Design of Multistoried Regular R.C. Buildings With and Without Shear Walls

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Abstract —*From the past records of earthquake, there is increase in the demand of earthquake resisting building which can be fulfilled by providing the shear wall systems in the buildings. For achieving economy in reinforced concrete building structures, design of critical section is carefully done to get reasonable concrete sizes and optimum steel consumption in members. In the present study, an attempt has been made to model 12 storey, 15 storey and 18 storey building with and without shear walls by static analysis method for earthquake zone III. E-TAB v9.74 software is used for the analysis. The objective of this study is to assess the comparative seismic performance of buildings in terms of displacement, storey drift, base shear, cost and carpet area. Buildings with shear wall are economical as compared to without shear wall.*

Keywords- *earthquake; seismic performance; shear wall; static method; lateral load;*

I. INTRODUCTION

RC Multi-Storey Buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, the beam and column sizes are quite heavy and there is lot of congestion at the joints and it is difficult to place and vibrate concrete at these places and displacement is quite heavy which induces heavy forces in member. Shear wall may become imperative from the point of view of economy and control of lateral deflection. Shear walls are vertical elements of the horizontal force resisting system. When shear walls are designed and constructed properly, they will have the strength and stiffness to resist the horizontal forces. In building construction, it is a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Shear walls are especially important in high-rise buildings subjected to lateral wind and seismic forces. The most important property of shear wall for seismic design as different from design for wind is that it should have good ductility under reversible & repeated over loads. Shear walls are quick in construction, as the method adopted to construct is concreting the members using formwork. Shear walls doesn't need any extra plastering or finishing as the wall itself gives such a high level of precision, that it doesn't require plastering.

II. GEOMETRY AND DESCRIPTION

For this study, a 12 storey, 15 storey and 18 storey building with 4 meters height for each storey, regular in plan is modeled. This buildings consists of four spans of 5 meter, 4.5 meter, 4.5 meter and 5 meter in X direction while three spans of 5 meter, 2.5 meter and 5 meter in Y direction. The rectangle plan of the building measures 19m x 12.5m. Shear walls were modeled for the same buildings having 2.5m width at periphery corners. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings. The buildings are assumed to be fixed at the base and the floors acts as rigid diaphragms. The sections of structural elements are rectangle but their dimensions are different. Each Storey height of buildings is assumed to be constant including the ground storey.

The buildings is modeled using software ETAB v 9.7.4; among the six different models two models each of heights 12 storey, 15 storey and 18 storey with and without shear walls were studied in medium zone 3 by Static analysis. After this, the design is performed for the models in the zone 3 and comparison is done for the lateral displacement, storey drift, base shear, total cost and carpet area.

The plan of the building model are given below

Model 1 – Floor plan of the bare framed structure.

Model 2 - Floor plan of the dual system with shear wall at periphery corner with L = 2.5m.

2.1. Preliminary data

The preliminary data taken for building for initialization are been given below along with the three different models

Number of stories = 12, 15 and 18   Grade of Concrete and steel = M25 and Fe415
Density of Concrete = 25KN/m³   Density of Brick = 20 KN/m³
Floor to Floor Height = 4 m   Base Height = 2m
Parapet Height = 1m   Thickness of Slab = 150mm
Thickness of Shear Wall = 150mm   Thickness of External Wall = 230mm
Thickness of Internal Wall = 115mm   Live Load = 3 KN/m²
Beam Sizes: B1 = 230mm x 380mm   B2 = 230mm x 450 mm
                B3 = 230mm x 530mm   B4 = 230mm x 600mm

B5 = 230mm x 680mm	B6 = 230mm x 750mm
B7 = 300mm x 750mm	

Column Sizes:

C1 = 300mm x 530mm	C2 = 300mm x 600mm
C3 = 300mm x 680mm	C4 = 300mm x 750mm
C5 = 380mm x 750mm	C6 = 380mm x 830mm
C7 = 380mm x 900mm	C8 = 450mm x 900mm
C9 = 450mm x 980mm	C10 = 450mm x 1050mm

2.1. Plan details

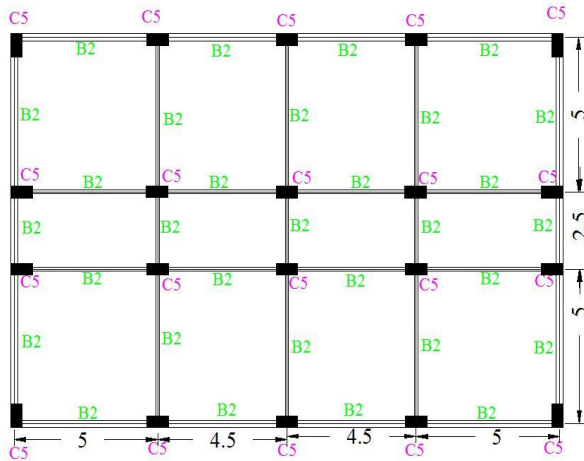The plans of the buildings are developed with the help of AutoCad showing beams columns and shear walls.
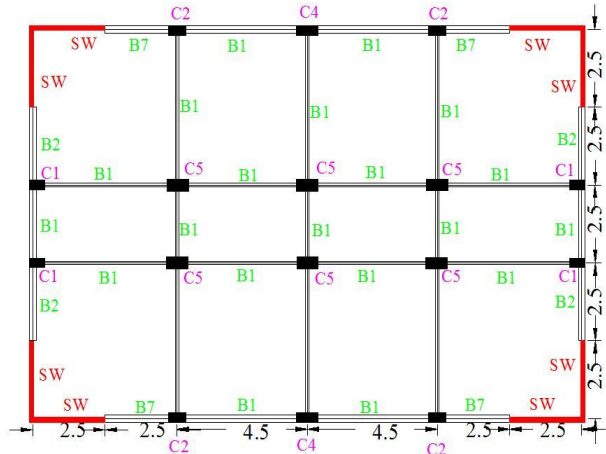

Figure 1. Storey 12 - bare frame

Figure 2. Storey 12 - shear wall frame
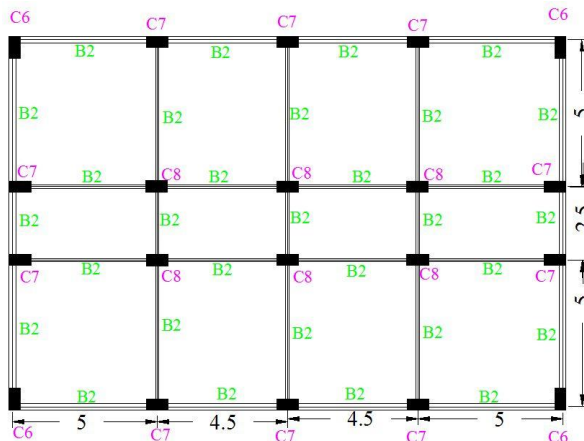
Figure 3. Storey 15 - bare frame
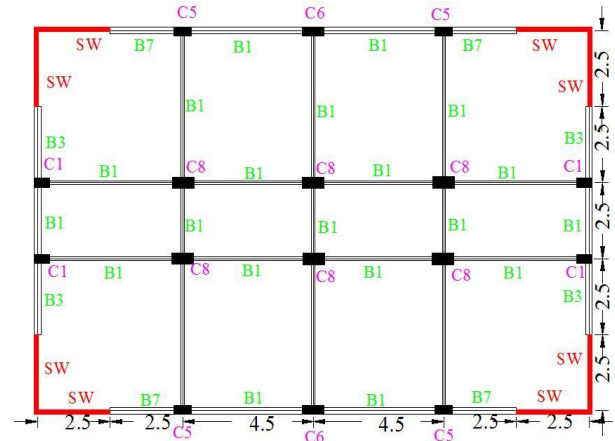
Figure 4. Storey 15 - shear wall frame
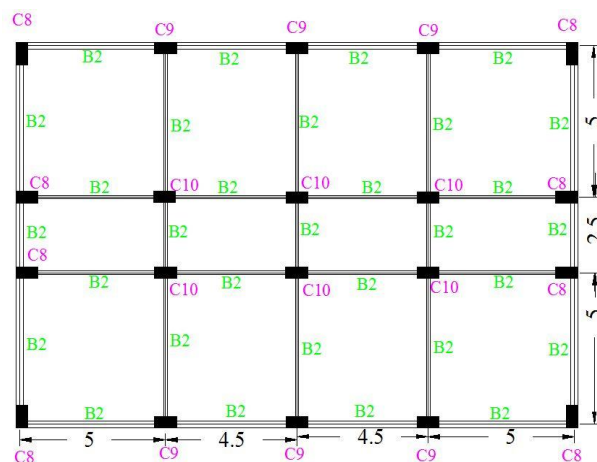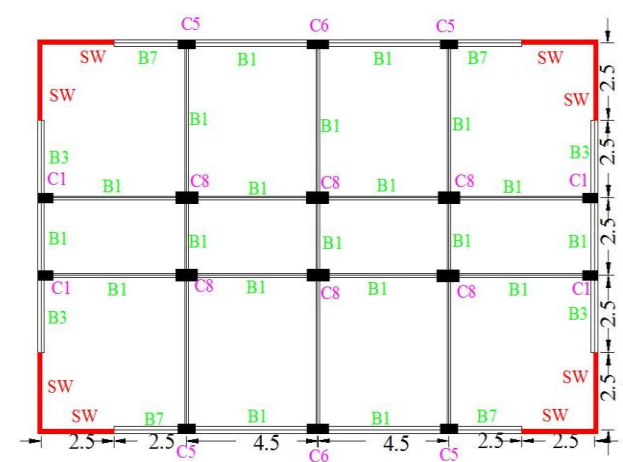

Figure 5. Storey 18 - bare frame

Figure 6. Storey 18 - shear wall frame

III.   RESULTS AND DISCUSSIONS

After the analysis in Etabs v.9.7.4 by static coefficient method, both the models each of 12 storey, 15 storey and 18 storey buildings are compared with each other with respect to the lateral displacements, storey drifts and base shear, cost and carpet area in Zone III as presented below.

3.1. Lateral displacement

The lateral displacement of 12, 15, 18 storey buildings without shear walls was then compared to the lateral displacement of 12, 15 and 18 storey buildings with shear walls in the zone 3 and the corresponding graphs were plotted. As per IS 1893 (Part 1) : 2002, Clause 7.11.1, the displacement shall not exceed 0.004 times the storey height.
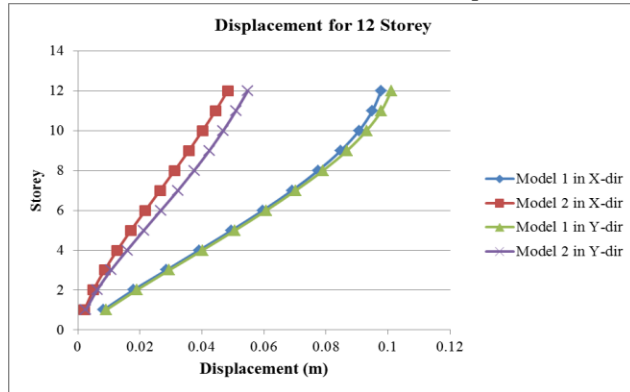

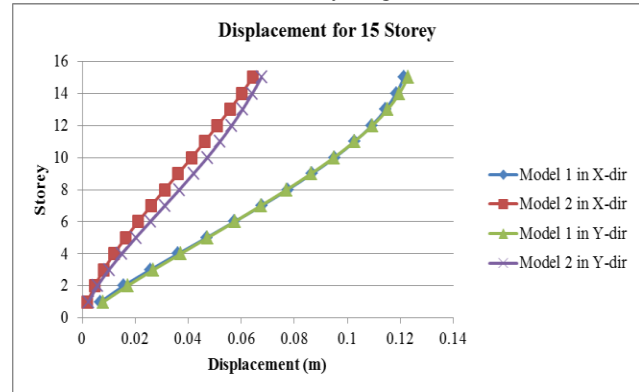*Figure 7. Displacement Curve for 12 Storey*

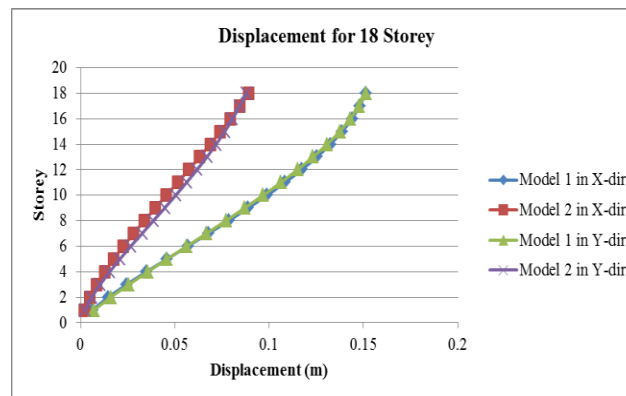*Figure 8. Displacement curve for 15 Storey*

Figure 9. Displacement Curve for 18 Storey

It is observed that the values of displacement of model 2 i.e. with shear walls decreases by 50% for 12 storey at top, by 44% for 15 storey at top and by 41% for 18 storey at top than the values of model 1 i.e. without shear walls. In no case the values of displacement is more than the permissible values.

3.2. Storey Drift

The storey drift of model 2 i.e. with shear walls was then compared to the storey drift of model 1 i.e. without shear walls of all different storey buildings in the zone 3 and the corresponding graphs were plotted. As per IS 1893 (Part 1) : 2002, Clause 7.11.1, the displacement shall not exceed 0.004 times the storey height.
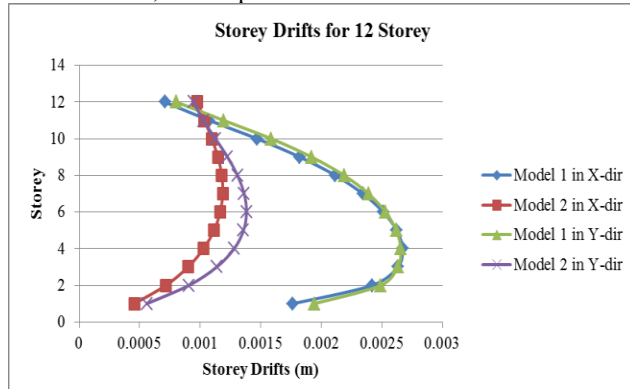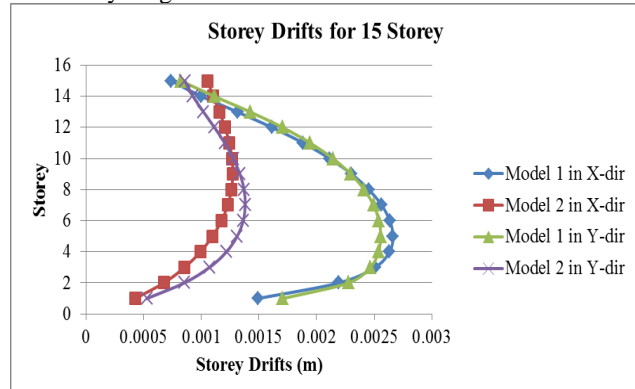

Figure 10. Storey Drift Curve for 12 Storey
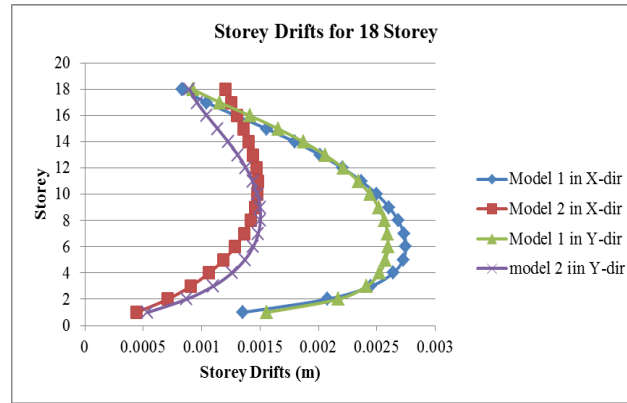

Figure 11. Storey Drift Curve for 15 Storey

Figure 12. Storey Drift Curve for 18 Storey

It is observed that, for 12 storey building the values of storey drift of model 2 i.e. with shear walls decreases by 74% at 1st storey and by only 3.72% for 11th storey but for 12th storey the values slightly increases than the values of model 1 i.e. without shear walls. For 15 storey building, the values of storey drift of model 2 i.e. with shear walls decreases by 71% at 1st storey and by only 11% for 13th storey but for 14th and 15th storey the values slightly increases than the values of model 1 i.e. without shear walls. For 18 storey building, the values of storey drift of model 2 i.e. with shear walls decreases by 67% at 1st storey and by only 13.7% for 15th storey but after 15th storey the values goes on increasing than the values of model 1 i.e. without shear walls. In no case the values of storey drift is more than the permissible values.

3.3. Base shear

The base shear of model 1 i.e. without shear walls was then compared to the base shear of model 2 i.e. without shear walls of all different storey buildings in the zone 3 and the corresponding graphs were plotted.
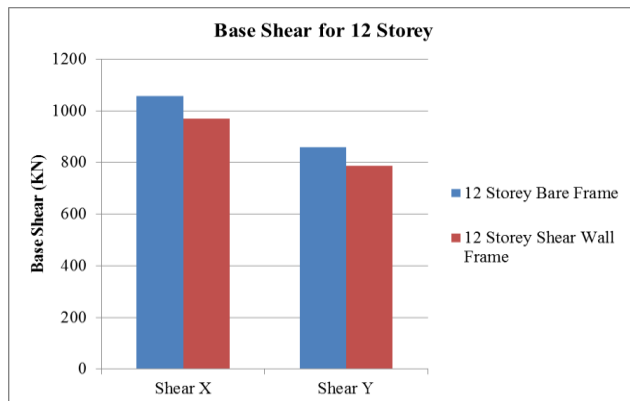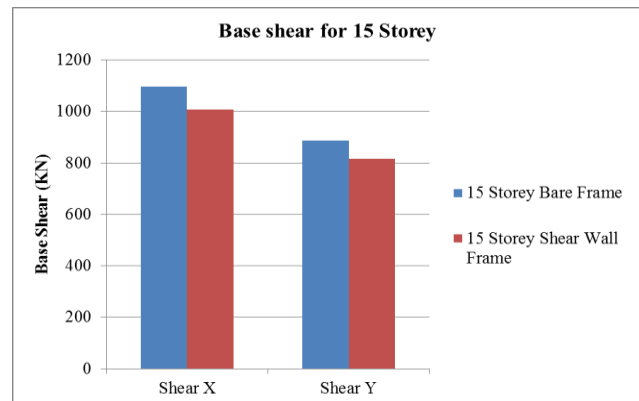

Figure 13. Base Shear Chart for 12 Storey

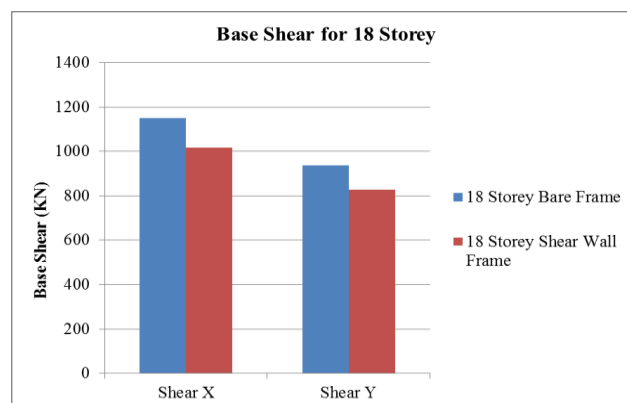*Figure 14. Base Shear Chart for 15 Storey*

Figure 15. Base Shear Chart for 18 Storey

It is observed that at the bottom the values for base shear of model 2 i.e. with shear wall decreases by 8% for 12 storey, by 8 % for 15 storey and by 11% for 18 storey than the values for model 1 i.e. without shear walls.

3.4. Cost comparison

The total cost of steel and concrete of model 1 i.e. without shear walls was then compared to the total cost of steel and concrete of model 2 i.e. without shear walls of all different storey buildings in the zone 3 and the corresponding charts were plotted.
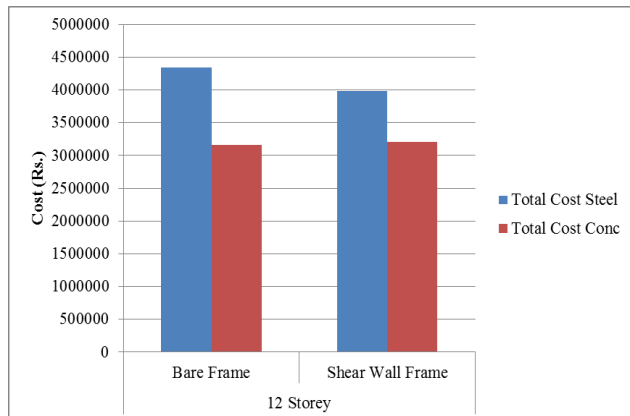

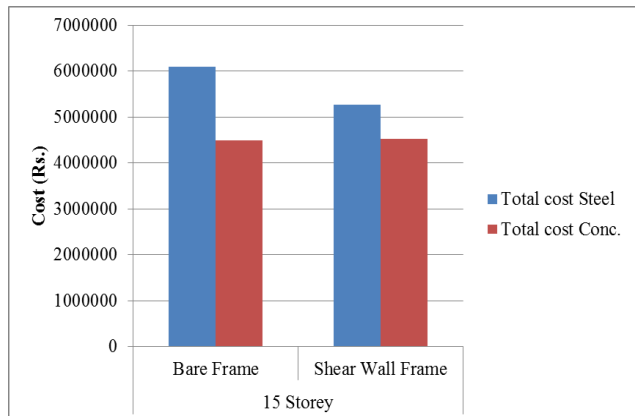**Figure 16. Total Cost of Steel and Concrete for 12 Storey**

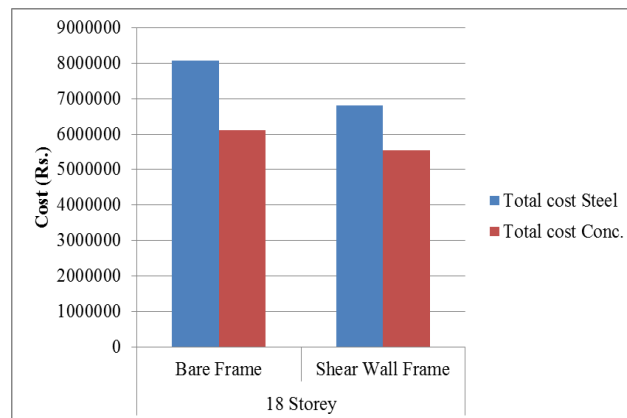**Figure 17. Total Cost of Steel and Concrete for 15 Storey**

Figure 18. Total Cost of Steel and Concrete for 18 Storey

It is observed that for 12 storey building, the total cost of shear wall model reduces by 8% for steel but increases by 1% for concrete than the bare frame model. For 15 storey building, the total cost of shear wall model reduces by 18% for steel but increases by 1% for concrete than the bare frame model. For 18 storey building, the total cost of shear wall model reduces by 15% for steel and by 9% for concrete than the bare frame model.

3.4.1 Cost Saving

From the above total cost calculations, cost saving was found in model 2 i.e. with shear walls which were calculated for all storey and chart is plotted
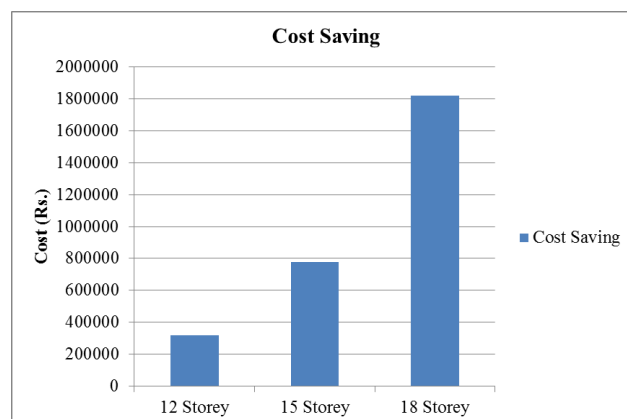

Figure 19. Total Cost Saving Chart in Shear Wall Model

From the total cost saving, it is observed that the cost of shear wall model has been reduced by 4% for 12 storey, by 7% for 15 storey and by 12% for 18 storey than the bare frame model.

3.5. Carpet area

The carpet area of 12 storey, 15 storey and 18 storey models without shear walls were compared to the 12 storey, 15 storey and 18 storey models with shear walls and the chart was plotted.
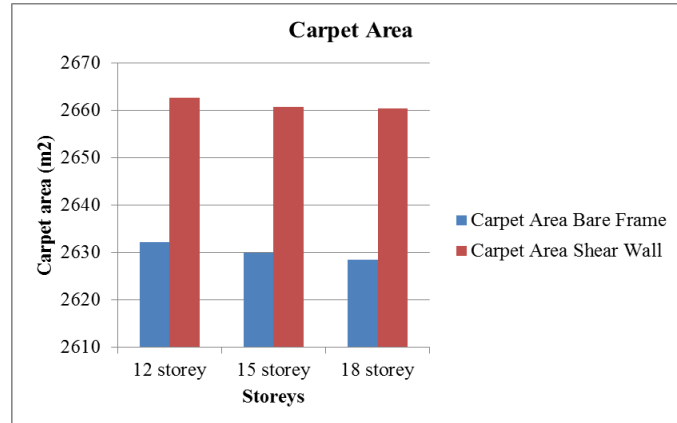

Figure 20. Carpet Area Chart for all Models

It is observed that more carpet area is available in shear wall models than the bare frame models. For 12 storey, 15 storey and 18 storey the carpet area of model 2 i.e. with shear walls increases by approximately 1% than the model 1 i.e. without shear walls.

3.5.1. Cost saving

From the above carpet area calculations, cost saving was found in model 2 i.e. with shear walls which were calculated for all storey and chart is plotted
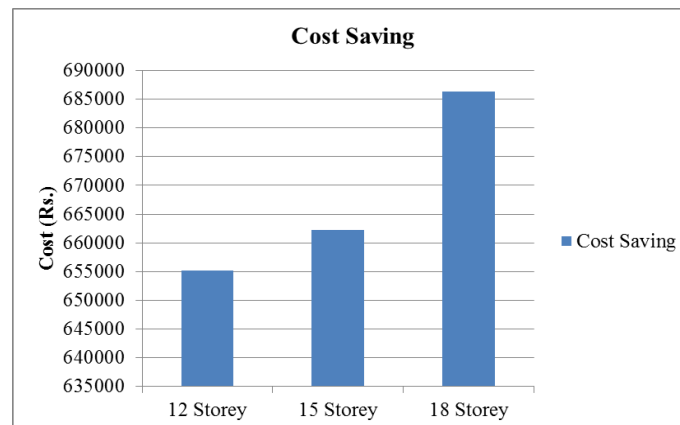

Figure 21. Cost Saving in Carpet Area for all Models

It is observed that with the increase in stories, the cost saving also goes on increases.

IV.   CONCLUSION

➢   Size of members like columns and beams can be reduced economically in case of structure with shear wall as compared to the same structure but without shear wall.
➢   Clear head room is increased by reducing the depth of beam in case of R. C. frame with shear wall.
➢   More carpet area will be available in the building as the sizes of columns are reduced when shear wall is provided.
➢   Less obstruction will be there because of reduced sizes of column and provision of shear wall.
➢   It is concluded that building with shear wall is constructed in lower cost as compared to structure without shear wall.
➢   As per analysis, it is concluded that the deflection at different level in multistoried building with shear wall is comparatively lesser as compared to R.C. building without shear wall.

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