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# Study of Shear Wall Frame Structure Subjected to Earthquake Loading in G+15 Building

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***Abstract*-Shear wall is one of the best structural elements that can be used to resist the lateral/horizontal forces caused by wind and earthquake in high rise building or multi-storey building. Shear wall generally provided in high-rise buildings to avoid failure and it used to improve the response of structure in multi-storey structure under lateral forces. The purpose of this study is to find the prime location of shear wall and investigate the effectiveness of the best shear wall in infill frame system. The structure is analyzed for the wind and earthquake forces, using Staad.ProV8i software. Study of G+15 building is presented by static analysis in bare frame system. Lateral displacement and axial force will be analyzed.**

***Key Words- Shear Wall, bare Frame Structure, Lateral Force, Axial Force.***

## INTRODUCTION

One of the factor that must be considered in high rise or multi-storey building is the lateral/horizontal force that acts on the highest floor/elevation. During past earthquake, many reinforced concrete buildings have either collapsed or experienced high level of damage. Through facts it was concluded that this was due to inadequate ductility, lateral stiffness and strength. A multi-storey building is subjected to lateral loads due to wind and earthquake force. When the building is designed without shear wall, the weight of beam and column is quite heavy, and it will cause the congestion in every joint of the structure. This congestion makes the building become prone to the lateral force and can be easily collapsed or damaged. Reinforced concrete walls, which included with shear walls, are the usual requirement for multi-storey buildings. Usually shear walls will be placed symmetrically or in the center of the structure so the load can be distributed evenly and effectively to the foundation.

Shear wall is one of the best structure elements for the high-rise or multi-storey building to resist the lateral force from wind and earthquake. Shear wall are usually placed in the stairs, between column lines, lift wells, shafts, and so on. It works by distributing the lateral force (wind and earthquake load) to the foundation. Shear wall make the structure of the building become more rigid/stiff and increase the strength of the structure. This study will determine the best location for the shear walls and the effectiveness of the shear walls using Staad.ProV8i software and two different models. Comparative graph will be presented in different cases on the basis of different parameter, such as lateral deformation and also the axial force.

### *Shear Wall*

Through facts it has been seen that lateral force causes shear and overturning moments in the walls due to which frames shape changes from a rectangle to a parallelogram. Structural walls are usually referred to as shear walls because they are carrying out large fractions of lateral shear force. Shear walls provides stiffness, strength and ductility to the structure. Overturning moment resistance, storey shear forces and storey torsion by the wall depends on its position, configuration and orientation of the wall. Traditionally, shear walls are provided in elevator shafts and stairwells. Large core of shear wall that is provided in the center also provide sufficient torsional resistance. To resist wind forces, any kind of wall arrangements can be used but in case of earthquakes when location of wall deviates, it is more difficult to ensure satisfactory overall building response.

### *Shear Wall Cross-section*

Generally, shear walls are present in the planar manner in the plan of the building. However, combinations of these planar forms are also used in the system. To satisfy the functional requirement, non planar sections like C, L, U, W, H, T etc are used. These non planar sections require 3-D analysis.

### *Failure Modes of Shear Wall*

Lateral forces derived from winds, earthquake or by blasting can cause shear and overturning moments in the walls due to which frames shape changes from a rectangle to a parallelogram. Shear walls are mainly are lateral force resisting system which can be caused by wind or earthquake loads. Shear wall failure due to lateral loads are flexural failure, horizontal failure, and vertical failure.

## DESCRIPTION OF THE BUILDING

Building details:

| No. | Details |
|---|---|
| 1. | Building frame type is Special Moment Resisting Frame (SMRF), which is fixed at base. |
| 2. | Building is located in Seismic Zone V. |
| 3. | Number of storey is G+15. |
| 4. | Spacing between bays is 5 m in x-direction and 4m in z-directions. |
| 5. | Number of bays in x and z-directions are 5 and 4 respectively. |
| 6. | Grade of concrete used is M 25 and grade of steel used |

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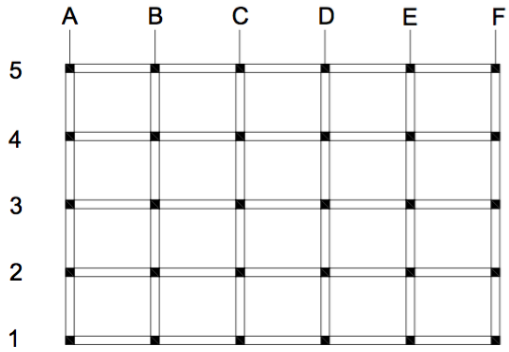
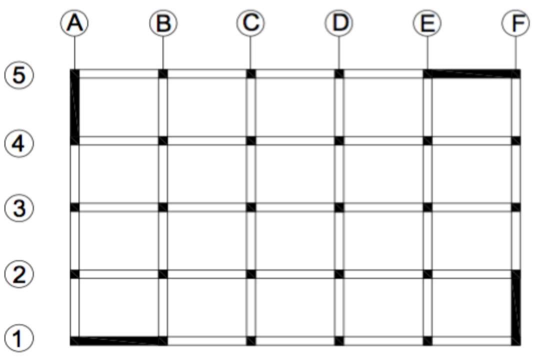
| | |
|---|---|
| | is Fe 415. |
| 7. | Floor to floor height is 3 m. |
| 8. | Parapet wall height is 1 m. |
| 9. | Parapet wall thickness is 230 mm. |
| 10. | Slab depth is 150 mm. |
| 11. | Thickness of external wall is 230 mm and thickness of internal wall is 115 mm. |
| 12. | Size of columns is 500 mm × 500 mm. |
| 13. | Size of beams is 300 mm × 450 mm. |
| 14. | Live load on floors is 3 KN/m2. |
| 15. | Live roof load is 1.5 KN/m2. |
| 16. | Floor finish load is 1 KN/m2. |
| 17. | Roof finish load is 1.5 KN/m2. |
| 18. | Building is resting on medium soil. |
| 19. | Importance factor is taken as 1. |
| 20. | Unit weight of RCC is 25 KN/m3. |
| 21. | Unit weight of masonry wall is taken as 20 KN/m3. |
| 22. | Thickness of Shear walls is 230 mm. |
| 23. | Elastic modulus of brick masonry wall is 22360 MPa. |
| 24. | Elastic modulus of concrete is 25000 MPa. |
| 25. | Size of all infill walls that is equivalent to diagonal strut is 610×230 mm. |
| 26. | Response Spectra is taken as per IS 1893 (Part-1): 2002. |
| 27. | Damping of structure is taken as 5 percent. |

Top view of building models:

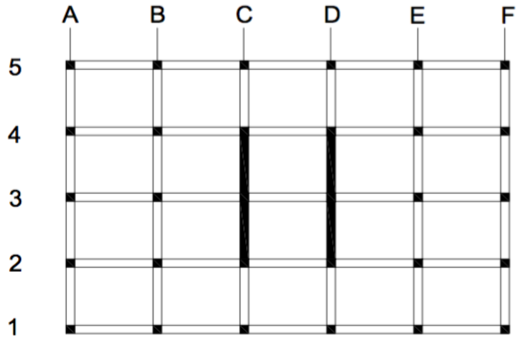
1. Without shear wall.




2. With shear wall at each side diagonally opposite to each other.




3. With shear wall located vertically in the midddle.




STRUCTURAL ANALYSIS PROCEDURE (USING STAAD.PRO)

All the models that are developed to determine the best location of shear wall on lateral load performance of the building were created in Staad.Pro V8i. While creating 3-D models, some basic assumptions were taking into consideration to decrease the complexity of the program and analysis run time. Also, it is known that there are lots of parameters that affect the behavior of the building system under loading, especially lateral loading. Material properties of the concrete and masonry are fixed for all the cases.

The modeling of the building using Staad.Pro can be described in the following steps:

Pre-processing

1. Post-processing
2. Analysis and design of the model
3. Results

Pre-processing

In this first step we define the prototype model, materials and properties for beam, column and masonry. We also define the support conditions and load cases.

Define prototype model data

First of all, we start with a new model by taking force units as Kilo-Newton and length unit as meter. Then select the frame type by open the structure wizard option in Staad.Pro and after that define the length, height and width in X, Z and Y direction by entering the sufficient number of bays in respective direction.

*Define member properties*

After deciding the frame we define the material of beam and column and also assign the properties to the beams and columns.

Define type of support, load cases and combinations

In order to perform the analysis of the structure, it is necessary to assign the type support. In this project, fixed supports are used at the base of the building.

Before defining load combination we need to define the different load cases, which are considered in the analysis. It

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is given in code IS 1893 (Part-1): 2000 that when the lateral load resisting elements are not oriented along orthogonal horizontal directions then the structure shall be designed for the effect due to full earthquake load in one horizontal direction plus 30 percent the earthquake load in other direction. Following load combinations are used in this thesis is per IS 1893 (Part-1): 2002.

1. 1.5 (DL + LL)
2. 1.2 (DL+LL ± EL)
3. 1.5 (DL ± EL)
4. 0.9 DL ± 1.5(EL)

Where,

DL = Dead Load
LL = Live Load
EL = Earthquake Load
WL = Wind Load

*Post-processing*

In this step different types of loads are assigned to various members of the structure.

*Assign load to the structure*

Loads play a vital role in the design of the building, so it should be carefully applied to the building. All the loads are assigned to the structure. Earthquake forces are assigned to the node created at the center of area of each floor level as per seismic forces calculated. Wind loads are also assigned to the structure. In order to assign uniformly distributed load (U.D.L.), member to which load is to be assigned is selected. Then the value of suitable load and distances are entered and assigned to the selected members of the structure. Floor load is assigned to the floors of the structure. Values of floor load and the range into which load has to be applied is entered and then assigned. Earthquake forces are applied in both the X and Z directions.

*Analysis and Design of the Model*

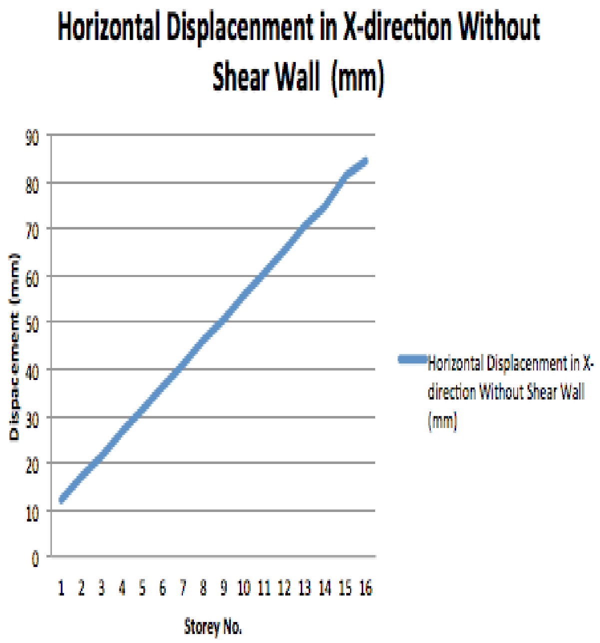
Analysis of the model is performed for all the static load cases. Analysis of the model is to be done before it is designed. After analysis is performed, suitable design code (IS 456) is selected from the dropdown list for designing the concrete frame. All the load combinations are selected for the design. Staad.Pro V8i will design the frame members (i.e. beams and columns) for most critical load combination.

RESULT

After the analysis is performed, results can be easily obtained.

1. Lateral displacement along X -direction in bare frame without shear wall.

| Storey No. | Lateral Displacement in X-direction (mm) |
|---|---|
| 16 | 84.26 |
| 15 | 81.58 |
| 14 | 74.54 |
| 13 | 70.40 |
| 12 | 65.54 |
| 11 | 60.68 |
| 10 | 55.82 |
| 9 | 50.96 |
| 8 | 46.09 |
| 7 | 41.23 |
| 6 | 36.37 |
| 5 | 31.51 |
| 4 | 26.65 |
| 3 | 21.78 |
| 2 | 16.92 |
| 1 | 12.06 |




From the data and the graph, the maximum displacement in x-direction is occurred in storey no. 16, the displacement is 84.268 mm.

2. Lateral displacement along Z-direction in infill frame without shear wall.

| Storey No. | Lateral Displacement in Z-direction (mm) |
|---|---|
| 16 | 58.69 |
| 15 | 54.33 |
| 14 | 51.58 |
| 13 | 47.75 |
| 12 | 44.20 |
| 11 | 40.64 |
| 10 | 37.09 |
| 9 | 33.53 |
| 8 | 29.97 |
| 7 | 26.42 |
| 6 | 22.86 |
| 5 | 19.31 |
| 4 | 15.75 |
| 3 | 12.19 |
| 2 | 8.64 |
| 1 | 5.08 |

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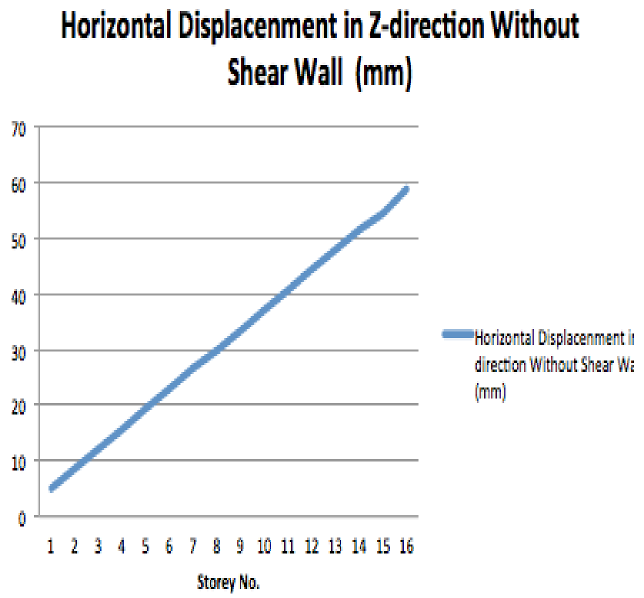
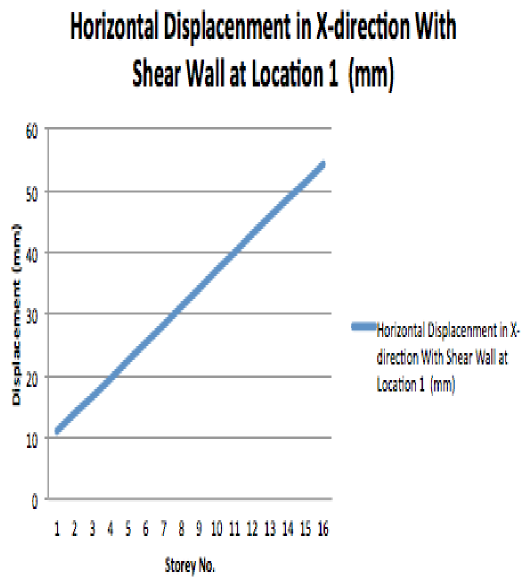



In storey no. 16, maximum displacement in z direction is occurred, the value is 58.698 mm.

3. Lateral displacement along X-direction in bare frame with shear wall at location 1.

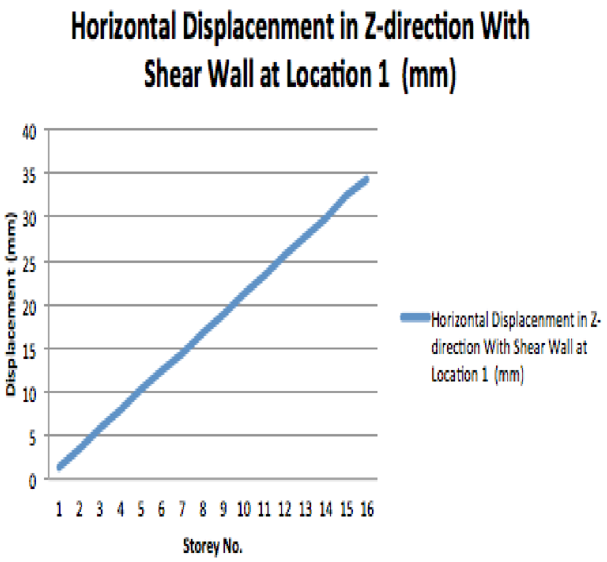
| Storey No. | Lateral Displacement in X-direction (mm) |
|---|---|
| 16 | 54.35 |
| 15 | 51.38 |
| 14 | 48.56 |
| 13 | 45.64 |
| 12 | 42.75 |
| 11 | 39.85 |
| 10 | 36.96 |
| 9 | 34.07 |
| 8 | 31.17 |
| 7 | 28.28 |
| 6 | 25.38 |
| 5 | 22.49 |
| 4 | 19.60 |
| 3 | 16.70 |
| 2 | 13.81 |
| 1 | 10.91 |




The maximum displacement still occurred in storey no. 16, but the value is reduced. The displacement in x direction becomes 54.356 mm.

4. Lateral displacement along Z-direction in bare frame with shear wall at location 1.

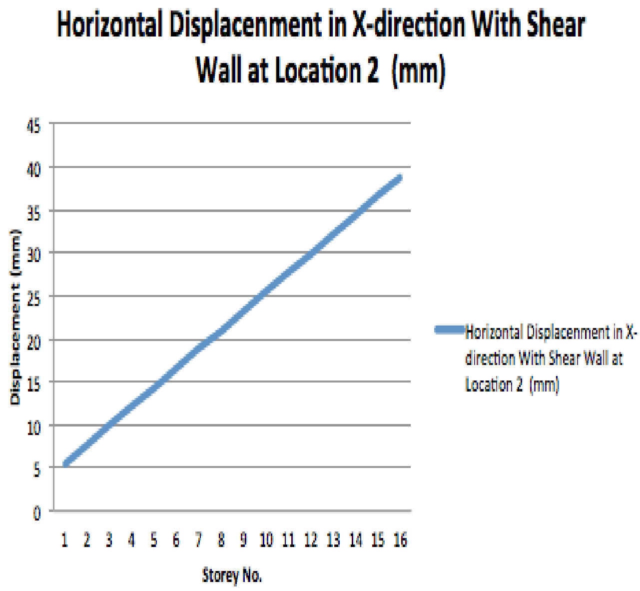
| Storey No. | Lateral Displacement in Z-direction (mm) |
|---|---|
| 16 | 34.32 |
| 15 | 32.51 |
| 14 | 29.89 |
| 13 | 27.81 |
| 12 | 25.60 |
| 11 | 23.39 |
| 10 | 21.18 |
| 9 | 18.96 |
| 8 | 16.75 |
| 7 | 14.54 |
| 6 | 12.33 |
| 5 | 10.11 |
| 4 | 7.90 |
| 3 | 5.69 |
| 2 | 3.48 |
| 1 | 1.268 |




From the data, the maximum displacement in z direction is smaller than the displacement in x direction, the value is 34.321 mm.

5. Lateral displacement along X-direction in infill frame without shear wall at location 2

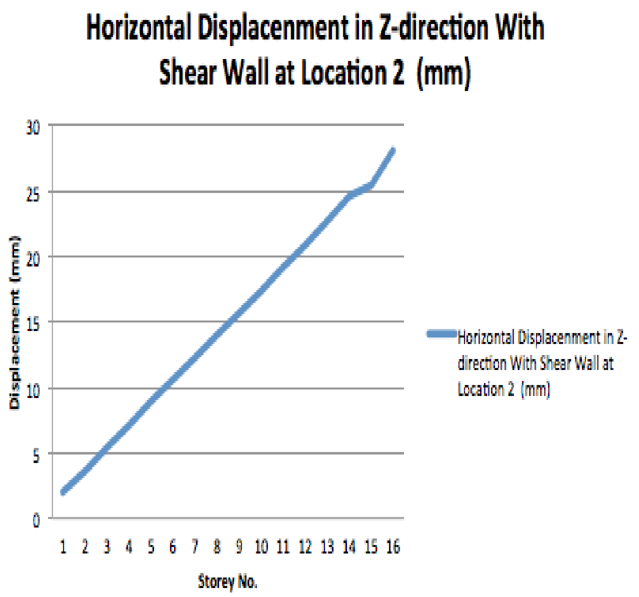
| Storey No. | Lateral Displacement in X-direction (mm) |
|---|---|
| 16 | 38.69 |
| 15 | 36.58 |
| 14 | 34.26 |
| 13 | 32.08 |
| 12 | 29.86 |
| 11 | 27.64 |
| 10 | 25.42 |
| 9 | 23.21 |
| 8 | 20.99 |
| 7 | 18.77 |
| 6 | 16.55 |
| 5 | 14.34 |
| 4 | 12.12 |
| 3 | 9.90 |
| 2 | 7.68 |
| 1 | 5.47 |




Compare with the displacement in x direction at location 1, the shear in location 2 has better perfomance to ressisting the lateral force, the maximum displacement value is 38.698 mm.

6. Lateral displacement along Z-direction in infill frame without shear wall at location 2.

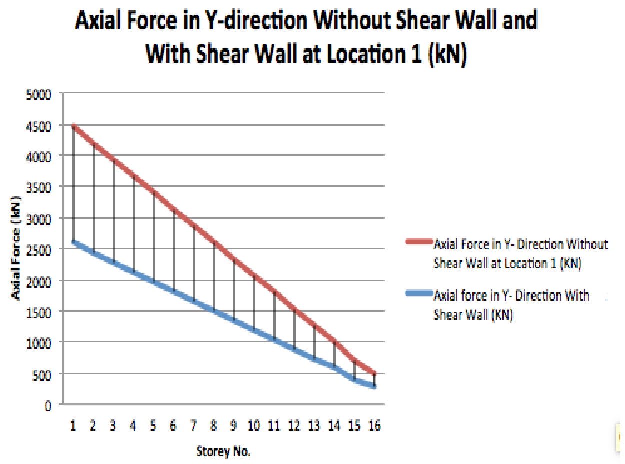
| Storey No. | Lateral Displacement in Z-direction (mm) |
|---|---|
| 16 | 27.98 |
| 15 | 25.36 |
| 14 | 24.56 |
| 13 | 22.54 |
| 12 | 20.83 |
| 11 | 19.12 |
| 10 | 17.41 |
| 9 | 15.70 |
| 8 | 13.99 |
| 7 | 12.28 |
| 6 | 10.56 |
| 5 | 8.85 |
| 4 | 7.14 |
| 3 | 5.43 |
| 2 | 3.72 |
| 1 | 2.01 |




The dispacement in z direction of location 2 is also smaller than the z direction displacement in location 1, the value of the maximum displacement is 27.986 mm.

3. Axial force along y-direction in bare frame without shear wall and with shear wall at location 1.

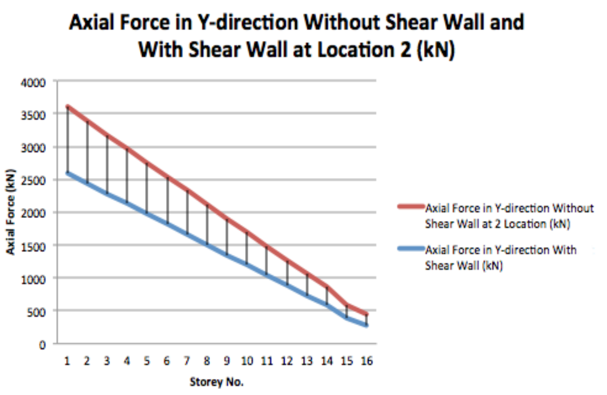
| Storey No. | Axial Force Along Y-direction (kN) | |
|---|---|---|
| | Without Shear Wall | Shear Wall at Location 1 |
| 16 | 278.96 | 211.35 |
| 15 | 385.24 | 322.59 |
| 14 | 589.96 | 431.36 |
| 13 | 729.06 | 541.78 |
| 12 | 884.56 | 651.79 |
| 11 | 1040.06 | 761.80 |
| 10 | 1195.56 | 871.80 |
| 9 | 1351.06 | 981.81 |
| 8 | 1506.56 | 1091.81 |
| 7 | 1662.07 | 1201.82 |
| 6 | 1817.57 | 1311.83 |
| 5 | 1973.07 | 1421.83 |
| 4 | 2128.57 | 1531.84 |
| 3 | 2284.07 | 1641.85 |
| 2 | 2439.57 | 1751.85 |
| 1 | 2595.08 | 1861.86 |




From the data comparison it shown that shear wall reduced 24% of axial force that act in every storey.

4. Axial force along y-direction in infill frame without shear wall and with shear wall at location 2.

| Storey No. | Axial Force Along Y-direction (kN) | |
|---|---|---|
| | Without Shear Wall | Shear Wall at Location 2 |
| 16 | 278.96 | 165.36 |
| 15 | 385.24 | 198.36 |
| 14 | 589.96 | 278.56 |
| 13 | 729.06 | 327.30 |
| 12 | 884.56 | 383.90 |
| 11 | 1040.06 | 440.5 |
| 10 | 1195.56 | 497.09 |
| 9 | 1351.06 | 553.69 |
| 8 | 1506.56 | 610.29 |
| 7 | 1662.07 | 666.89 |
| 6 | 1817.5 | 723.49 |
| 5 | 1973.07 | 780.09 |
| 4 | 2128.57 | 836.69 |
| 3 | 2284.07 | 893.29 |
| 2 | 2439.57 | 949.89 |
| 1 | 2595.08 | 1006.49 |




The data shown that the shear wall that located at location 2 has better performance than the shear wall at location 1, the shear wall at location 2 can reduce up to 41% of the maximum axial force.

## CONCLUSION

The present study has analyzed in bare frame system without and with shear wall at different locations. Shear wall plays a significant role in increasing the performance of building under the lateral forces.

## PRECISE CONCLUSIONS

The results shows that the presence of shear wall in bare frame structure modifies the lateral force behavior of the RC framed building to a large extend.

From the results presented in previous chapter the following conclusions are drawn –

1. When bare Frame System without shear wall is considered

- In Model 1, about 84.26 mm of lateral displacement in X-direction and about 58.69 mm of lateral displacement in Z-direction get. And axial force in column is 278.96 KN Gets.

2. When bare Frame System without shear wall is considered at location 1.

- In Model 2, about 54.35 mm of lateral displacement in X-direction and about 34.32 mm of lateral displacement in Z-direction get reduced. Also and axial force in column is 211.35 KN get reduced.

3. When bare Frame System without shear wall is considered at location 2.

- In Model 3, about 38.69 mm of lateral displacement in X-direction and about 27.98 mm of lateral displacement in Z-direction get reduced. And axial force get reduced 165.36 KN.

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