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Comparative Study of Locations of Shear Walls in Irregular RC Structures by Using Response Spectrum Analysis

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ABSTRACT - The lateral load resisting system is the key factor which aids towards the stability of a structure when structure is subjected to lateral loads due to wind and earthquake. The displacement and storey drift can be reduced effectively by applying the shear wall. Many researchers observed that the performance of shear wall is affected by its position in the building. In this paper, G+10 RC L-shaped irregular building with shear wall at different locations is analysed for storey drift, base shear and torsion by Response spectrum method as per IS: 1893 (Part1)-2016 using ETABS software. Shear walls are placed at core, parallel to both plan directions separately and exterior corners. The results are compared for base shear, storey drift and torsion. Based on analysis, it is found that base shear and torsion increases with the use of shear wall in building as the stiffness of the building increases. The storey drift in the building decreases due to the increased stiffness. The considered building models are also checked for the torsional irregularity as per IS: 1893 (Part1)-2016. The obtained results show that provided locations for shear wall in all model does not induce any torsional irregularity.

Keywords - shear wall, torsion, irregularity, Response spectrum , Base shear

I. INTRODUCTION

The demand of multi-storey building has increased as the population and cost of land has increased and availability of land has decreased. But these buildings are highly affected by the earthquake forces. The earthquakes are the most unpredictable and devastating among the natural disasters. So, to resist these lateral forces, shear wall is the most commonly used structural element. The addition of shear wall increases stiffness in the frames. The location of shear wall in the building play an important role, so it should be such that, it generates minimum eccentricity between centre of mass and centre of rigidity. Larger the eccentricity larger the torsional effect, which lead to larger displacement and drifts in the building. At present, shear wall has been provided as core type shear wall or constructed as load bearing walls in many high-rise building constructions. But these buildings are highly affected by the earthquake forces. The earthquakes are the most unpredictable and devastating among the natural disasters. So, to resist these lateral forces, shear wall is the most commonly used structural element. The addition of shear wall add more stiffness in the frames. The location of shear wall in the building play an important role, so it should be such that, it generates minimum eccentricity between centre of mass and centre of rigidity. Larger the eccentricity larger the torsional effect, which lead to larger displacement and drifts in the building. At present, shear wall has been provided as core type shear wall or constructed as load bearing walls in many high-rise building constructions.

II. LITERATURE REVIEW

Anshuman et al. (2011) [1] determined the solution for shear wall location in multi-storey building based on its both elastic and elasto-plastic behaviours. An earthquake load is calculated and applied to a building of fifteen stories located in zone IV. Elastic and elasto-plastic analyses were performed using both STAAD Pro 2004 and SAP V 10.0.5 (2000) software packages. Shear forces, bending moment and story drift were computed in both the cases and location of shear wall was established based upon the above computations.

Mohan and Prabha (2011) [2] modelled two multi-storey buildings, one of six and other of eleven storey for earthquake zone V in India. Six different types of shear walls with its variation in shape were considered for studying their effectiveness in resisting lateral forces. They studied the effect of the variation of the building height on the structural response of the shear wall and also highlighted the accuracy and exactness of Time History analysis in comparison with the most commonly adopted Response Spectrum Analysis and Equivalent Static Analysis.

Agrawal and Charkha (2012) [3] studied a high rise building in zone-V with some preliminary investigation which is analysed by changing various position of shear wall with different shapes for determining parameters like storey drift, axial load and displacement. They concluded that the displacement of building is uni-directional and uniform for all the grids in the case of zero eccentricity for seismic loading and with the increase in eccentricity, the building shows non-uniform movement of right and left edges of roof due to torsion and induces excessive moment and forces in member.

Ghoreishiamiri (2012) [4] determined the effect of Reinforce Concrete Core Shear Wall on relative drift of reinforced concrete building with cores, in comparison with buildings with concrete frames, and then the effect of irregular plans on the characteristics of this structural system had been analysed. Three buildings with 15, 20 and 25 stories height with structural system of specific concrete frame were analysed and compared with the same buildings in height which have structural system of 2C shape Reinforced Concrete Core Shear Wall building. This analysis had been applied by regular and irregular plan. After comparing the outputs, it was concluded that Reinforced Concrete Core Shear Wall has a great effect on reducing the relative drift of buildings with both regular and irregular plan.

Chittiprolu and Kumar (2014) [5] studied on an irregular high rise building with shear wall and without shear wall to understand the lateral loads, story drifts and torsion effects. From the results it is inferred that shear walls are more resistant to lateral loads in an irregular structure.

III. MODELLING AND ANALYSIS OF IRREGULAR BUILDING

A G+10 RC irregular building with plan irregularity is modelled by using the software ETABS and dynamic analysis (Response Spectrum Analysis) is performed.

IV. BUILDING DESCRIPTION

The plan of building is a L-shaped irregular with certain percentage of plan irregularities. The dimension of the building plan is 24m and 20m at the rate of 4 m bay width in x and y direction respectively. The building is considered as a RC special moment resisting frame. The stipulated details of the building elements as well as seismic zone and soil condition are summarised in table 1.

Table 1 - Details of building

Details of Building	**Value**
Bay width in x and y direction	4 m
Grade of Concrete	M25
Grade of Rebar	Fe415
Storey Height	3.5 m bottom, 3m typical
Size of Beam	300 mm x 450 mm
Size of Column	450 mm x 450 mm
Thickness of slab	150 mm
Thickness of Shear Wall	150 mm
Dead load	Self-Weight
Live Load	2.5 kN/m^2
Floor Finish	2 kN/m^2
Poisson’s Ratio	0.2
Type of Soil	Medium
Seismic Zone (Z)	V
Response Reduction Factor (R)	5

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Importance Factor (I)	1
Damping Ratio	5%

Enumeration of building models

1. Building frame without shear wall (M1) as shown in fig.1
2. Building frame with shear wall at core (M2) as shown in fig.2
3. Building frame with shear wall parallel to X-direction (M3) as shown in fig.3
4. Building frame with shear wall parallel to Y-direction (M4) as shown in fig.4
5. Building frame with shear wall at all exterior corners of building (M5) as shown in fig.5

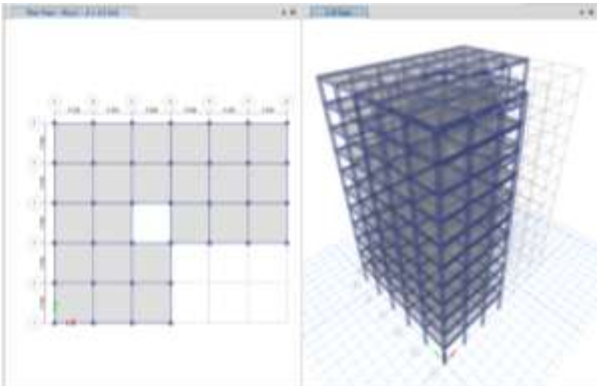

Fig-1 Building frame without shear wall (M1)

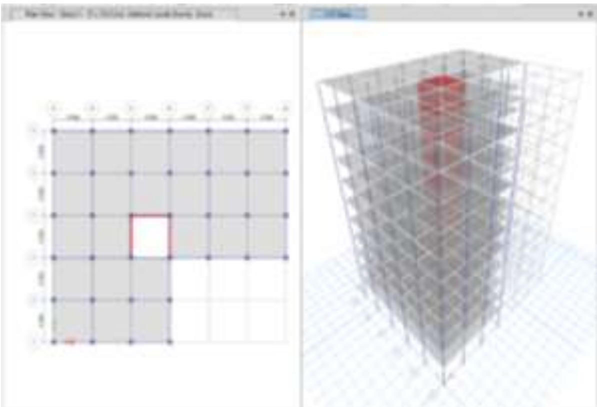

Fig-2 Building frame with shear wall at core (M2)

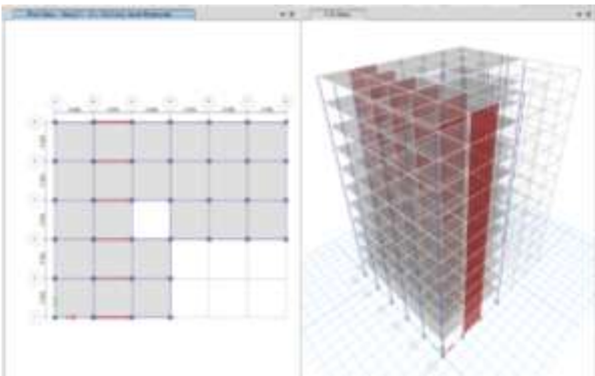

Fig-3 Building frame with shear wall parallel to X-direction (M3)

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6. First-Order Heading (SIZE 12 &BOLD)

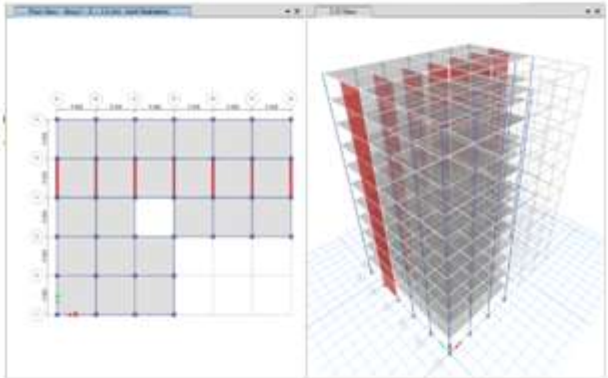

Fig-4 Building frame with shear wall parallel to Y-direction (M4)

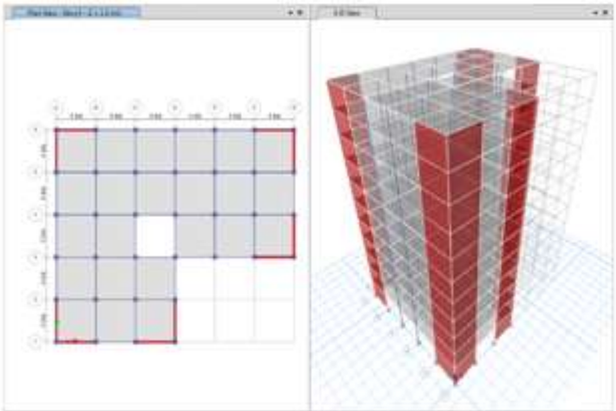

Fig-5 Building frame with shear wall at all exterior corners of building (M5)

V. RESULTS AND DISCUSSION

The analysis is done by using the Response Spectrum Analysis Method in x and y direction i.e. RSx and RSy respectively. The obtained results i.e. base shear, storey drift and torsion of various building models in seismic zone V in x and y direction are given in fig.6 to fig.11.

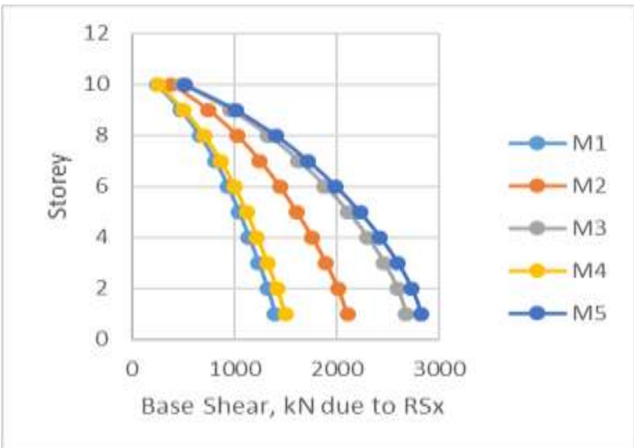

Fig-6 Storey vs Base shear (in x-direction)

From the fig 6 and fig 7, it is observed that base shear increases with shear wall as compare to bare frame building. It is observed that building with shear wall at exterior corners (M5) has greater base shear as compared to shear wall at other locations (M2, M3 and M4) for RSx and RSy.

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From the above fig 8 and fig 9, it is observed that maximum storey drift of the building decreases with the use of shear wall. It is observed that the building with shear wall at exterior corners (M5) has least maximum storey drift as compared to shear wall at other locations (M2, M3 and M4) for RSx and building with shear wall parallel to y-direction (M4) has least maximum storey drift as compared to shear wall at other locations (M2, M3 and M5) for RSy.

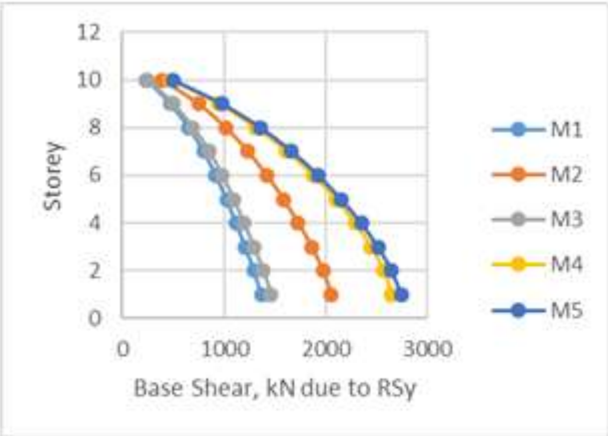

Fig-7 Storey vs Base shear (in y-direction)

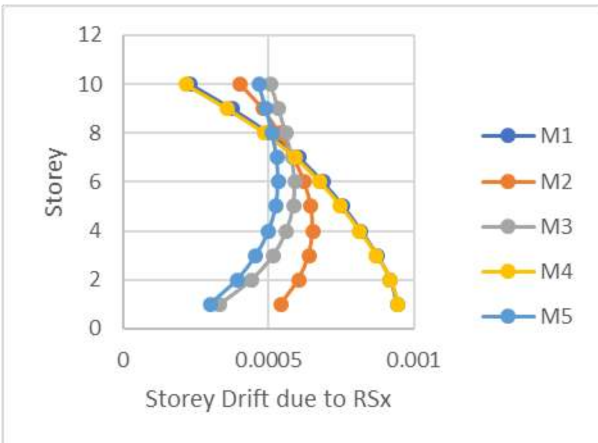

Fig-8 Storey vs storey drift (in x-direction)

From the fig 10 and fig 11, it is observed that torsion of the building increases with the use of shear wall. It is observed that the building with shear wall parallel to y-direction (M4) has least torsion as compared to shear wall at other locations (M2, M3 and M5) for RSx and building with shear wall parallel to x-direction (M3) has least torsion as compared to shear wall at other locations (M2, M4 and M5) for RSy.

VI. CONCLUSIONS

The following conclusions are:

1. Base shear of the building increases with the use of shear wall in the building as expected.
2. The building with shear wall at exterior corners (M5) has greater base shear as compared to shear wall at other locations (M2, M3 and M4) for both direction analysis i.e. RSx and RSy.
3. Storey drift in the building decreases with the use of shear wall in the building.

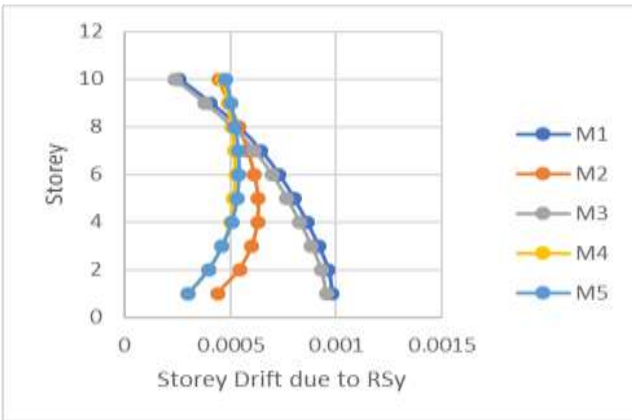

Fig-9 Storey vs storey drift (in y-direction)

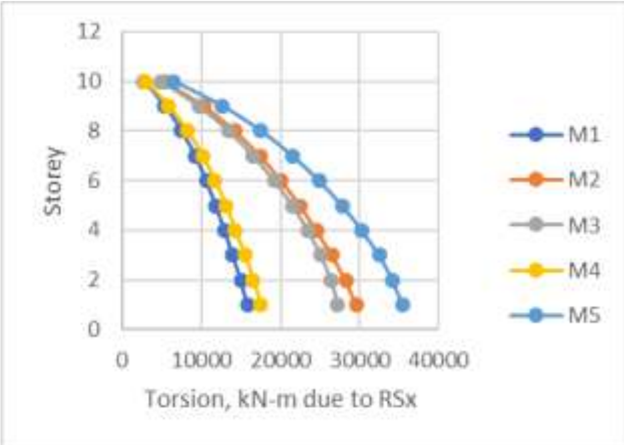

Fig-10 Storey vs Torsion

4. The building with shear wall at exterior corners (M5) has least maximum storey drift as compared to shear wall at other locations (M2, M3 and M4) for RSx analysis. Whereas for RSy analysis, the building with shear wall parallel to y-direction (M4) has least maximum storey drift as compared to shear wall at other locations (M2, M3 and M5). Although, the difference in drift values for RSx and RSy analysis in M5 and M4, respectively, has observed very small and all values are within the limit of the codal provision.
5. Torsion in the building changes with the use of shear wall as the eccentricity (distance between centre of mass and centre of rigidity) as well as stiffness of the building changes.
6. The building with shear wall parallel to y-direction (M4) has least torsion as compared to shear wall at other locations (M2, M3 and M5) for RSx analysis. Whereas for RSy analysis, building with shear wall parallel to x-direction (M3) has least torsion as compared to shear wall at other locations (M2, M4 and M5).
7. All considered lateral load resisting arrangements in the irregular building plan for stipulated dimensions with shear wall are suitable to resist the lateral force in zone V with medium soil condition. Because all obtained results are within the limits given in the IS code.

Since torsion is the most critical factor leading to major damage or complete collapse of buildings therefore, it is very essential that irregular buildings should be carefully analysed for torsion and the designer should try avoid excess irregularities especially in the multi storied buildings.

Shear walls are definitely good mechanism for lateral loads mitigation but the position of shear walls in the building should be made judiciously. In the present study, the Shear walls at exterior corners (M5) has found perform better than other modal cases being considered in the analysis. Lateral load resisting capacity of the building increases significantly in case of shear wall introduction, as it is clear from the storey drift in x and y directions.

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