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Seismic Performance of High Rise Buildings with Different Types of Shear Wall

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Abstract. In today's construction world, aesthetic tall structures play a major role. The design of aesthetic high - rise buildings need to be checked for its safety against extreme load conditions such as earthquake, wind, etc. The provision of composite shear wall is one of the efficient methods to make high rise buildings seismic resistant. In this paper different types of shear walls, namely, concrete shear wall, silica fume concrete shear wall, steel plate shear wall and steel-silica fume concrete composite shear wall are considered for lift wall in 22 and 52 storeyed high-rise buildings. The seismic performance of these buildings is analysed using response spectrum method by ETABS. The factors such as storey displacement, storey drift and storey shear are studied and found that there is a significant reduction when compared to the conventional shear wall.

1. Introduction

At present, the construction world moves towards the execution of tall buildings with vertical and horizontal irregularities. Generally, regular and uniform buildings are preferred as they resist earthquakes better than irregular structures. For the construction of lift wall in the medium and tall structures, RCC is being used worldwide. In the recent past, RCC lift walls are replaced with composite materials which are having better strength and stiffness properties [1 - 6]. While going for the structural design of high-rise buildings for seismic loading it must be checked for seismic resistance to avoid loss of life and economic loss due to earthquake. In this project, an attempt has been made to investigate analytically the behavior of composite shear wall as a lateral-load resisting system in comparison to other types of normal shear walls. Different types of shear walls such as concrete shear wall, silica fume concrete shear wall, steel plate shear wall and steel-silica fume concrete composite shear wall are considered. The composite shear wall is made with steel plate inside and with reinforced silica fume concrete outside. Using ETABS software the shear walls are modeled in 22 and 52 storeyed building and their behavior are compared using response spectrum analysis as specified in IS 1893:2016 [7]. The factors such as storey displacement, storey drift and storey shear of each building are plotted and are compared.



2. Objective

- To analyse the high rise buildings with different types of shear wall using response spectrum method.
- To compare the seismic performance of high rise building with shear wall under study.

3. Structural modeling and analysis

For the analysis, a G+21, G+ 51 and G +20 storeyed RCC framed buildings irregular in plan are modeled in ETABS software. The plan of both G +21, G + 51 is similar; but the number of storey is different (Figure 1a). The plan of the third building, G + 20 storey is different from the other two buildings as shown in figure 1b. The details of the building are given below.

The floor height is taken as 3 m; thickness of the shear wall is 250 mm; the size of rectangular columns is 0.3m x 0.8m, 0.3m x 0.6m; the size of circular columns is 0.6 m dia; the size of the beam is 0.25 m x 0.45m, 0.25m x 0.30m; thickness of slab is 120 mm; materials used are M25 concrete, Fe 415 & Fe 500 HYSD bars, silica fume concrete, Fe 250 steel plate; soil type is type 2; seismic zone is IV. For modeling steel plate-silica fume concrete composite shear wall, the stress-strain properties of silica fume concrete are taken from the experimental work done by Vindhya and Suresh Babu (2016). Response spectrum analysis as specified in [7] is carried out to study the seismic performance of the buildings.

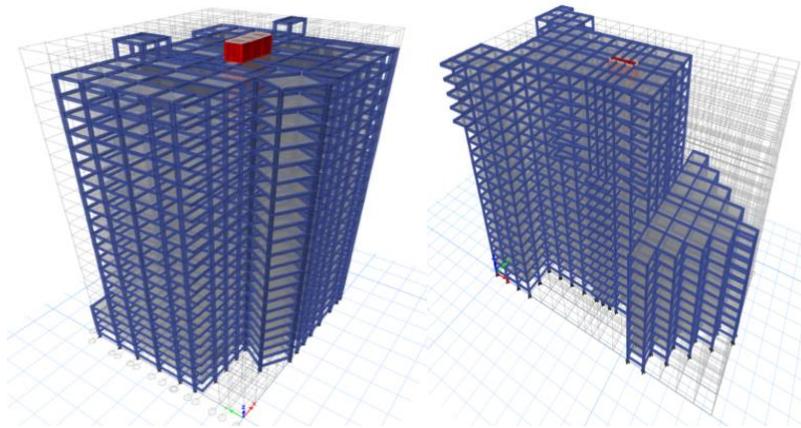


Figure 1. 3D view of buildings under study.

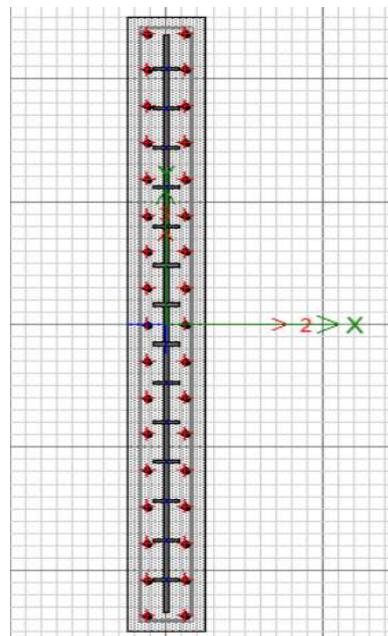


Figure 2. Modeling of steel plate-silica fume concrete composite shear wall.

4. Results and Discussion

4.1. Response of the G +21 storeyed building

Figure 3 shows the storey drift in X and Y direction due to seismic loads obtained from response spectrum analysis of 22 storeyed building with different types of shear walls. In both RESP-X and RESP-Y there is a large reduction in storey drift using composite shear wall over other types of shear walls considered in this project. The storey drift is slightly more in Y-direction than X-direction; however, the storey drift is within the limit in both directions.

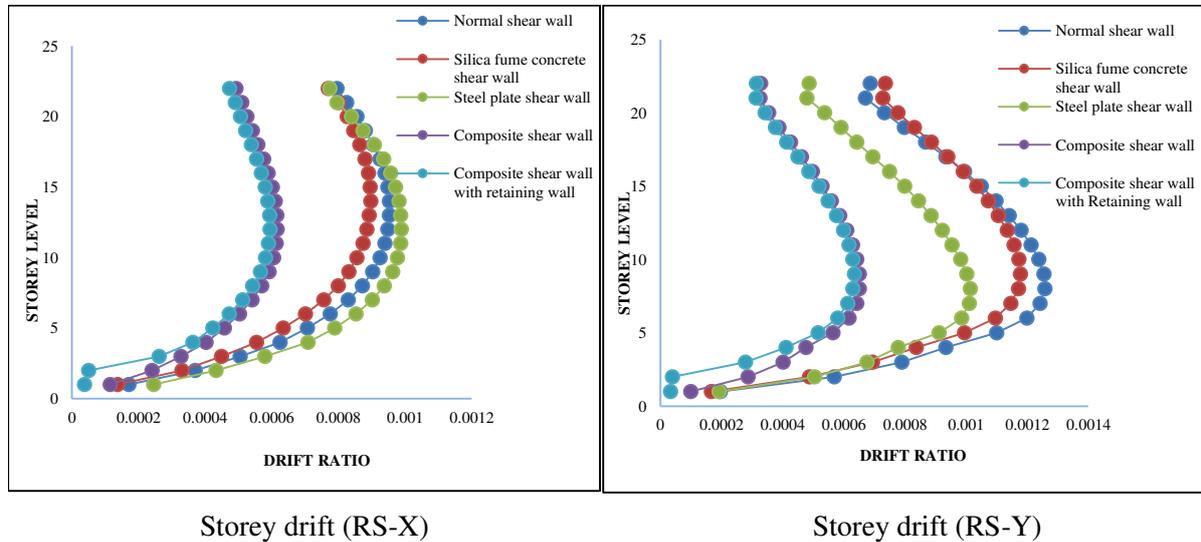


Figure 3. Storey drift of G +21 storeyed building.

Figure 4 shows the reduction in displacement value by providing composite shear wall when compared with normal RCC shear wall, silica fume concrete shear wall and steel plate shear wall. Around 33 % reduction in displacement by providing steel-silica fume concrete composite shear wall is observed.

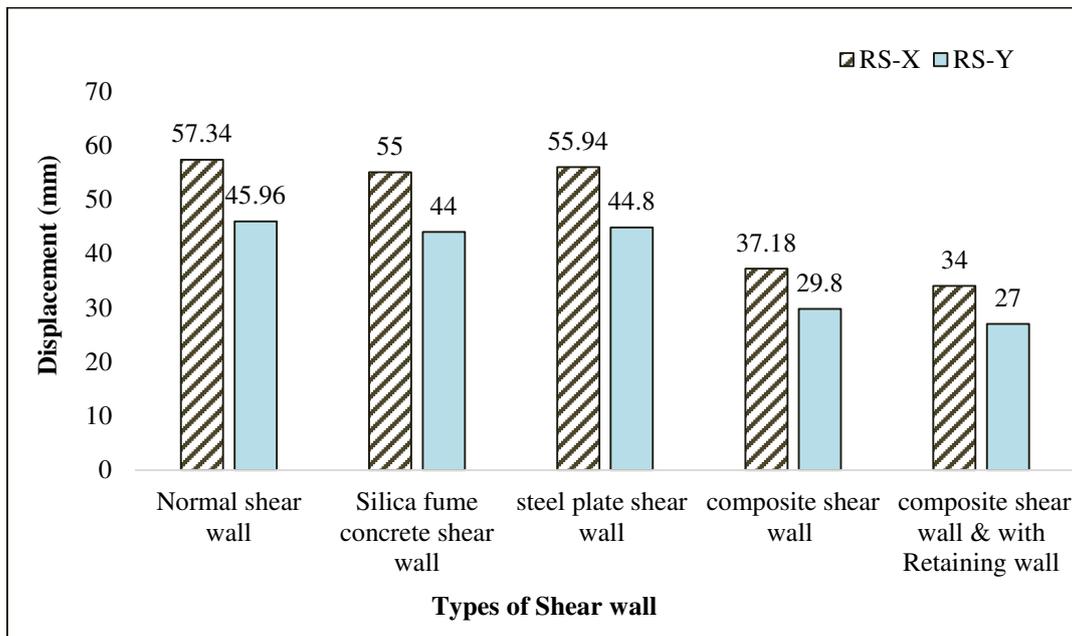


Figure 4. Max storey displacement of G + 21 storeyed building.

In figure 5, storey shear is plotted for different types of buildings in X & Y directions. It is seen that the storey shear is reduced in composite type of buildings when compared to the conventional and other

shear wall type buildings. Almost 50% reduction in storey shear is noticed using composite shear wall and this will in turn reduces the demand for bending and shear in the structural elements.

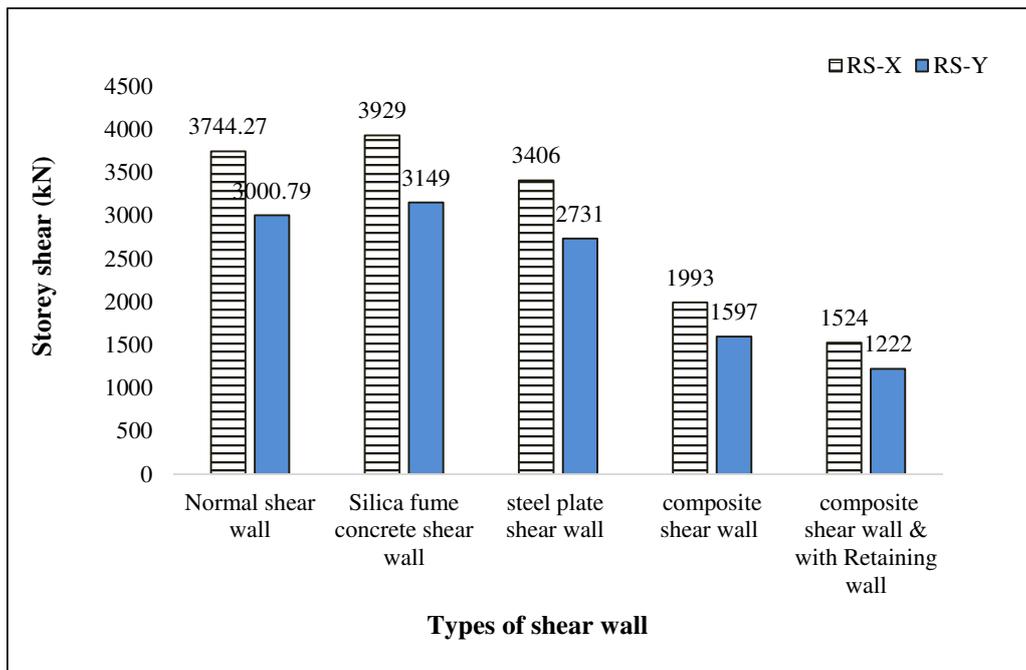


Figure 5. Max storey shear of G +21 storeyed building.

4.2. Response of G + 51storeyed building.

Figure 6 represents the storey drift RESP-X & RESP-Y of the same building when the storey number is increased into 52. Hence the storey number is increased. Also there is a large reduction in storey drift by providing composite shear wall. From the graph it is evident that composite shear wall can play a major role in the reduction of storey drift during earthquake. It will help to reduce the seismic effect on tall buildings.

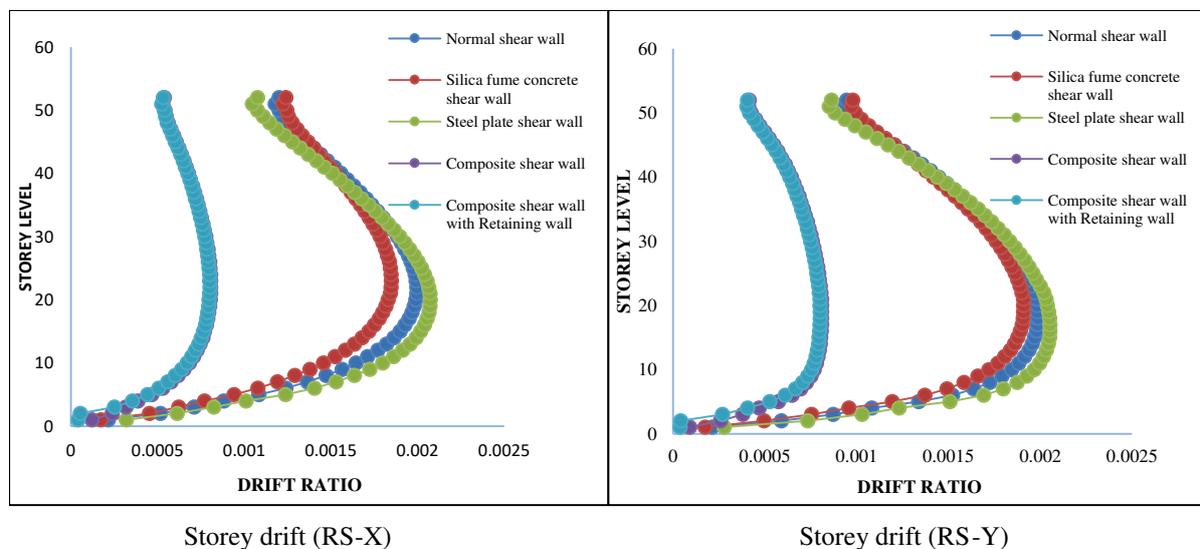


Figure 6. Storey drift of G + 51 storeyed building.

There is a large reduction in displacement value by providing composite shear wall in 52 storeyed building. From the graph plotted in figure 7, it is clear that almost 60% reduction in displacement occurs while providing composite shear wall instead of normal shear wall.

In figure 8, it is evident that there is a large reduction in storey shears by providing composite shear wall (A reduction of storey shear from 3806 kN to 1353 kN).

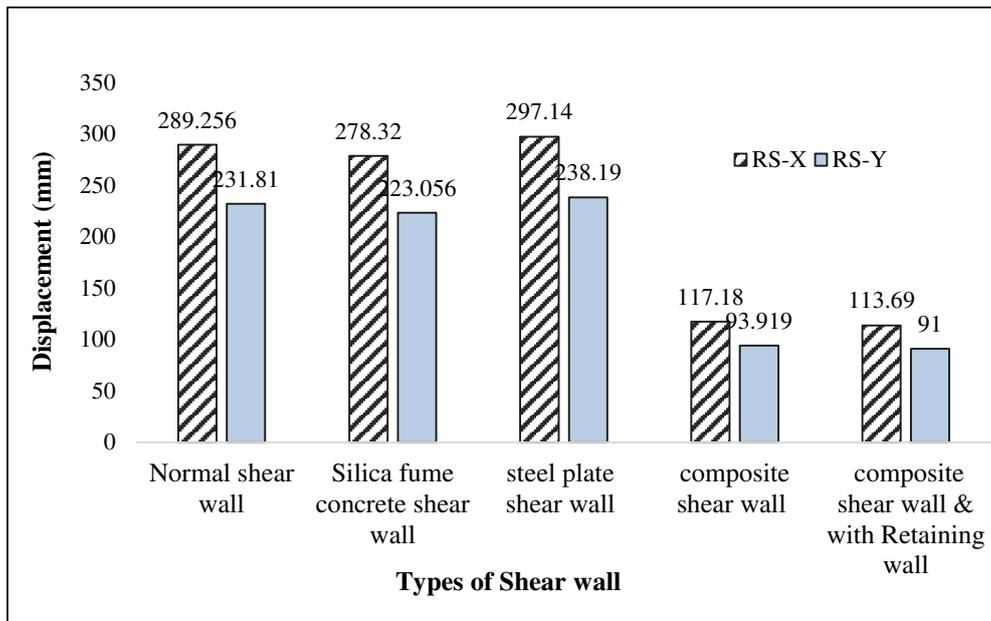


Figure 7. Max storey displacement of G + 51 storeyed building.

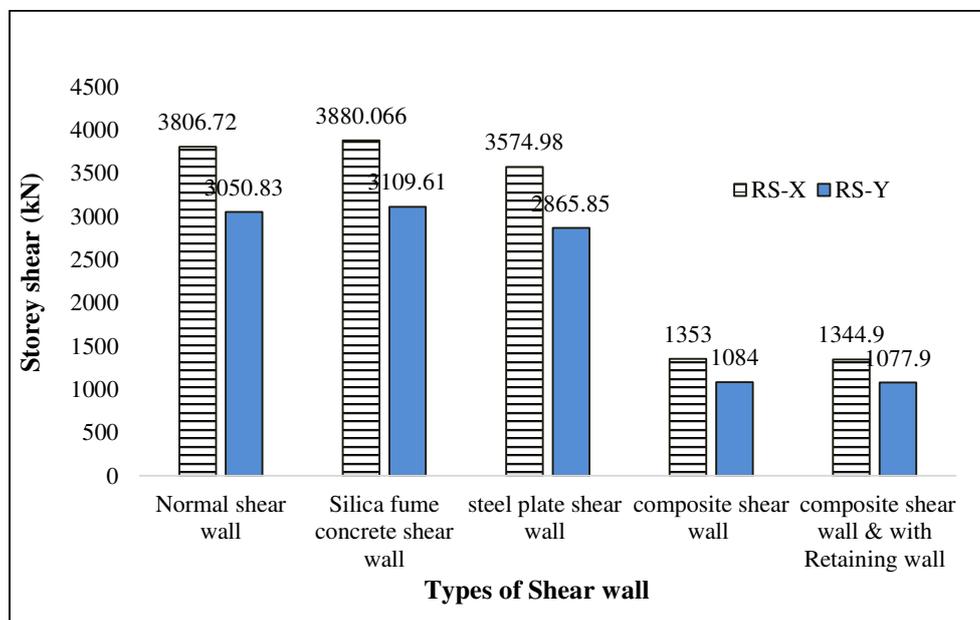


Figure 8. Max storey shear of G + 51 storeyed building.

4.3. Response of G+20 storeyed building.

In this case, building consists of more number of cantilever portions and is irregular in both plan and elevation. Figure 9,10 and 11 represent the response of building subjected to seismic load in both X and Y directions. In figure 9, silica fume concrete shear wall has less storey drift than steel plate and normal shear wall. While comparing with normal shear wall, composite shear wall reduces the drift in each floor to a large extent. Hence while going for aesthetic appearance, composite shear wall would be the best choice to reduce the seismic effect on tall structures.

Figure 10 shows the displacement of the building when different types of shear walls are provided. Here steel plate and normal shear wall have almost the same displacement. By providing silica fume concrete shear wall, displacement is reduced from 83.7 mm to 78.6 mm in RESP-Y and 42 to 37.8 mm in RESP-X. Hence silica fume concrete is effective in reducing displacement due to seismic load. While comparing with normal shear wall, it is evident that composite shear wall can reduce the displacement due to seismic load by 60%.

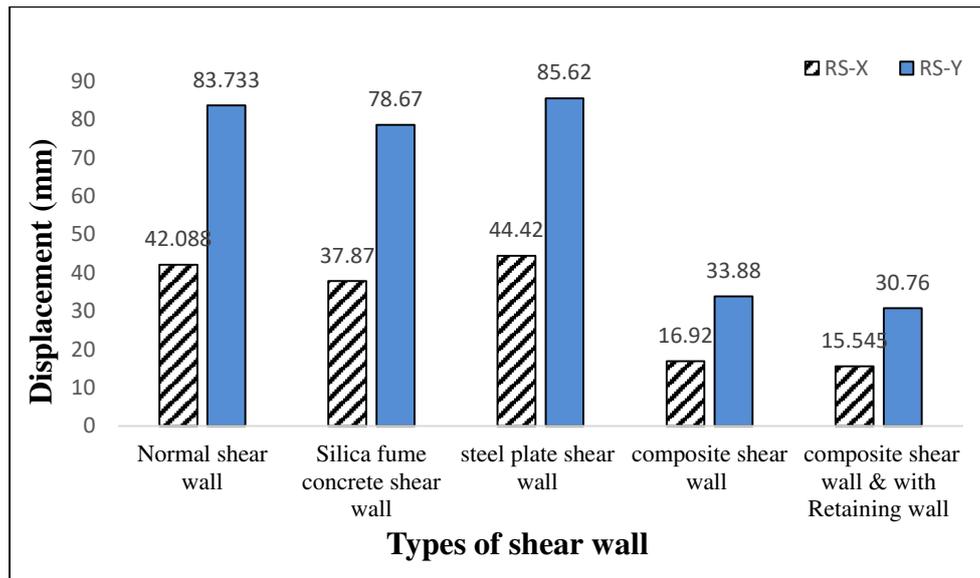


Figure 10. Max storey displacement of G+20 storeyed building.

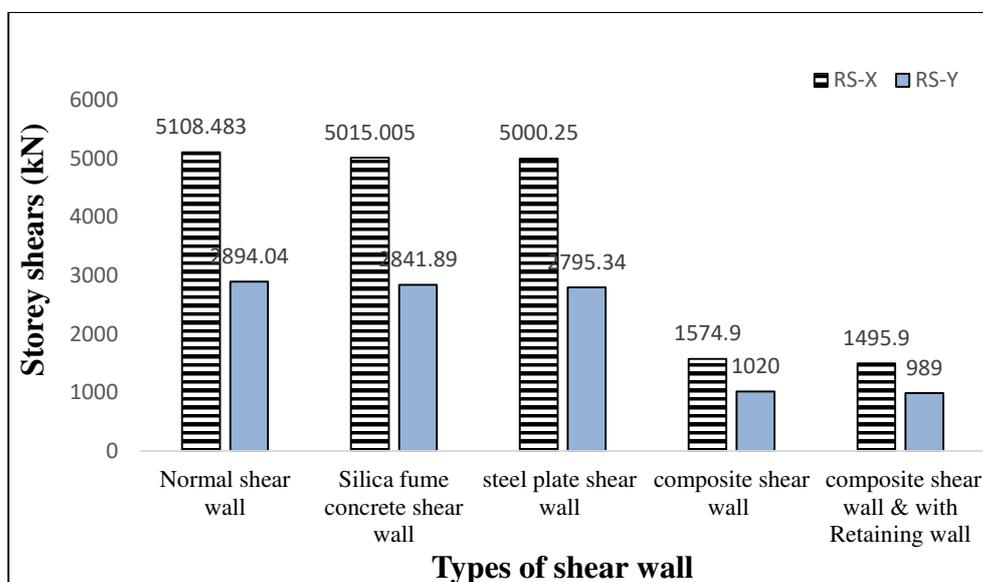


Figure 11. Max storey shear of G+20 storeyed building.

From figure 11, it is clear that by providing composite shear wall in aesthetic tall building, storey shear will also reduce considerably (here it reduces from 5000 kN to 1574 kN).

5. Conclusions

Providing steel-silica fume concrete composite shear wall instead of normal RCC shear wall, in aesthetic tall buildings, the building becomes more seismic-resistant since it provides attractive structural properties in regions. The advantages provided to the structure due to the provision of composite shear wall are.

1. A significant reduction in the storey drift of the aesthetic tall building due to composite shear wall compared to the normal RCC shear wall. The storey drift is also reduced when number of storey increased in building with composite shear wall.
2. While comparing with normal shear wall it is evident that composite shear wall can reduce the seismic effect to a larger extent because nearly 60% reduction in displacement occurs by providing composite shear wall.
3. The study reveals that the composite shear wall has a major role in the reduction of storey shear.

6. References

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