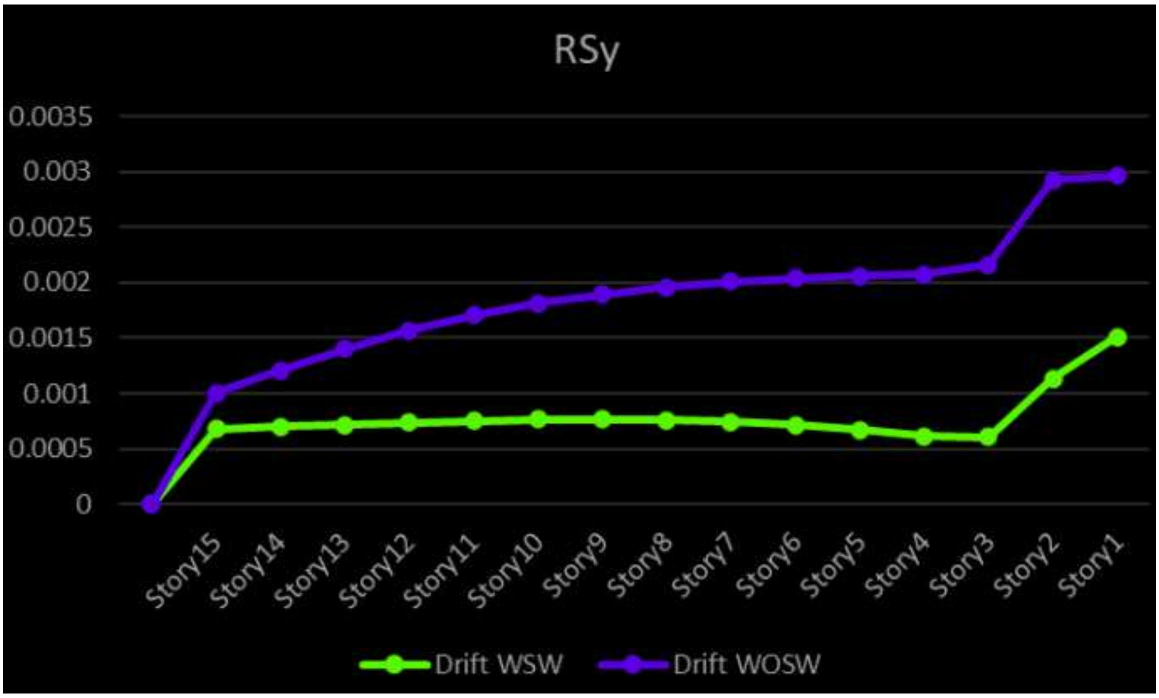

Figure 11: Response Spectrum In Y Direction

Figure 12: Storey Stiffness in X direction

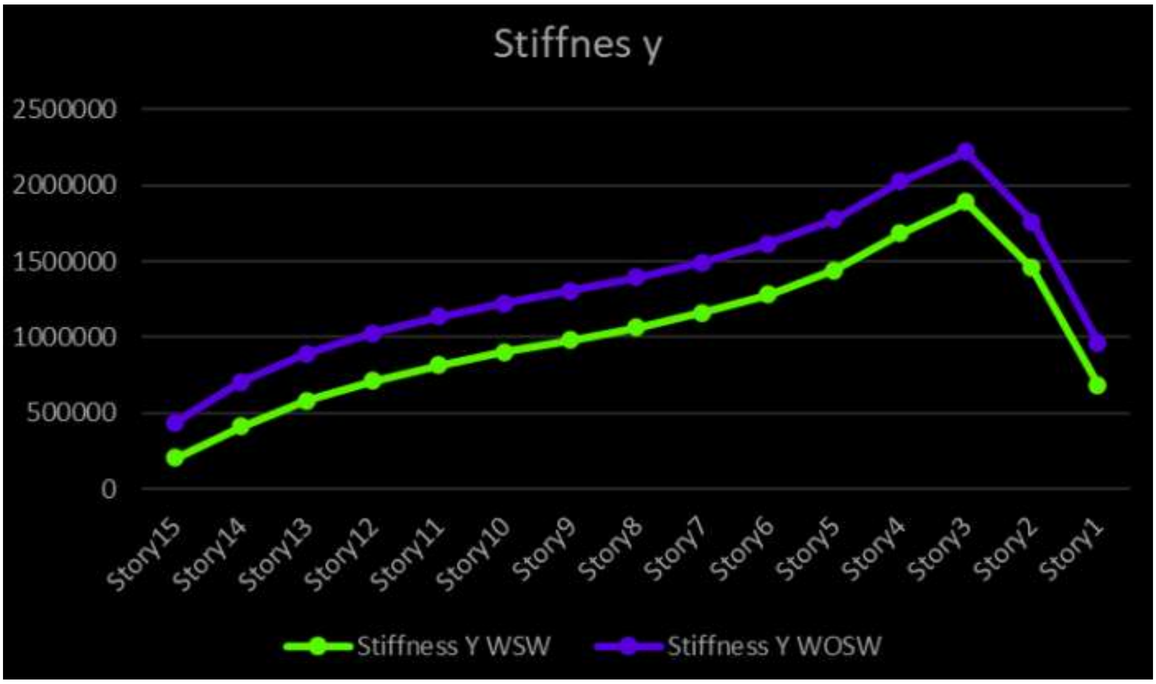

Figure 13: Storey Stiffness in Y Direction

Figure 14: Storey Shear in X Direction

Figure 15: Storey Shear in Y Direction

7.
4 Stiffness

The stiffness of a storey is calculated as the lateral force that causes unit translational lateral deformation in that storey, with the bottom of the storey being prevented from moving laterally; in other words, only translational motion of the storey's bottom is restricted, while rotation is unrestricted. According to the graphs comparing the storey stiffness of buildings with and without shear walls in the X and Y directions (WSW and WOSW, respectively). Graphs display the differences between them.

7.5 Storey Shear

According to the graphs below, the building's shear is greatest at the ground floor and lowest at the top, whether the structure has a shear wall or not, both of which are allowed by IS code.

8. Conclusion

- For the purposes of the ETABS study, two different building types—one with and one without shear walls—are taken into consideration. Shear walls are utilised in structures using the Response Spectrum approach, specifically the I-shaped method.

- For the two different types of buildings compared, namely G+15 constructions with shear walls and normal buildings, there has been a reduction in lateral displacement and storey drift. In RC constructions, shear walls are not incorporated.
- It has been demonstrated that the parameter storey stiffness has a stronger effect on earthquake occurrence for G+15 story structures with an I-shaped shear wall. Shear wall constructions function better than those without them.
- In zone 4, wind does not predominate the analysis and has no impact on the outcomes, demonstrating that wind has no bearing on the construction analysis there.

9. References

Azad, M. S., & Abd Gani, S. H. (2016). Comparative study of seismic analysis of multistory buildings with shear walls and bracing systems. International Journal of Advanced Structures and Geotechnical Engineering (IJASGE), 5(03), 72–77.

Bhaskar, A., Kumar, A., Gupta, M., & Sharm, A. U. S. P. (2020). Seismic Design And Analysis OF (G+ 6) Residential Building IN Zone 3&4 Using STAAD Pro and It's Cost Estimation. IRJMETS.

Biswas, R. K., Uddin, M. M., Chowdhury, M. A., & Khan, M. A.-I. (2013). Comparative Analysis of a 15 Story Flat Plate Building with and Without Shear Wall and Diagonal Bracing Under Wind and Seismic Loads. Journal of Mechanical and Civil Engineering, 9(2), 97–101.

Dharanya, A., Gayathri, S., & Deepika, M. (2017). Comparison Study of Shear Wall and Bracings under Seismic Loading in Multi-Storey Residential Building. International Journal of ChemTech Research, 10(8), 417–424.

Gupta, R., & Bano, A. (2019). Performance Evaluation of Various Shapes of Shear Wall using Response Spectrum Analysis. International Journal of Recent Technology and Engineering (IJRTE), 8.

Kumar, K. S. (2020). Wind loading on tall buildings: Review of Indian Standards and recommended amendments. Journal of Wind Engineering and Industrial Aerodynamics, 204, 104240.

Pandey, N. (2021). Stability Analysis of Shear Wall At Different Locations In Multi-Storeyed Geometrically Irregular Building Using ETABS. International Journal of Engineering Research in Current Trends (IJERCT), 4.

Sardar, S. J., & Karadi, U. N. (2013). Effect of change in shear wall location on storey drift of multi Storey building subjected to lateral loads. International Journal of Innovative Research in Science Engineering and Technology, 2(9).

Sasmal, S. (2009). Performance evaluation and strengthening of deficient beam-column sub-assemblages under cyclic loading.

Sharifi, S., & Toopchi-Nezhad, H. (2018). Seismic response modification factor of RC-frame structures based on limit state design. International Journal of Civil Engineering, 16(9), 1185–1200.

Standard, I. (1993). Ductile detailing of reinforced concrete structures subjected to seismic forces-code of practice. New Delhi: Bureau of Indian Standards.

Verma, A., & Goliya, R. K. (2016). Comparison of Static Wind Load on High Rise Building According to Different Wind Loading Codes and Standards. International Journal of Engineering Research, 5(05)