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Significance of Shear Walls in Highrise Irregular Buildings

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ABSTRACT: The usefulness of shear walls in the structural planning of multistorey buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Reinforced concrete framed buildings are adequate for resisting both vertical and horizontal loads acting on them. Extensive research has been done in the design and analysis of shear wall highrise buildings. However, significance of shear wall in highrise irregular structures is not much discussed in literature. A study on an irregular highrise building with shear wall and without shear wall has been carried out to understand the lateral loads, displacement shear effects. It is relevant that high rise building are increasing day by day hence its study is necessary for development point of view. So we thought to use Staad Pro V8i to analyse the certain irregular high rise building by changing the location of shear walls and see what the effects on structure are? The present work contains the experimental investigation on irregular shape building for efficiently locating shear walls at varying places. The usefulness of shear walls in the structural planning of multistorey buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from earthquakes. A study on an irregular high-rise building with shear walls and without shear wall has been conducted to understand the effect on stability of building and other factors as displacement, bending moment, axial force.

KEYWORDS: Seismic forces, Lateral resistance, Shear walls, Displacement.

I. INTRODUCTION

The tallness of a building is relative and cannot be defined in absolute terms either in relation to height or the number of stories. But, from a structural engineer's point of view the high rise building can be defined as one that, by virtue of its height, is affected by lateral forces due to wind or earthquake or both to an extent that they play an important role in the structural design.^[5]

They are mainly flexural members and usually provided in highrise buildings to avoid the total collapse of the high rise buildings under seismic forces. Shear wall has high in-plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads. However, when the buildings are tall, say more than twelve story or so, beam and column sizes workout large and reinforcement at the beam and column junction works out quite heavy, so that, there is a lot of congestion at these joints and it is difficult to place and vibrate concrete at these places, which does not contribute to the safety of buildings. These practical difficulties call for introduction of shear walls in high rise buildings. Deep straight walls or angular, U shaped and box shaped shear walls were used based on functional and architectural requirement of the high rise building.^[1]

Shear walls are a sort of structural system that has lateral resistance to the building or structure. They are vertical components of the structure i.e. the horizontal force resisting system. They are made to counteract the result of lateral masses engaged on the structure. In residential construction, shear walls are straight external walls that usually provide all of the lateral support for the building. To perform correct analysis, a structural engineer should confirm some data

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like structural masses, pure mathematics of the structure, support conditions, and materials properties. The results of such an analysis usually substantiate support reactions, stresses and displacements. This data is then compared with the factors that indicate the conditions of failure. Advanced structural analysis could examine dynamic response, stability and non-linear behaviour. Earthquakes have become a frequent event all over the world. It is very difficult to predict the intensity, location, and time of occurrence of earthquake. Structures adequately designed for usual loads like dead, live, wind etc may not be necessarily safe against earthquake loading. It is neither practical nor economically viable to design structures to remain within elastic limit during earthquake. The design approach adopted in the Indian Code IS 1893(Part I): 2002 'Criteria for Earthquake Resistant Design Of Structures' is to ensure that structures possess at least a minimum strength to withstand minor earthquake occurring frequently, without damage; resist moderate earthquakes without significant structural damage though some non-structural damage may occur; and aims that structures withstand major earthquake without collapse.^[12] Shear walls resist two types of forces: Shear forces and Uplift forces. Shear forces are generated in stationary buildings by accelerations resulting from ground movement and by external forces like wind and waves. Uplift forces exist on shear walls because the horizontal forces are applied to the top of the walls.^[5] The usefulness of shear walls in the structural planning of multistorey buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes.^[7] Reinforced concrete framed buildings are adequate for resisting both vertical and horizontal loads acting on them. Extensive research has been done in the design and analysis of shear wall highrise buildings. However, significance of shear wall location in highrise irregular structures is not much discussed in literature. A study on an irregular highrise building with shear wall and without shear wall has to be studied to understand the lateral loads, bending moment and shear effects.

II. LITERATURE REVIEW

Various studies are carried out related to our work as:

1. Research on lateral-load resisting system in high rise building was carried out and from the study, it was observed that shear wall was very high-in plane stiffness and strength, which can resist large horizontal loads and support gravity loads. Earthquake loads were calculated and applied to building of 15 stories located in zone IV. Analysis was performed using SAP V 10.0.5 (2000) software package.
2. Seismic analysis of RCC building with and without shear wall using software ETAB v 9.5.0. They compared parameters like lateral displacement, story drift and cost required for economy and effectiveness of shear wall. 10 storey building model with 3m height for each storey was studied on the software.
3. Study on G+11 storey residential building with precast reinforced concrete load bearing wall was done. This study analysed load bearing wall and one way slab for gravity and lateral load using ETABS software.
4. Analysis was performed on building with and without shear wall using E TAB v9.0.7 software. Models were prepared for G+12, G+25 and G+38 located in zone 2, 3, 4 and 5 with square plan area of 16m x 16m and 3.5m height.

All the above study was conducted on buildings, but irregularity of the building was not considered in any of case.

III. METHODOLOGY

A residential building of 17 storey irregular structure with typical floor of height 3m is considered for the analysis. The building has mass irregularity. The structure is planned to be reinforced concrete with cement. The superstructure is modelled using standard software Staadpro V8i as a space frame with a grid of columns in the vertical direction, interconnected with beam members in the orthogonal directions at each floor level. The nodes (the meeting points of beams with beams and beams with columns) will be treated as rigid joints due to monolithic construction. The end nodes at the bottom of the model will be modelled as fixed supports due to rigid connection of the columns with footings at the foundation level. The columns will also be inter-connected at the plinth beams to increase the stability of the structure, wherever necessary. All slabs are modelled as membrane. Geometry of the building for the column as

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least lateral dimension of 230mm and minimum width of main beams as 230mm is considered. Design service loads are expected to act on the structure during its intended life and they are considered with reference to relevant codes of IS 875 part1- 1987 for dead loads and imposed loads, IS 875 part3-1987 for wind loads, IS 1893 part1-2002 for earthquake loads. The dead and imposed loads of all the reinforced concrete members will be given as self weights of the members; all the floor loads expressed as load per square area is applied as distributed floor loads onto the supporting beams as per clause 24.5 of IS 456: 2000. All wall loads are applied as uniformly distributed load per unit length onto the supporting beams; the wind and earthquake loads are applied as lateral loads at each floor level. Material grades of M30 & Fe 500 were used for the design. Fig. 1 shows the plan view of the structure without shear wall. Dimension of the plan is 18.5m x 18.5m.

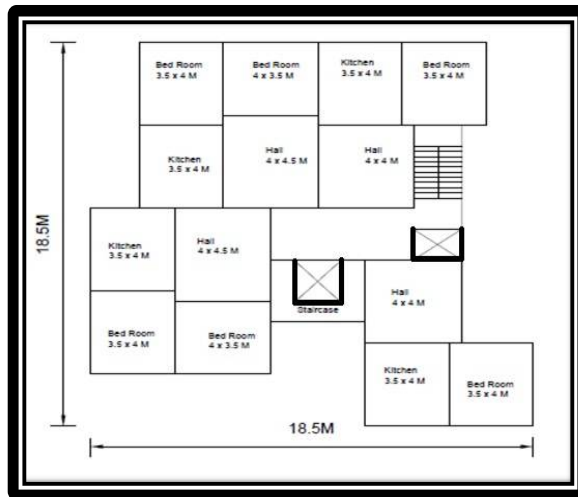
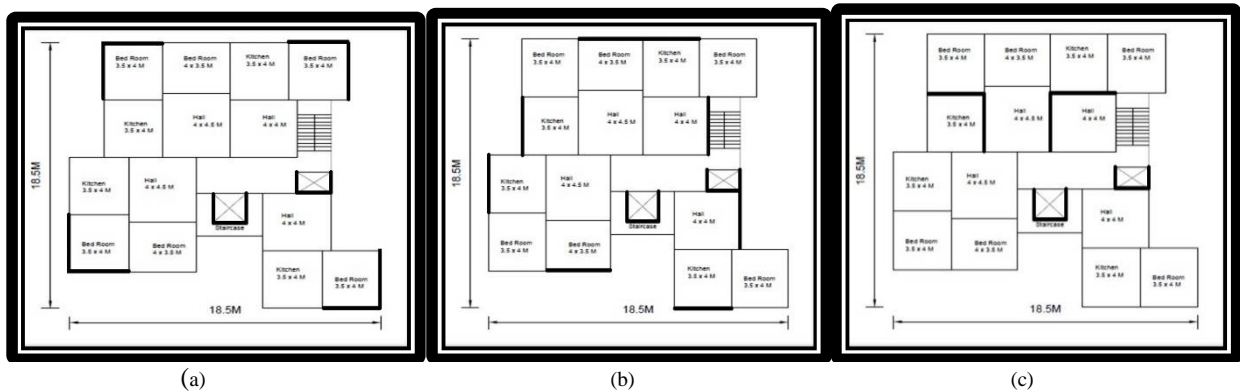


Fig.1.Plan of building (18.5m x 18.5m) of 17 storey.

Five different models are prepared with different locations of shear wall as shown in Fig. 2. (a, b, c, d, and e). The thick bold line shows shear wall locations in plan.



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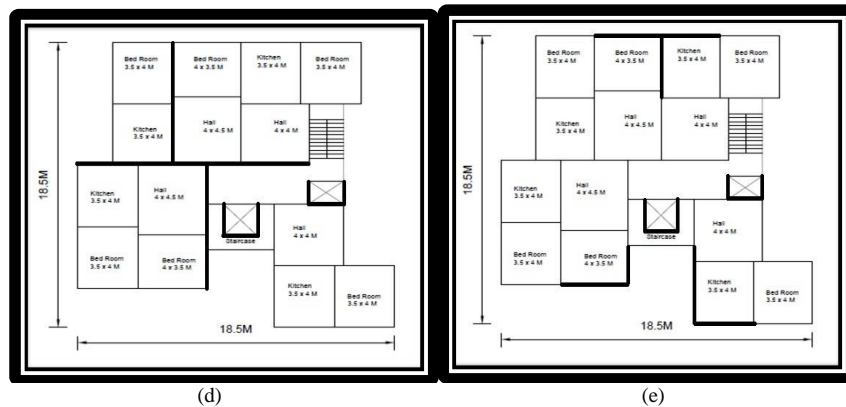


Fig. 2. Different models with shear walls at different locations (Bold line indicating the location of shear wall in all model) plan of size 18.5m x18.5m of 17 storey building.

IV. EXPERIMENTAL RESULTS

Six different models have been analysed for different locations of the shear wall and then results are compared as:

I. Building without shear wall

II. Building with shear wall at sides (5 models with shear wall at different location).

Models	Axial force (kN)
Model 0	1953.308
Model 1	2396.61
Model 2	2122.574
Model 3	3026.835
Model 4	2559.607
Model 5	3439.684

Table 1. Maximum values of axial force for all models for 17 storey building.

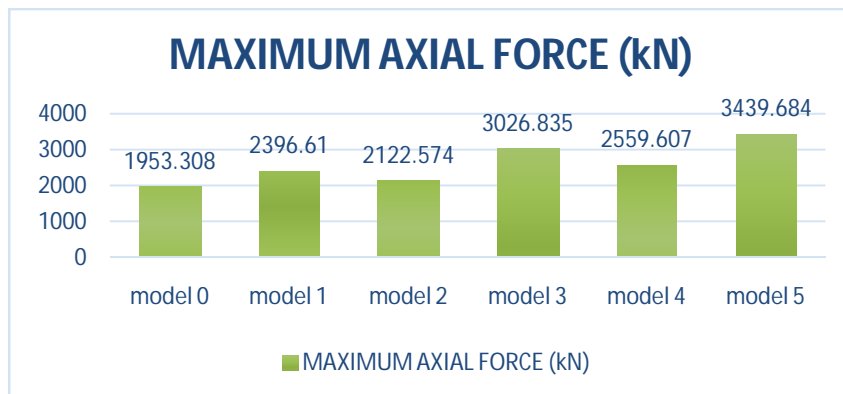


Fig. 3. Axial force comparison of different models for 17 storey building.

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Axial force in model 0 (without shear wall) is minimum and much higher for model 3 & model 5. Model 2 has slightly more axial force than model 0

Models	Moment (kN-m)
Model 0	113.156
Model 1	611.684
Model 2	809.722
Model 3	787.34
Model 4	702.386
Model 5	683.178

Table 2. Maximum values of bending moment for all models for 17 storey building.

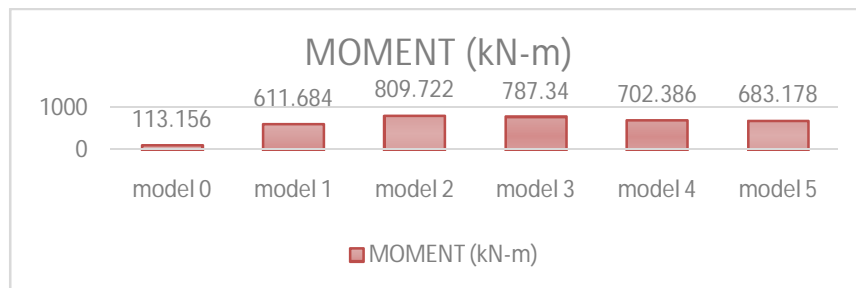


Fig. 4. Moment comparison of different models for 17 storey building.

Moment carrying capacity of model 2 is maximum and is minimum for model 0 (without shear wall).

Models	Displacement (mm)
Model 0	40.82
Model 1	21.856
Model 2	12.535
Model 3	23.19
Model 4	18.14
Model 5	23.448

Table 3. Maximum values of displacement for all models for 17 storey building.

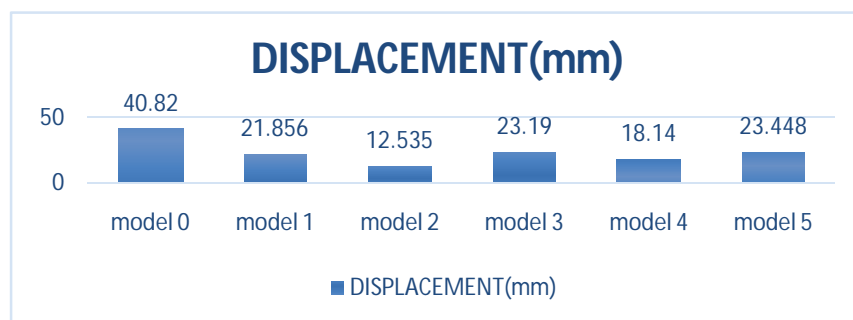


Fig. 5. Displacement comparison of different models for 17 storey building.

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Amongst all model the top lateral displacement is least for model 2 and displacement for model 0 (without shear wall) is approximately triple as compared to model 2. Axial force in model 0 (without shear wall) is minimum and much higher for model 3 & model 5. Model 2 has slightly more axial force than model 0. Also moment carrying capacity of model 2 is maximum and is minimum for model 0 (without shear wall).

V. CONCLUSION

- [1] Providing shear wall at corners of the building i.e. model 1 gives considerably half the displacement as the building without shear wall.
- [2] Model 3, 4, 5 also gave better result as compare to model in which shear wall is not provided.
- [3] But displacement in model 2 is comparatively much less than all other models with and without shear wall.
- [4] Shear wall provided at outer face of building as shown in model 2 is best suitable for irregular shape building.
- [5] Moment carrying capacity of model 2 is also higher than all other models.
- [6] There is about 4 times less displacement for model 2 as compare to model without shear wall, as you can see in table 3.

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