# Seismic Analysis of Unsymmetrical RC Building Resting on Flat and Sloping Ground with Shear Wall at Different Positions

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***Abstract*— Due to increase in population, there is scarcity of land. Scarcity of land shows picture of construction of high-rise buildings. This building structures are subjected to vertical load due to gravity and lateral load due to wind or earthquake. High rise buildings are susceptible to lateral loading (wind or seismic force). As the height of structure increases it becomes more-slender which leads to sway of the structure when the lateral loads are acting on the structure. Buildings present in hilly areas are different from buildings on plain ground as the area is irregular and unsymmetrical. In hilly areas the structure is constructed with different column heights. Hence, they tend to severe damage due to lateral loads such as earthquake or wind load. Therefore, in order to resist these forces different resisting force systems are used. Shear wall is one of the important resisting systems used today's architecture design. This study gives brief about unsymmetrical building analysis with shear wall resisting system. The main objective of this study is to found the most effective and suitable position of shear wall for the building with unsymmetrical area and compare the flat ground building & sloping ground building considering different parameters.**

**Keywords-** unsymmetric, shear wall, story displacement, story shear, story drift ratio, etc.

## I. INTRODUCTION

Nowadays population and industrialization are increases day by day. Due to increase in population, there is scarcity of land. Scarcity of land leads to construction of high-rise buildings. Generally High-rise buildings are subjected to two types of forces one is due to gravity loading and other is due to lateral forces such as wind and earthquake. As these lateral forces are predominant and due to height structures also becomes slender so lateral displacement of the structure is promoted and this is unsafe Buildings present in hilly areas are different form buildings on flat ground as the area is irregular and unsymmetrical. Symmetry plays many roles in architectural design. Symmetrical buildings tend to be more stable. It also adds to the beauty of the model that it is more visible. At the same time, asymmetrical buildings have more displacement due to earthquakes than symmetrical buildings because asymmetrical buildings are not smooth and subject to high pressure. However, asymmetrical areas may exist and symmetry may not be possible, then it is important to examine asymmetrical patterns. lateral load resisting systems like shear wall, space trusses, bracing system, tubular structures are there. The shear wall is one of the effective and easily implemented lateral load resisting systems which was used for the analysis. Shear wall is a structural member in a RCC structures used for resist the lateral forces such as wind and earthquake forces. It starts at level of foundation and ends at top height of building. Shear wall helps resist earthquake induced debris and strengthen the structure. Shear walls are commonly used for providing lateral stability.

## II. LITERATURE REVIEW

Kanchan Rana (2017) et al observed that the minimum story drift was found at structure having shear wall at center edges while maximum story drift for without shear wall structure. K Veera Babu (2022) et al had used the response spectrum analysis method they concluded that, with increase in slopes the bending, shear & torsion values are increases. Sachin Kumar Dangi (2019 From study it is observed that maximum base shear is found in building with shear wall at corner & periphery and minimum in bare frame. Base Shear found maximum on 45° slope and minimum on 15° ground slope, it means Base Shear increases with the inclination of the slope. Also, in this study they found that, the position of the shear wall at periphery is the optimum position for the lateral load resistance and the position of the shear wall at corner is the optimum position for countering axial loads. Miss.Pratiksha Thombre (2016) et al This paper presents Analysis of different configuration of buildings is carried on sloping and level ground. The behavior of the structure on sloping ground have studied. On sloping ground the displacement of building shows the same behavior as of regular building. The displacements value gets smaller as the slopes increases due to curtailment of column. Nitish Kumar Sharma (2019) et al observed that story displacement & story drift value for symmetric building was less while for unsymmetric building it was more.

## III. METHODOLOGY

[A] Methodology:(1) Analysis of G+6 RC building with unsymmetrical shape with different positions of shear wall on sloping ground and flat ground using response spectrum method in Etabs software. (2) Estimate story displacement, story drift, story shear. (3) Analysis and results for the different models and conclusion based on analysis and results. [B] Research objectives:(1) To analyze multistory unsymmetric RC building with shear wall at different positions with variation in slope. (0º and 20º) using Etabs software.

(2) To compare the behavior of unsymmetric RC building with shear wall and without shear wall on Flat & sloping ground.

(3) To find the suitable positions of shear wall for unsymmetric RC building with sloping ground and flat ground.

## IV. MODELING & ANALYSIS

In this study G+6 unsymmetric RC building was used for the analysis. Also, there were flat ground and sloping ground was considered. For the sloping ground 20-degree slope considered. The building models are modelized and analyzed by ETABS v18 software by response spectrum analysis method as per IS 1893:2016. For the Analysis results of the structure the following parameters are considered (1) Maximum Story Displacement (2) Story Shears (3) Maximum Story Drifts. All the columns of the building are considered as 450 mm x 450 mm, while all the beams as 230mm x 400mm. the size of shear wall used as 150 mm in size. For the center position of shear wall considered two panels which are

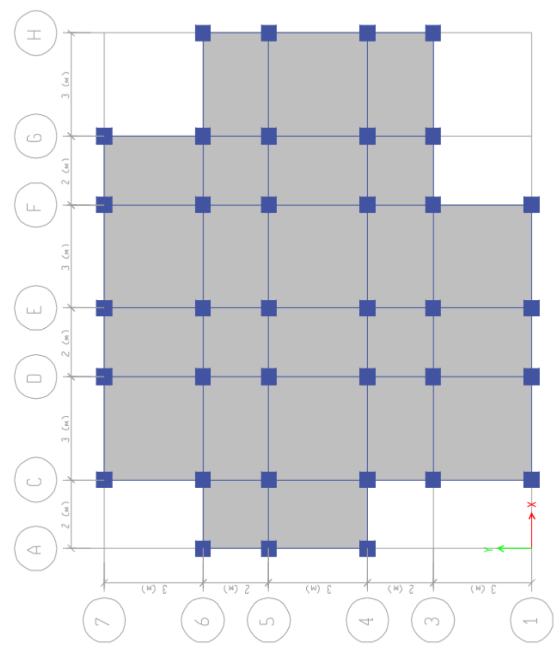



Fig 1: - Plan View of the modeling building

approximately at center witch include Center of mass of building area. First four models are at flat ground while last four models are at sloping ground of 20-degree slope. The different positions of shear wall were planned for the analysis. The following cases of building were considered for analysis:

- Flat ground building without Shear wall-[model1]
- Flat ground building with Shear wall at alternative positions- [model-2]
- Flat ground building with Shear wall at center- [model3]
- Sloping ground building with Shear wall at Internal corner- [ model-4]
- Sloping ground building with no Shear wall- [model-5]
- Sloping ground building with Shear wall at alternative positions- [model-6]
- Sloping ground building with Shear wall at center- [model-7]

❖ Sloping ground building with Shear wall at Internal corner- [model 8]

Table-1: Building parameters:

| BUILDING PARAMETERS | DISCRIPTION |
|---|---|
| Type of frame | RCC structure |
| Plan size | 15m X 13m |
| No. of stories | G+6 (7 stories) |
| Floor height | 3m |
| Column size | 450mm X 450mm |
| Beam size | 230mm X 400 mm |
| Slab thickness | 150mm |
| Wall size external | 230mm |
| Wall size internal | 150mm |
| Shear wall size | 150mm |
| Live load | 3 KN/$m^2$ |
| Floor finish load | 1.5 KN/$m^2$ |
| Frame load external wall | 12.41 KN/m |
| Frame load internal wall | 8.1 KN/m |
| Grade of concrete | M30 |
| Grade of steel | Fe500 |
| Density of concrete | 25 KN/$m^2$ |
| Seismic zone | V |
| Type of soil | Medium (type II) |
| Damping % | 5% |
| Importance factor | 1 |
| Response reduction factor | 5 |
| Basic wind speed | 44 m/s |
| RCC design code | IS 456:2000 |
| Steel design code | IS 800:2007 |
| Wind design code | IS 875:2015 |
| Seismic design code | IS 1893:2016 |

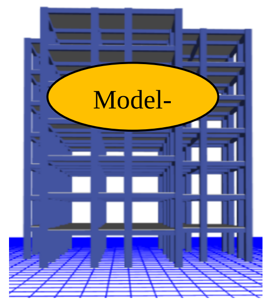


fig-2 Flat ground building without shear wall

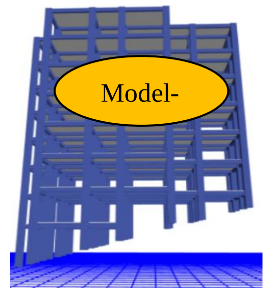


fig-6 Sloping ground building without shear wall

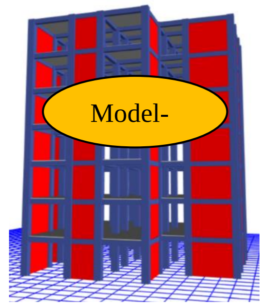


fig-3 Flat ground building with shear wall at alternative positions

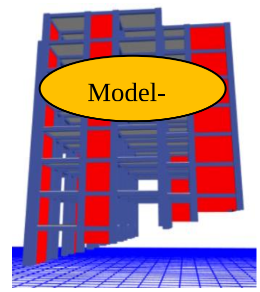


fig-7 Sloping ground building with shear wall at alternative positions

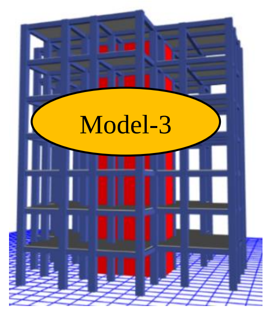


fig-4 Flat ground building with shear wall at center

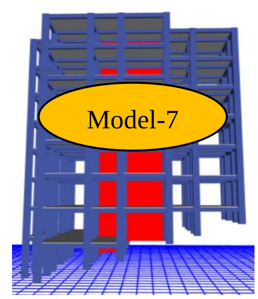


fig-8 Sloping ground building with shear wall at center

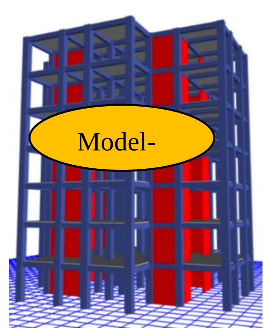


fig-5 Flat ground building with shear wall internal

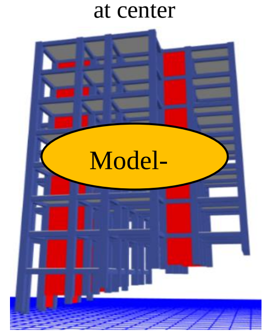


fig-9 Sloping ground building with shear wall at internal corner

From the Table-2 maximum story displacement was 139.5 mm at story-7 for model-1. the graph of displacement was of increasing function (fig 10). The graph of displacement looks like deflected shape of the building. The displacement shape curve is slightly of upward opening. & the maximum story shear was 7646.17 KN found at base. graph of story shear was of step functioned graph (fig 11). The maximum story drift was found at story no. 3 which was 0.00735. from the (fig 12) the graph of story drift was of increasing-decreasing functioned.

Table-2: Analysis results for different models:

| Story no. | Analysis results for flat ground building | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model-1 | | | Model-2 | | | Model-3 | | | Model-4 | | |
| | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ |
| Base | 0 | 7646 | 0 | 0 | 8375 | 0 | 00 | 7987 | 0 | 0 | 7890 | 0 |
| 1 | 16.73 | 7388 | 2.22 | 2.84 | 8135 | 0.95 | 3.22 | 7726 | 1.07 | 5.55 | 7659 | 1.85 |
| 2 | 44.07 | 6789 | 3.97 | 8.81 | 7595 | 1.99 | 8.71 | 7175 | 1.83 | 16.73 | 7137 | 3.73 |
| 3 | 71.54 | 5880 | 5.42 | 16.59 | 6744 | 2.60 | 15.28 | 6345 | 2.19 | 30.29 | 6320 | 4.53 |
| 4 | 96.06 | 4698 | 6.59 | 25.17 | 5573 | 2.87 | 22.28 | 5230 | 2.35 | 44.16 | 5206 | 4.64 |
| 5 | 116.10 | 3261 | 7.35 | 33.81 | 4037 | 2.89 | 29.19 | 3780 | 2.36 | 57.00 | 3756 | 4.31 |
| 6 | 130.63 | 1585 | 7.32 | 42.04 | 2036 | 2.78 | 35.65 | 1903 | 2.24 | 68.01 | 1896 | 3.73 |
| 7 | 139.51 | 1585 | 2.45 | 49.64 | 2036 | 2.59 | 41.41 | 1903 | 2.01 | 77.32 | 1896 | 3.11 |
| Story no. | Analysis results for sloping ground building | | | | | | | | | | | |
| | Model-5 | | | Model-6 | | | Model-7 | | | Model-8 | | |
| | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ | Displacement (mm) | Shear (KN) | Drift ratio $x10^{-3}$ |
| Base | 0 | 7679 | 0 | 0 | 8099 | 0 | 0 | 8243 | 0 | 0 | 8297 | 2.74 |
| 1 | 19.51 | 7480 | 7.32 | 4.70 | 7863 | 1.72 | 6.01 | 7983 | 2.18 | 6.18 | 8052 | 2.26 |
| 2 | 44.24 | 6902 | 8.25 | 11.54 | 7301 | 2.28 | 12.98 | 7392 | 2.33 | 14.80 | 7472 | 2.87 |
| 3 | 68.20 | 5996 | 8.01 | 19.76 | 6457 | 2.74 | 20.65 | 6507 | 2.56 | 24.82 | 6593 | 3.34 |
| 4 | 89.31 | 4801 | 7.09 | 28.58 | 5325 | 2.94 | 28.48 | 5322 | 2.62 | 35.20 | 5414 | 3.47 |
| 5 | 106.41 | 3335 | 5.78 | 37.39 | 3858 | 2.95 | 35.98 | 3802 | 2.52 | 45.20 | 3894 | 3.35 |
| 6 | 118.69 | 1618 | 4.20 | 45.82 | 1954 | 2.82 | 42.80 | 1881 | 2.29 | 54.38 | 1953 | 3.08 |
| 7 | 126.05 | 1618 | 2.54 | 53.68 | 1954 | 2.63 | 48.66 | 1881 | 1.97 | 62.54 | 1953 | 2.74 |

For the model-2, the maximum story displacement was 49.64 mm (Table-2) which was 64.41% less than the flat ground building without shear wall. But the max story was 8374.74 KN which was 8.7% more than the flat ground building without shear wall. Also, the maximum story drift was 0.002895 at story no. 5 it means max story drift shifts from story no. 3 to story no. 5. In this case the displacement curve is of downward opening deflected. So, it means that the displacement graph was changes its deflected shape for structure with shear wall to the structure without shear wall. The maximum story displacement was 41.41mm (Table-2) for model-3 which was 70% less than the flat ground building without shear wall. Also, in this case the graph of displacement was almost straight-line graph with increasing from bottom to top. (fig 10) the max story shear was 7987 KN which was only 4.3% more than the flat ground building without shear wall & 4.6 % less than the flat ground building with shear wall at alternate position. maximum story drift was 0.002357 at story no 5 which was again less than the flat ground building with shear wall at alternate position. For Model-4 from Table-2 the maximum story displacement was 77.32 mm. by comparing with flat ground building with shear wall at center it was 8.6 % more. Again, in this case maximum story shear was 7890.48 KN which was only 1.2% less than flat ground building with shear wall at center. Also, the maximum story drift was more than flat ground building with shear wall at center which was

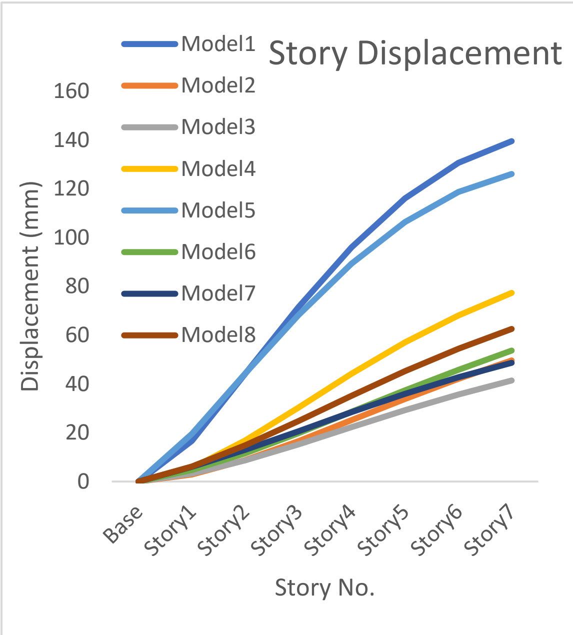



fig 10: - story number vs story displacement.

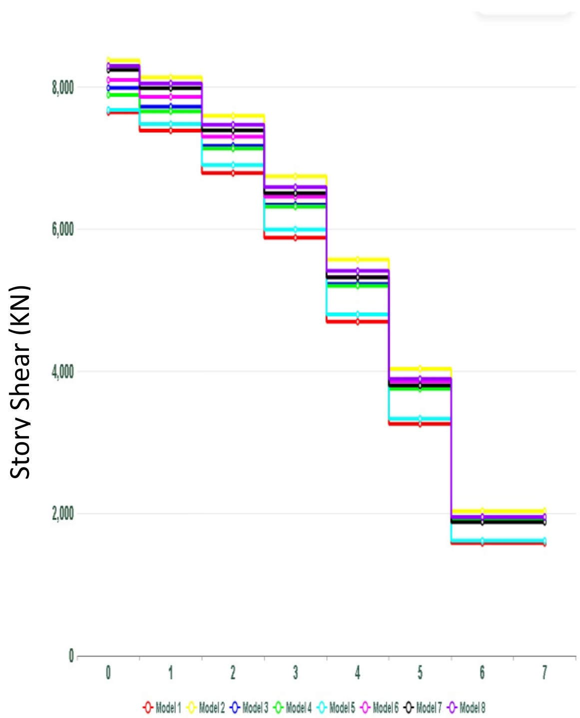
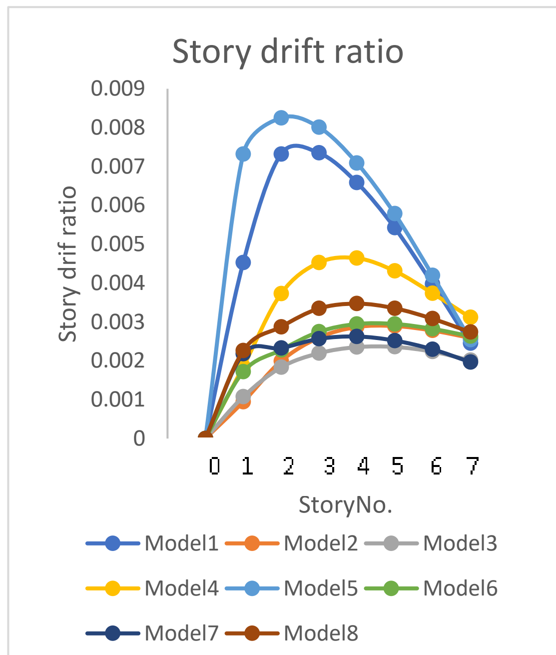



fig 11: - story number vs story shear

0.004641 at story no.4.For the sloping ground building from the model-5 analysis results the maximum story displacement was 126.1 mm at story 7 & maximum story shear was 7679.18 KN found at base. (Table-2) the displacement value for the sloping ground building without shear wall which was less than the flat ground building without shear wall. The maximum story drift was found at story no. 2 which was 0.0082.the graph of displacement was of increasing function (fig 10) while graph of story shear was of step functioned graph and graph of story drift was of increasing-decreasing functioned (fig 12). Also, as compare to the flat ground building without shear wall the slope was decreased by 13 mm but the story drift increased from 0.00735 to 0.0082. Consider model-6, from table-2 the maximum story displacement was 53.68 mm which was 57.43% less than the sloping ground building without shear wall. But the max story was 8099 KN which was 5.18% more than the sloping ground building without shear wall. The maximum story drift was 0.002948 at story no.5.consider the model-7, the maximum story displacement was 48.66 mm (fig 10) which was 61.40% less than

fig 12:




story no. Vs Story drift

the sloping ground building without shear wall. Also, in this case the graph of displacement was almost straight-line (fig 10). The maximum story shear was 8243.04 KN at base which was 7.34% more than the sloping ground building without shear. In this case also, maximum story drift was 0.002625 at story no 3 which was less than the sloping ground building with shear wall at alternate position. the model-8 (Table 2) the maximum story displacement was 62.54 mm. by comparing with Flat ground building without shear wall it was 49.5 % less. And story shear value also more than sloping ground building with the shear wall at center position and alternate positions.

## VI. CONCLUSION

(1) The story displacement value reduced by the 70% & 61.40% from building with the flat & sloping ground building without shear wall to the flat ground building with shear wall at center respectively.
(2) The deflection value of flat ground building without shear wall is more than the deflection value of sloping ground building without shear wall, while deflection value of flat ground building with shear wall at center is less than the deflection value of sloping ground building with shear wall at center.
(3) The maximum story shear is more for shear wall at alternate position due to self-weight of shear wall and minimum for without shear wall condition.
(4) For the flat ground building the maximum story drift ratio is more than sloping ground building.

(5) The best suitable and effective position of shear wall for the flat & sloping ground unsymmetric RC buildings is at the center position.

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