Significance of Shear Wall in Multi-Storey Structure With Seismic Analysis

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Abstract. In past decades, shear walls are one of the most appropriate and important structural component in multi-storied building. Therefore, it would be very interesting to study the structural response and their systems in multi-storied structure. Shear walls contribute the stiffness and strength during earthquakes which are often neglected during design of structure and construction. This study shows the effect of shear walls which significantly affect the vulnerability of structures. In order to test this hypothesis, G+8 storey building was considered with and without shear walls and analyzed for various parameters like base shear, storey drift ratio, lateral displacement, bending moment and shear force. Significance of shear wall has been studied with the help of two models. First model is without shear wall i.e. bare frame and other another model is with shear wall considering opening also in it. For modeling and analysis of both the models, FEM based software ETABS 2016 were used. The analysis of all models was done using Equivalent static method. The comparison of results has been done based on same parameters like base shear, storey drift ratio, lateral displacement, bending moment and shear force.

1. Introduction
Adequate stiffness is very important in high rise buildings to resist the lateral loads brought by wind or seismic events. RC shear walls are designed for buildings located in seismic areas, because of their high strength, stiffness and high ductility. A great portion of the lateral load on a building as well as the shear force resulting from load, are often assigned to structural elements made of RCC. Shear walls have very large in-plane stiffness and hence it can resist lateral load and control deflection very efficiently. Using of shear walls or their equivalent becomes important in certain high-rise buildings, if inter-storey deflections caused by lateral loadings are to be controlled. Properly-designed shear walls not only provide safety but also give a proper measure of protection against costly structural as well as non-structural damage during seismic activity. Shear walls provide large stiffness and strength to buildings, which effectively reduces lateral deformation of the structure and hence reduces damage to structure. The shear wall is one of the essential structural components placed in multi-storey buildings which are situated in earthquake zones as they have large resistance to lateral earthquake forces. RC shear
walls should have sufficient ductility to avoid brittle failure under the action of strong lateral earthquake forces. In this paper, first modal is a bare frame residential building without shear wall and other model has shear wall considering openings. With the help of ETABS software, its effectiveness is checked. The linear static analysis method is used in which model is subject to the linear force which state that model is in elastic property. Comparison is made between both the models on parameters like lateral displacement, storey drift, base shear, bending moment, shear force of the structure.

2. Structural Modeling

| Table 1 Geometric details of building |
|-----------------|-----------------|
| No. of stories  | G+8 Residential building. |
| Floor to floor height | 3.0 m |
| Plan area       | 30m x 13m        |
| Size of column  | 300x600 mm       |
| Size of beam    | 230 x 450 mm and 150 x 450 mm |
|                 | 230 x 600 mm and 150 x 600 mm |
| Thickness of slab | 150 mm          |
| Thickness external wall | 230 mm          |
| Thickness of internal wall | 115 mm          |
| Bricks type     | Light weight    |
| Density of brick | 7kN/m³          |
| Grade of concrete | M25             |
| Grade of steel  | Fe500           |
| Thickness of shear wall | 230 mm |
|                 | 150 mm          |

| Table 2 Seismic details of building |
|-----------------|-----------------|
| Zone            | II              |
| Reduction factor | 3               |
| Importance factor | 1               |
| Soil type       | I               |
3. Loading calculations

All loads are calculated as per IS 875-1987(Part I and II).

| Load   | Load type | Details                                           | Name value |
|--------|-----------|---------|--------------------------------------------------|
| Dead   | Dead load | Uniform load on slabs (floor finish + dead slab)  | 4.75 kN/m² |
|        |           |         | Uniform load on beams: (wall load)               | 4.0 kN/m²  |
|        |           |         |                                                   | 3.0 kN/m²  |
|        |           |         |                                                   | 1.6 kN/m²  |
| Live   | Live load | Uniform load on slabs                            | 2 kN/m²    |

4. Problem Statement

Model 1: Model without shear wall (bare frame)
Model 2: Model with shear wall

Figure 1. Plan of building
5. Result

5.1. Base shear

From figure 3, it can be seen that the maximum value of base shear increases by 146% in model with shear wall.

![Figure 2(a). 3D View of without shear wall model](image)

![Figure 2(b). 3D View of with shear wall model](image)

![Figure 3. Comparison of maximum base shear](image)
5.2. Lateral displacement in x-direction

From the figure 4(a), the maximum displacement in X-direction was noted in without shear wall model, the value of displacement decreases by 90.97% in shear wall model.

![Comparison of lateral displacement in x-direction](image)

**Figure 4(a).** Comparison of lateral displacement in x-direction

5.3. Lateral displacement in y-direction

From the figure 4(b), the maximum displacement in Y-direction was noted in without shear wall model, the value of displacement decreases by 85.35% in shear wall model.

![Comparison of lateral displacement in y-direction](image)

**Figure 4(b).** Comparison of lateral displacement in y-direction
5.4. Lateral displacement at given point

5.4.1. Lateral displacement at given point in x-direction

From the figure 5(b), the maximum displacement in X-direction was noted in without shear wall model, the value of displacement decreases by 90.90% in shear wall model.

Figure 5(b). Comparison of lateral displacement in x-direction
5.4.2. Lateral displacement at given point in y-direction

From the figure 5(c), the maximum displacement in Y-direction was noted in without shear wall model, the value of displacement decreases by 87.14% in shear wall model.

![Displacement at Corner Column Position in Y-Direction](image)

**Figure 5(c).** Comparison of lateral displacement in y-direction

5.5 Storey drift in x and y-direction

5.5.1. Storey Drift in x-direction

From the figure 6(a), it can be seen that reduction of storey drift in X-direction in model with shear wall when compared to the without shear wall model and it decreases by 90.20% in Y-direction (by considering maximum values).

![Storey Drift in X-direction](image)

**Figure 6(a).** Comparison of storey drift in x-direction
5.5.2. Storey Drift in y-direction

From the figure 6(b), it can be seen that reduction in storey drift in Y-direction in model with shear wall when compared to the without shear wall model and it decreases by 84.78% in Y-direction (by considering maximum values).

![Storey Drift in Y-direction](image)

**Figure 6(b).** Comparison of storey drift in y-direction

5.6. Maximum Bending Moment in Beam

From the figure 7(a), it can be seen that the maximum value of bending moment increases by 71.58% in model with shear wall.

![Maximum Bending Moment in Beam](image)

**Figure 7(a).** Comparison of maximum bending moment
5.7. Maximum Shear Force in Beam

From the figure 7(b), it can be seen that the maximum value of shear force increases by 53.53% in model with shear wall.

![Comparison of maximum shear force](image)

**Figure 7(b).** Comparison of maximum shear force

5.8. Bending moment and shear force for given beam

![Selected floor beam](image)

**Figure 8(a).** Selected floor beam
5.8.1. Bending moment for selected beam

From the figure 8(b), it can be seen that the bending moment decreases in model with shear wall as compared to without shear wall model.

![Bending Moment for Selected Beam](image)

**Figure 8(b).** Comparison of bending moment for 2nd, 5th and roof floor level

5.8.2. Shear Force for Selected Beam

From the figure 8(c), it can be seen that the shear force decreases in model with shear wall as compared to without shear wall model.

![Shear Force for Given Beam](image)

**Figure 8(c).** Comparison of shear force for 2nd, 5th and roof floor level
6. Conclusions

- In multi-storey buildings, provision of shear walls is found to be effective in increasing the overall seismic response and characteristics of the structure.
- Shear walls are considered for analysis of RC frame in which equivalent static method can be effectively used.
- Shear wall ultimately increases the stiffness and strength of the structure and affect the seismic behavior of the structure.
- From the analytical result, it is observed that base shear increases in the model with shear wall when compared to the model without shear wall. This is due to increase in stiffness of building.
- The considerable reduction in lateral displacement is observed in the shear wall model when compared the model without shear wall. The reduction of displacement of storey is due to increase in stiffness of structure.
- For better seismic performance, a building should have proper lateral stiffness. Low lateral stiffness leads to large deformation and strains, damage to non structural elements.

Therefore, it is necessary to consider the shear walls in the seismic analysis of the structure which significantly increases the strength of overall frame and decreases the probability of collapse of the structure.

7. References

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