

Study of Behaviour of Multi-Storey Building with Shear Walls

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ABSTRACT - The primary purpose of all kinds of structural systems used in the building is to support gravity loads. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Buildings are also subjected to lateral loads caused by wind, blasting or earthquake. The objective of this paper is to evaluate the response of shear walls placed in the buildings subjected to seismic loads and to study best possible location for positioning of shear wall to resist the seismic load efficiently. Shear wall is a structural member designed to counteract the lateral forces acting on a structure. These walls are more important in seismically active zones when shear forces on the structure increases due to earthquakes. Shear walls have more strength, stiffness and resist in-plane loads that are applied along its height. Buildings with shear walls which are properly designed and detailed have shown very good performance in past earthquakes. Various research studies have been conducted on the design of shear wall and its performance to seismic forces. This paper compiles the evaluation of seismic performance of shear wall.

Keywords: Seismic loads, Shear wall, position, Seismic performance.

1. INTRODUCTION

Shear wall 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. When shear walls are designed and constructed properly, they will have the strength and stiffness to resist the horizontal forces. Shear walls are especially important in high-rise buildings subject to lateral wind and seismic forces.

Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

Shear walls are constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, they will have the strength and stiffness to resist the horizontal forces. Shear walls are one of the most effective building elements in

resisting lateral forces during earthquake. By constructing shear walls damages due to effect of lateral forces due to earthquake and high winds can be minimized. Shear walls construction will provide larger stiffness to the buildings thereby reducing the damage to structure and its contents.

The ideal position of shear wall will be a symmetric position. This will help to avoid torsion as the first mode and brings in a lot of lateral resistance. Generally, multi-storey high rise buildings suffer higher lateral displacement in the presence of wind and earthquake loads. It becomes important to reduce such lateral movement within the acceptable limits. Larger the displacement, higher the induced moments, shear and discomfort. The Indian Standard code IS 1893 (Part 1): 2002 *Criteria for Earthquake resistant design of structures* suggests the permissible lateral displacement to be not more than 0.004 times the height of the building.

Classification of Shear Wall:

1. Simple rectangular types and flanged walls
2. Coupled shear walls
3. Rigid frame shear wall
4. Framed walls with in filled frames
5. Column supported shear wall

Codal Provisions for shear wall in IS: 13920-1993: The code IS 13920 recommends that the thickness of any part of the wall should preferably be not less than 150 mm.

- Flanged walls also have higher bending resistance and ductility. The code restricts the effective flange width of flanged walls to (a) Half the distance to an adjacent shear wall web, and (b) one-tenth of the total wall height.

- The wall should be reinforced with uniformly distributed reinforcement in both vertical and horizontal directions, with a minimum reinforcement ratio of 0.0025 of the gross section in each direction. The bar diameter should not exceed one-tenth the wall thickness, and the bar spacing in either direction should not exceed

(a) 1/5 of the horizontal length of wall,

- (b) Thrice the wall (web) thickness, and
- (c) 450 mm



Action:

Shear walls have high in-plane stiffness thus it resists the lateral loads and control the deflection more efficiently. Shear walls are flexible in the orthogonal plane and can distribute the lateral loads in their own plane by developing resistance against moment and shear. The efficiency and performance also depends on the positioning of the shear walls, whether they are provided at the corners of the building, or at the middle periphery of the building, or placed at the center like a core termed as Shear core system. Shear core system is proved to be more effective.

Role:

1. It significantly reduces lateral displacement/storey drift.
2. Reduces the time period of vibration of the building.
3. Reduces moments and induced torsion during earthquakes.
4. Increases stiffness of the building

Shear walls are easy to construct, because reinforcement detailing of walls is relatively straight-forward and therefore easily implemented at site. Shear walls are efficient, both in terms of construction cost and effectiveness in minimizing earthquake damage in structural and nonstructural elements (like glass windows and building contents).

In a high rise building, a shear wall shall continue from basement to a desired level up to which the effect of lateral forces due to design earthquake load reaches its permissible limit. An ordinary brick wall also acts as a shear wall as it prevents a building frame from distortion, but in modern high rise buildings brickwork

is very little instead we use other material like glass wood or partition wall hence there is extra provision for shear wall.

It is generally provided in lift pit and outer walls or in any portion inside a frame where there is very little opening for doors and windows as a shear wall should be continuous from top to bottom.

To avoid the failure, a diaphragm on roof take earthquake load and convert it as vertical load and transfer to shear wall. So the earthquake load is beared by shear walls. So we provide reinforcement in shear wall to bear that load. These are load bearing walls. Normal brick walls are not load bearing walls.

Following are some of the position of shear wall:

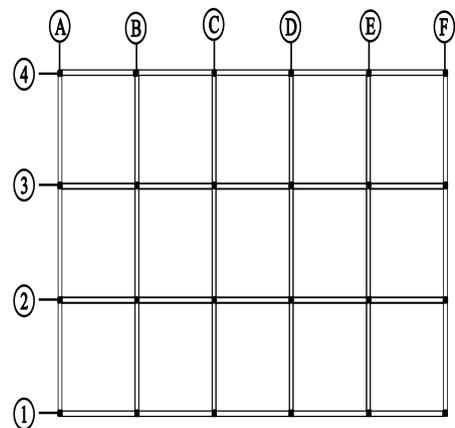


Fig. (a) Without shear wall

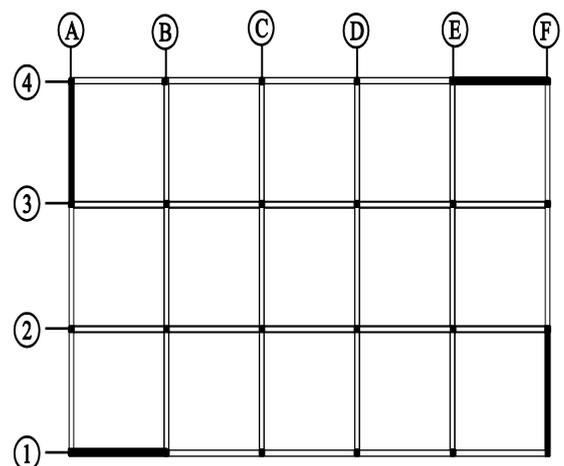


Fig. (b) Shear wall at each side diagonally opposite to each other

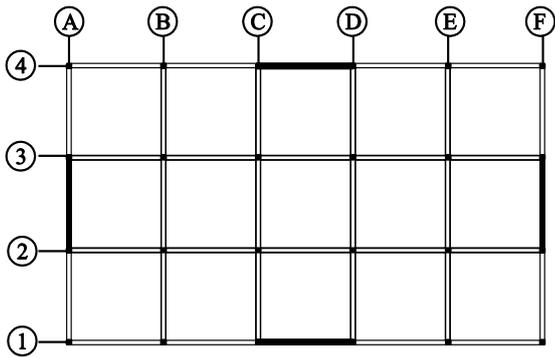


Fig. (c) Shear wall in the middle of each side

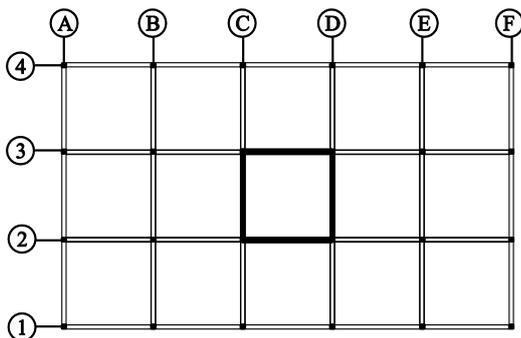


Fig. (d) Core shear wall

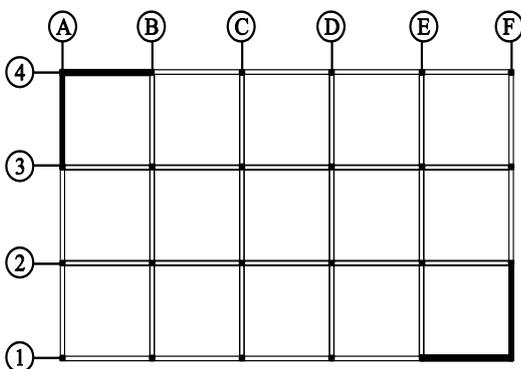


Fig. (e) Corner shear wall diagonally opposite to each other

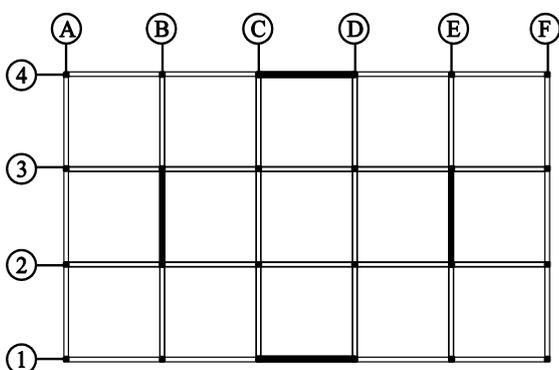


Fig. (f) Exterior + Interior shear wall

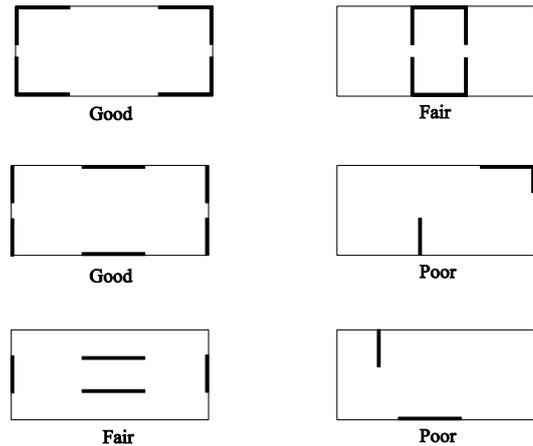


Fig. Geometry and location of shear walls

2. REVIEW OF LITERATURE

- ❖ Wen-I Liao et al. conducted an experimental investigation on high seismic performance shear wall. The test results of four large-scale shear walls, (two shear walls under shake table tests and two shear walls under reversed cyclic loading) were presented. The force -displacement hysteretic loops were presented for the shear walls under reversed cyclic loading. From the experimental results, it was found that the tested high performance shear walls have better ductility than that of conventional shear walls.
- ❖ Varsha.R.Harne considered a six storey RCC building which is subjected to Earthquake loading in zone II to determine the strength of RC wall by changing the location of shear wall using STAAD.Pro. Seismic coefficient method is used to calculate the earthquake load as per IS 1893 – 2002 (Part I). Four different models like structure without shear wall, structure with L type shear wall, structure with shear wall along periphery, structure with cross type shear wall were modeled for analysis. Compared to other models the shear force and bending moment, for structure with shear wall along the periphery is found to be maximum at the ground level and roof level respectively. Hence the shear wall provided along the periphery of the structure is found to be more efficient than all other types of shear wall.
- ❖ Nanjma Nainan conducted analytical study on dynamic response of seismo resistant building frames. The effects of change in height of shear wall on storey displacement in the dynamic response of building frames were obtained. From the study it was concluded that it is sufficient to raise the shear wall up to mid height of building frames instead of raising up to entire height of the building.

- ❖ Dr.B.Kameshwari analysed the influence of drift and inter storey drift of the structure on various configuration of shear wall panels on high rise structures. The bare frame was compared with various configurations like i) Conventional shear wall ii) Alternate arrangement of shear wall iii) Diagonal arrangement of shear wall iv) Zig Zag arrangement of shear wall v) Influence of lift core shear wall. From the study it was found that Zig Zag shear wall enhanced the strength and stiffness of structure compared to other types. In earthquake prone areas diagonal shear wall was found to be effective for structures.
- ❖ “Analysis of Building with and without Shear Wall at Various Heights and Variation of Zone III and Zone V”

P. Kalpana, R.D. Prasad, B.Kranthi Kumar

It is well recognized that the incorporation of lateral load resisting systems in the form of shear walls, bracing systems etc. improve the structural performance of buildings subjected to lateral forces due to earthquake excitation. The seismic behavior of buildings is strongly affected by the arrangement of shear walls, the rigidity of floors and the connections of floors to the walls. The building with structural shear walls improves the lateral load resistance. In the present project, an analytical parameter study is done for the structural shear walls with varying height for different models. The load combinations are considered as per IS 1893 (Part-1):2002. The result in terms of axial forces, lateral displacement and bending moment in the structural shear walls with varying height are compared for different building models considered. As well as two reinforced concrete framed regular buildings with different zones locations of shear walls situated in seismic zone III and zone V have been analyzed in this study. Five-storied buildings were taken with shear-walls and without shear-walls. The design is above verified for this same structure using extended three dimensional analysis of buildings (STAAD Pro V8i) software.

The final conclusions of the study was that the displacements are reduced in building with shear wall compared to building without shear wall. The building with shear wall has more earthquake resistance compared to building without shear wall. There is no variation on wind effect for with and without shear wall building. There is small variation on bending moment and axial force for with and without shear wall. The node displacements are more for Zone V compared to Zone III for earthquake load. The axial forces are decreased with increasing structural height for all models.

Comparison of Zone III and Zone V for the wind effect, the nodal displacements in the exterior columns with shear wall and without shear wall structure are same.

- ❖ “To Study the Effect of Shear Wall at Different Locations by Using Staad. Pro Software in Bare Frame System and In Infilled Frame System” Varun Sourav, Sheo Kumar

The purpose of this study is to find the prime location of shear wall and then investigate the effectiveness of best shear wall in bare frame system and infill frame system. The structure is analyzed for earthquake and wind forces in both the types of structural system i.e. bare frame system and Infilled frame system. In this project, study of G+10 building at Bhuj is presented with some investigations which are analyzed in both the structural system i.e. Bare frame structure and Infilled frame structure. The building is located in Zone-V. In this study standard package of STAAD Pro V8i is used. Comparison of these models for different parameters like Lateral displacement in X & Y Direction, storey drift and axial force in columns carried out.

The results shows that the presence of shear wall in bare frame structure and unfilled frame structure modifies the lateral force behavior of the RC framed building to a large extend. When Brace Frame System without and with shear wall is considered total displacement of the building decreases considerably when the frame building is provided with shear wall. From the results it has been concluded that when shear walls are placed as a core shows best location of shear wall since lateral displacement and axial forces are less as compared to other models.

- ❖ “Seismic Analysis of RrC Framed Building for Different Position of Shear wall” Anil Baral, Dr. S.K.Yajdani

This paper presents the response of building with different positioning of shear wall using both Equivalent Static Method (Seismic Coefficient Method) and Response spectrum Analysis. Five different Model of RCC building, one with no shear wall and other four models with different position of shear wall which is subjected to earthquake load in zone V has been studied. This study also incorporates how the bending moment, shear force for beam and axial force for column vary with change in positioning of RC shear wall. Building are modeled and analyzed using standard package ETABS 2013. Results obtained were:

- Shear wall elements are very much efficient in reducing earthquake displacement of frame and horizontal deflection when shear wall are placed in opposite sides of opposite sides in High rise building.

- The location of shear-wall in opposite sides has significant effect on the seismic response than shear wall placed on any other location of building.
- Shear wall construction will provide large stiffness to the building by reducing the damage to the structure.
- STAAD.Pro has the capability to calculate the reinforcement needed for any concrete section. The program contains a number of parameters which are designed as per IS: 456(2000). Beams are designed for flexure, shear and torsion.
- Axial forces and bending moment in column are reduced more for shear wall in opposite sides as compare to without shear wall at corner, adjacent and centre of building.

❖ “Seismic Analysis of RCC Building with Shear Wall at Different Locations Using STAAD Pro”

Kanchan Rana, Vikas Mehta

An attempt was made for seismic analysis of RCC building with shear wall at different locations using STAAD.Pro. A 6 storey building was taken under consideration. Four different model of RCC building were used, one with no shear wall and other four models with different position of shear wall. The parameters like storey drift, lateral displacement, and base shear will be studied and suitable location of shear wall was determined among these models. This study also incorporates how the shear force, bending moment for beam and axial Force for column vary with change in the position of RC shear wall. The whole analysis is done on STAAD. Pro V8i software.

3. CONCLUSIONS

1. The shear wall provided along the periphery of the structure is found to be more efficient than all other types of shear wall.
2. It was found that the tested high performance shear walls have better ductility than that of conventional shear walls.
3. It is sufficient to raise the shear wall up to mid height of building frames instead of raising up to entire height of the building.

4. REFERENCES

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