International Journal of Research in Engineering, Science and Management
Volume-2, Issue-1, January-2019
www.ijresm.com | ISSN (Online): 2581-5792

Dynamic Response of Regular and Irregular High Rise Buildings under the Influence of Shear Walls

Yeakambaram Sai Srikanth[1], K. K. D. Varaprasadarao[2]
[1]M. Tech. Scholar, Dept. of Civil Engineering, Vikas College of Engineering and Technology, Vijayawada, India
[2]Assistant Professor, Dept. of Civil Engineering, Vikas College of Engg. and Technology, Vijayawada, India

***Abstract*: This study presents the procedure for seismic performance estimation of high-rise buildings based on a concept of the capacity spectrum method. In 3D analytical model of 22 storied buildings have been generated regular and irregular buildings Models and analyzed using structural analysis tool ETABS. To study the effect of concrete core wall & shear wall at different positions during earthquake, seismic analysis using both linear static, linear dynamic and non-linear static procedure has been performed. The deflections at each storey level have been compared by performing Response spectrum method performed to determine capacity, demand and performance level of the considered building models. From the below studies it has been observed that non-linear Response spectrum method provide good estimate of global as well as local inelastic deformation demands and also reveals design weakness that may remain hidden in an elastic analysis and also the performance level of the structure. In this study regular and irregular building was studied for G+21 story building to check the deflection, Building shear, Bending and building torsion by using Response spectrum method under influence of shear walls.**

***Keywords*: High rise buildings, regular building, irregular building, ETABS, G+21, Deflection, Building shear, Bending, Building Torsion.**

1. Introduction

Many medium-rise apartment buildings are being constructed, in India, using shear walls to provide earthquake resistance to reinforced concrete frames. These shear walls may have openings for the windows, doors and duct spaces for functional reasons. The number, location and size of openings affect the behavior of a structure as well as stress in the shear wall. Framed structures with shear wall are frequently adopted as the structural system for high-rise building structures. This structural system would also have many openings for the entrance to elevators or staircases etc. Generally, plane stress elements and beam elements are used to model the shear wall and frames respectively in the analysis of this kind of building. A plan stress element should have drilling degrees of freedom to represent the connection of shear wall core and frames. Otherwise, the bending moment at the end of a beam cannot be transferred to the shear wall. The openings may be of large size that is in the case where it is like function halls, conference halls, and movie theaters. The number, location, size, and shape of opening affects the behavior of structure in the form of deflection, stress in the members. These openings seriously effect the efficiency and accuracy of the analysis.

A. Regular buildings

The buildings are Symmetry about X and Y direction is called Regular buildings. Generally for this buildings the length of building is equal to width of building is same. The load distribution is uniform in vertical direction.

B. Irregular buildings

The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated. There are two types of irregularities

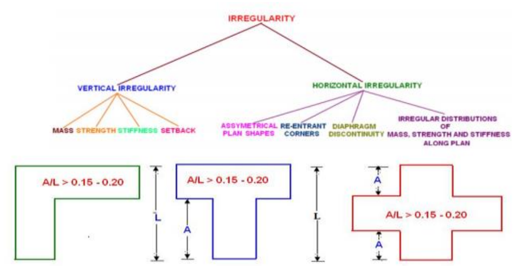

Fig. 1. Re-entrant corner irregularity

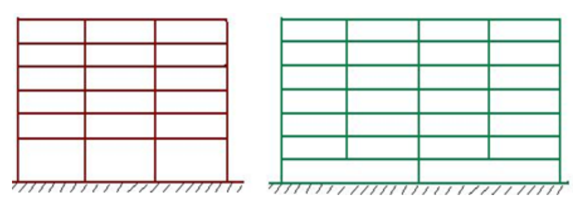

Fig. 2. Irregular distribution of stiffness in the building system

C. Shear wall

Shear walls are vertical stiffening elements designed to resist lateral forces exerted by wind or earthquake. The shape and location of shear wall have significant effect on their structural behavior under lateral loads. Lateral loads are distributed through the structure acting as a horizontal diaphragm, to the shear walls, parallel to the force of action. These shear wall resist horizontal forces because their high rigidity as deep beams, reacting to shear and flexure against overturning. A core eccentrically located with respect to the building shapes has to carry tension as well as bending and direct shear.

D. Objective of the study

The following are the main objectives of the project

- To study the seismic behavior of multi story building by using IS 1893:2002
- To compare the multi story buildings with and without shear wall at different locations on multi story Building with regular and irregular shapes .
- To compare the results of Story Drift, Shear force, Bending moment, Building torsion of buildings without shear wall at different locations on multi story Building with regular and irregular shapes.
- To study the buildings in ETABS V9.7.4 in Response spectrum analysis.

2. Literature review

Ehsan Salimi Firoozabad, Dr. K. Rama Mohan Rao, Bahador Bagheri., et al. (2012). In the present study main focus is to determine the effect of shear wall configuration on seismic performance of buildings. From this study, it was concluded that different position of shear walls can reduce the top story drift at least twice, which means the drift of building is reduced 100 percent from highest value to lowest one.

Shahzad Jamil Sardar and Umesh. N. Karadi., et. al. (2013) In this project, study of 25 storeys building in zone V is presented with some investigation which is analyzed by changing various location of shear wall for determining parameters like storey drift, storey shear and displacement is done by using standard package ETAB. From this study it was concluded that the seismic analysis of reinforced concrete frame structure is done by both static and dynamic analysis to determine and compare the base shear; it has been found that maximum base shear in model-5 along longitudinal and transverse direction as compared to the other models.

Najma Nainan., et. Al. (2012) From this study it was concluded that the analytical study on the dynamic response of seismo-resistant building frames was done. The storey displacements for various heights of shear wall in the dynamic response of building frames are obtained. From the study, the following conclusion can be drawn out.

3. Methodology and modelling of building

Response Spectrum Method:

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002 (part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 2013 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).

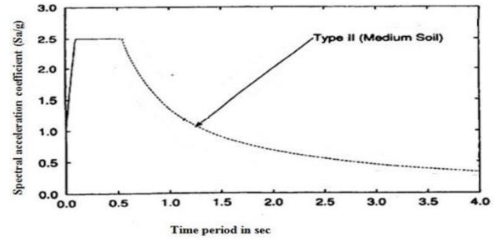

Fig. 3. Response spectrum for medium soil type for 5% damping

Response spectrum for medium soil type for 5% damping
Different types of loads acting on the structure.
Types of loads acting on the structure are:

- Dead loads
- Imposed loads
- Wind loads
- Snow loads
- Earthquake loads
- Special loads

A. Problem statement

In the present study, analysis of G+21 stories building in Zone V seismic zones is carried out in ETABS.

Basic parameters considered for the analysis are

- Grade of concrete : M30
- Grade of Reinforcing steel : HYSD Fe500
- Dimensions of beam : 230mmX300mm
- Dimensions of column : 230mmX480mm
- Thickness of slab : 120mm
- Height of bottom story : 3m
- Height of Remaining story : 3m
- Live load : 3.5 KN/m^2
- Floor load : 1.5 KN/m^2
- Density of concrete : 25 KN/m^3
- Seismic Zone : Zone 5
- Site type : II
- Importance factor : 1.5
- Response reduction factor : 5
- Damping Ratio : 5%
- Structure class : B
- Basic wind speed : 39m/s
- Risk coefficient (K1) : 1.08
- Terrain size coefficient (K2): 1.14
- Topography factor (K3) : 1.3
- Wind design code : IS 875: 1987 (Part 3)
- RCC design code : IS 456:2000
- Steel design code : IS 800: 2007
- Earth quake design code: IS 1893 : 2002 (Part 1)

B. Models in ETABS v 9.7.4

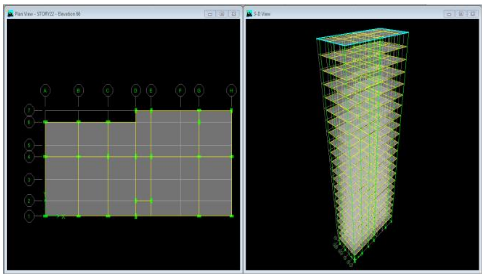

Fig. 4. Building without Shear wall

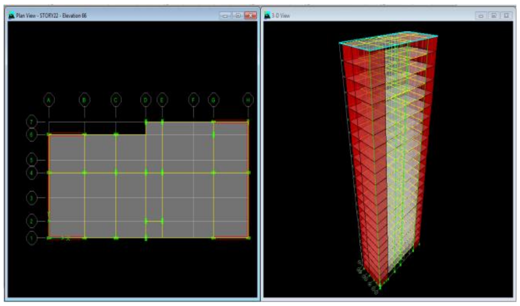

Fig. 5. Building with Shear wall at corner

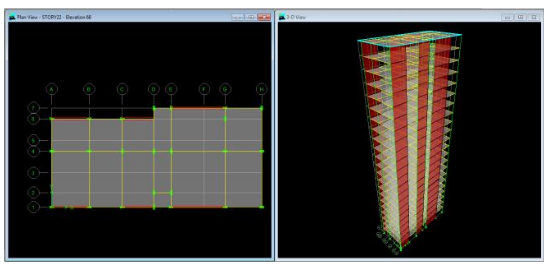

Fig. 6. Building with Shear wall at alternative position

4. Results and analysis

A. Irregular building

1) Story drift

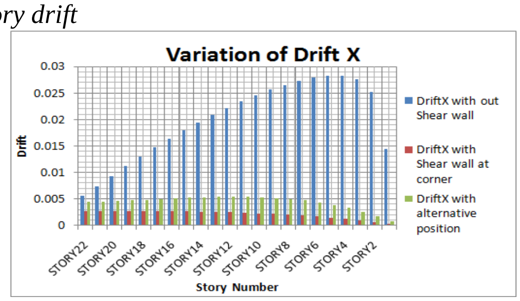

Fig. 7. X direction

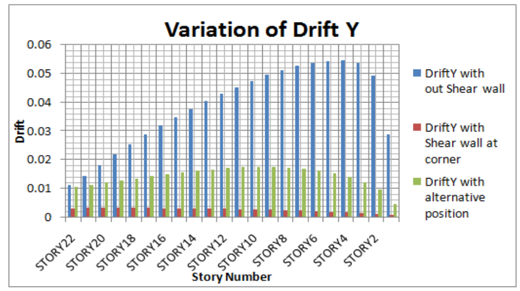

Fig. 8. Y direction

2) Shear force

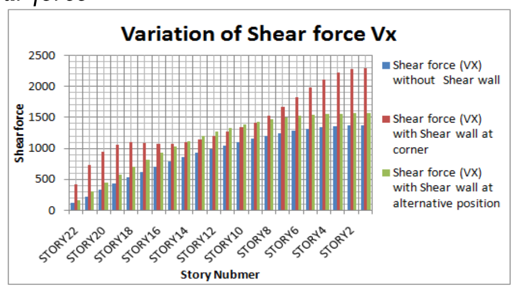

Fig. 9. X direction

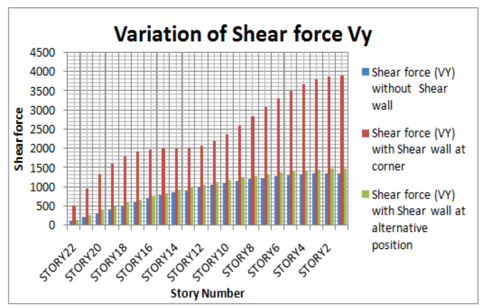

Fig. 10. Y direction

3) Bending moment

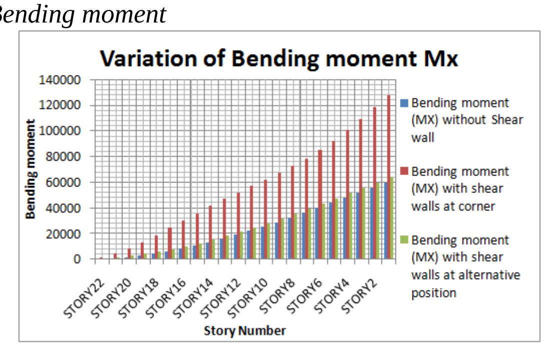

Fig. 11. X direction

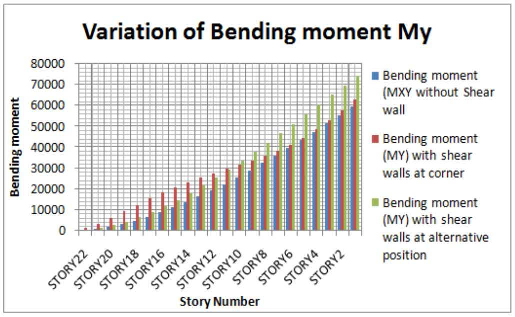

Fig. 12. Y direction

4) Building torsion

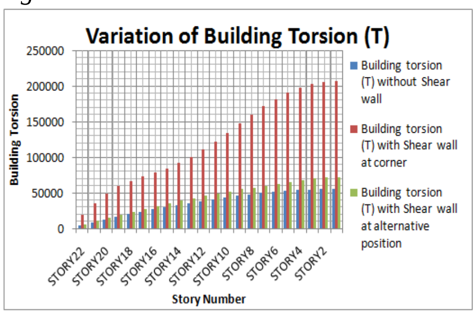

Fig. 13. Building torsion

B. Regular building

1) Story drift

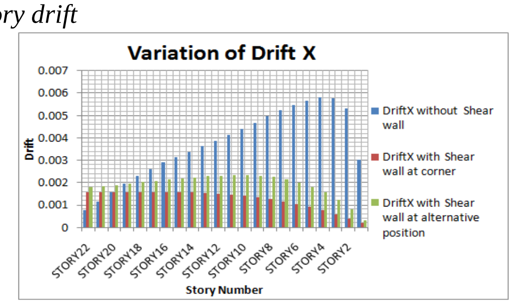

Fig. 14. X direction

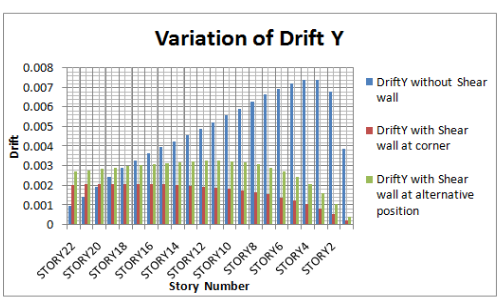

Fig. 15. Y direction

2) Shear force

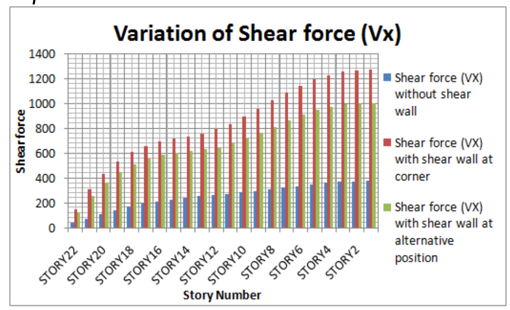

Fig. 16. X direction

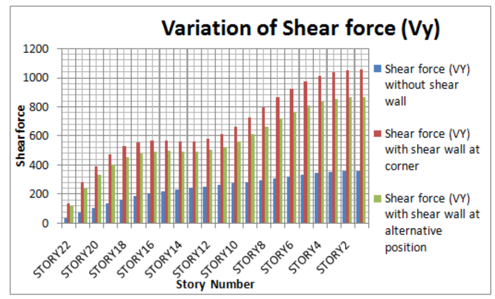

Fig. 17. Y direction

3) Bending moment

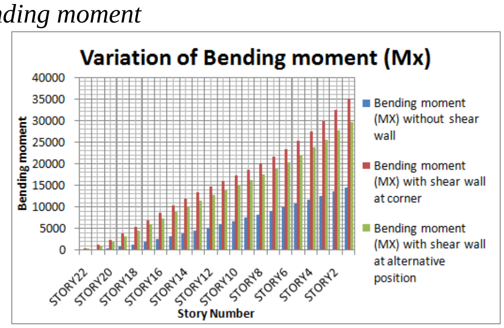

Fig. 18. X direction

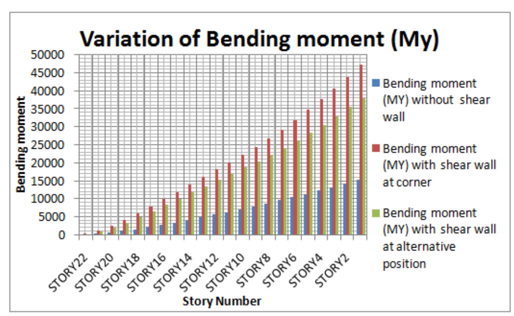

Fig. 19. Y direction

4) Building torsion

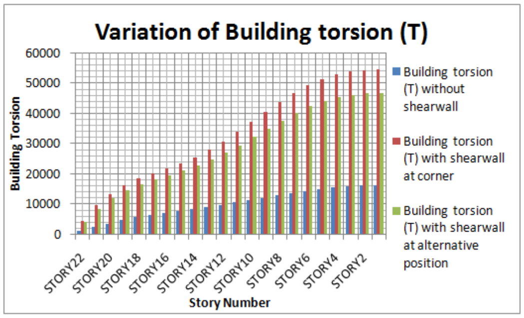

Fig. 20. Building torsion

5. Conclusion

From the above study the following conclusions were made

- For regular building and irregular buildings the values of drift in both X and Y direction are less for building using shear wall than building without shear wall and the shear walls at corner will give better results than shear walls at alternative position for both X and Y direction.
- The values of Shear force in both X and Y-Direction found lower value for building without shear wall without shear wall at alternative position and shear wall at corner than buildings. And the shear wall at alternative position has higher values than shear wall at corner position.
- The values of Building Torsion (T) found lower value for building without shear wall without shear wall at alternative position and shear wall at corner than buildings. And the shear wall at alternative position has higher values than shear wall at corner position.
- From bending moment (M) point of view the values of bending moment are found to be less values for the building with shear wall alternative position than building with shear wall at corner.
- Opening in the shear walls lead to a significant increase in the bending moment and shear force in the columns connected to that shear wall and when opening is to top the percentage of the increase percentage increase it is less for the opening percent.
- It was observed for a particular opening in wall when the opening position is shifted from one position to other position.
- From this study it was concluded that increase in the percentage of Shear wall results in decrease in the drift and increases the Shear force, Bending moment, Building Torsion

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