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Comparison of Symmetrical High-Rise Buildings with and Without Shear Walls Using ETABS

Sharat V Sanikoppa¹, Dr. M N Shivakumar²

PG (Structural Engineering) Student, Bapuji Institute of Engineering and Technology, Davangere, India¹

Associate Professor, Department of Civil Engineering, Bapuji Institute of Engineering and Technology,
Davangere, India²

ABSTRACT: Earthquake is the most hazardous and non-predictable natural disaster which affects not only human beings but as well as the infrastructures. Therefore whenever a building is to be constructed at seismic zone and seismic forces are to be considered for the analysis as well as for design purpose. High rise buildings take more damage due to lateral loads acting on the building. To reduce the impact due to lateral loads, shear walls are to be considered. Shear walls (SW) are the vertical structures constructed to overcome the effects of lateral loads acting on the building. In this study, three different G+12, G+16, G+20 stories high rise buildings are considered where shear walls are provided at the core as well as at the corners. Seismic zone III is taken for the study. Analysis is done by response spectrum method using ETABS software. Results such as Story drift, Story stiffness and Lateral displacement of buildings with shear walls are compared with buildings without shear walls. The results found that shear walls acts as backbone of the building which increases the strength and stiffness of the structure which makes the building more stable.

KEYWORDS: Seismic zone III, SW, response spectrum method, ETABS.

I. INTRODUCTION

Due to increase in construction of high rise buildings, effect of earthquake load has created more problems to the designer for providing sufficient strength and stability against earthquake⁽³⁾. These natural calamities caused much loss to human lives as well as the buildings. To reduce the effects of earthquake load, SW are used in the construction. Shear walls are the vertical elements constructed to resist the effects of lateral loads acting on the structure⁽¹⁾. When SW are designed and constructed properly, they will give good strength and stiffness to the building. Analysis of the building can be done by static analysis and dynamic analysis. Dynamic analysis is divided into response spectrum method and time history analysis⁽⁴⁾. High rise buildings are mainly analysed by response spectrum method. In response spectrum analysis, multiple modes of vibrations were used in the frequency domain⁽²⁾. According to IS code, response of a structure during an earthquake is obtained directly from earthquake response spectrum⁽⁵⁾. The structures are modeled and analysed by using ETABS software.

The objective of the present paper is to study the response spectrum analysis of the buildings having SW and without SW using ETABS software. Comparing the results and concluding which type of structure is good for construction in seismic zones.

II. MODELING AND BUILDING DESCRIPTION

The modeling and analysis of the structure is done by using ETABS 2013 software. Table 3.1 shows the description of the buildings. The building dimension considered is 25x25m. The buildings are of G+12, G+16 and G+20 stories. The buildings are considered to be in seismic zone III. SW provided is of 250mm thickness.

Table 1: Building description

Storey height	3.5m
Foundation Depth	4m
Seismic zone	III
Type of soil	Medium soil
Importance factor	1.2
Zone factor	0.16
Response reduction factor	5 (SMRF)
Grade of steel	Fe 500
Grade of concrete	M 30

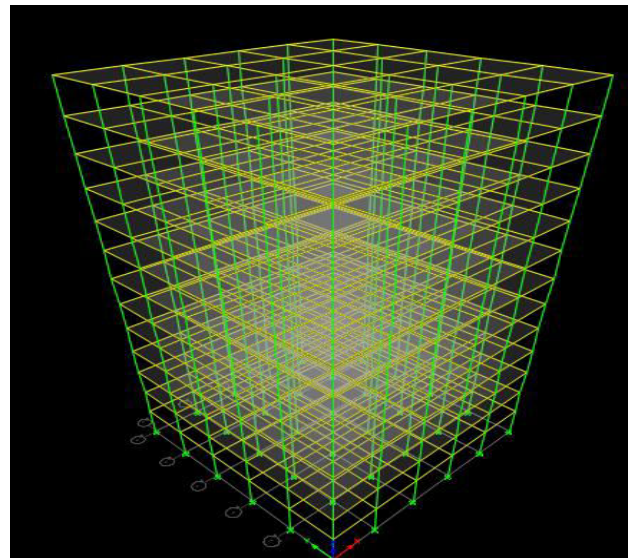
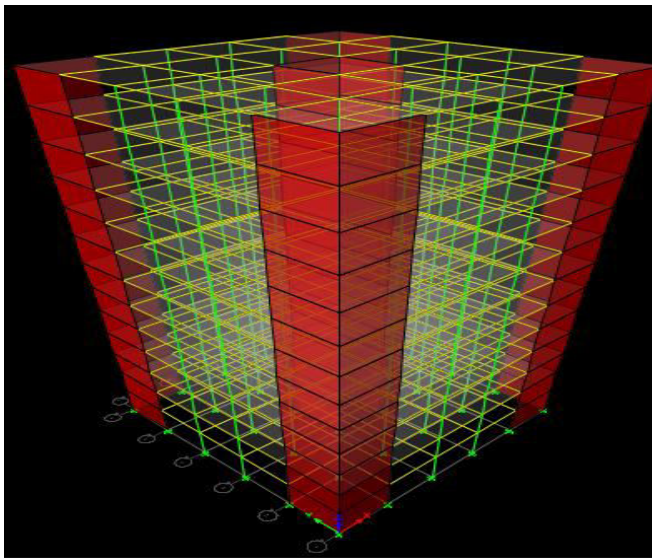


Fig 1: Building with and without SW

Loads:

Table 2: Loads applied

Live load	4kN/m ²
Floor finish	1.5kN/m ²
Wall load	13.5kN/m ²

Load Combinations:

Fig 2 represents the load combinations used in the analysis of the buildings as per IS codes

DL + LL
1.5(DL + LL)
1.5(DL ± WL)
1.5(DL ± EQL)
1.5(DL ± RS)
1.2(DL + LL ± WL)
1.2(DL + LL ± EQL)
1.2(DL + LL ± RS)
0.9DL ± 1.5WL
0.9DL ± 1.5EQL
0.9DL ± 1.5RS

Fig 2: Load combinations**III. ANALYSIS**

Analysis is done by response spectrum method. In this method, multiple modes of vibrations are used in the frequency domain. For each mode, a response is recorded from the design response spectrum, based on the modal mass and the modal frequency; they are then combined to estimate the total response of the structure⁽⁷⁾. Engineers prefer the response spectrum method to deal with earthquakes for several reasons:

- Provides a real representation of earthquake in the form of a static equivalent load.
- Permits an obvious understanding of different vibration modes contributions to the whole seismic response of the structure.
- Provides an easy way to find forces in the members that are exposed to an earthquake.

IV. RESULTS AND DISCUSSION**1) Lateral displacement**

Table 3: Max. lateral displacement					
G+12 with SW (mm)	G+12 without SW (mm)	G+16 with SW (mm)	G+16 without SW (mm)	G+20 with SW (mm)	G+20 without SW (mm)
81.3	162.9	104.7	183.7	103.8	178.7

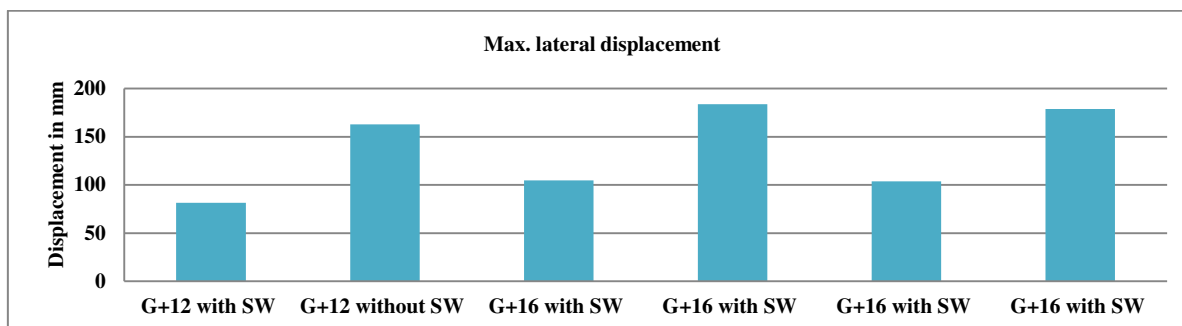


Fig 3: Comparison of lateral displacement

2) Time period

Table 4: Time period of structure						
	G+12 with SW	G+12 without SW	G+16 with SW	G+16 without SW	G+20 with SW	G+20 without SW
Mode	(s)	(s)	(s)	(s)	(s)	(s)
	1.514	2.365	2.279	3.184	2.499	3.454

3) Storey drift

Table 5: Max. storey drift					
G+12 with SW (mm)	G+12 without SW (mm)	G+16 with SW (mm)	G+16 without SW (mm)	G+20 with SW (mm)	G+20 without SW (mm)
1.664	3.654	2.256	4.013	1.865	3.123

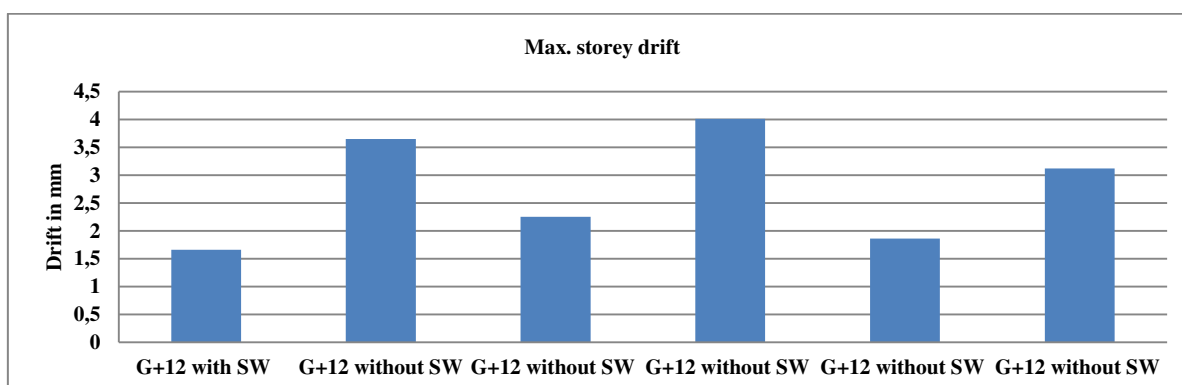


Fig 4: Comparison of storey drift

4) Storey stiffness

Table 6: Max. storey stiffness					
G+12 with SW (%)	G+12 without SW (%)	G+16 with SW (%)	G+16 without SW (%)	G+20 with SW (%)	G+20 without SW (%)
179	141	183	159	192	164



Fig 5: Comparison of storey stiffness

The results are obtained from ETABS software. From the results it is observed that the time period for the structures without SW is more than 60-70% compared to that of buildings without SW. As per IS code, time period should not be more than 8 seconds⁽¹²⁾. Lateral displacement of the building with SW is having 50-60% less displacement compared to buildings without SW. As per IS code, lateral displacement should not be greater than $H/250$ ⁽¹²⁾. Storey drift of the buildings with SW are 60-70% less than the buildings without SW. As per IS code, storey drift should not exceed $0.004 \cdot h$ ⁽¹¹⁾. Stiffness of the structure is more for the buildings having SW. As per IS code, stiffness of the structure should not be less than 70%⁽¹²⁾.

V. CONCLUSION

From the above results, following conclusions were made,

- When lateral forces act on the building, lateral displacement is more in the building without SW; by providing SW lateral displacement is reduced.
- By comparing the storey drift, we can say that drift is less for the buildings having SW.
- Stiffness is more for the buildings having SW compared to buildings without SW.
- By observing the comparisons, we can say that the buildings with SW are stiffer and stronger.
- But providing SW becomes uneconomical, hence it can be provided where lateral forces are more.

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