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Performance of RC Framed Shear Wall Building with its Different Orientation under the Effect of Earthquake and Wind Loads

A A Jadhav[1], A. A. Galatage[2]

[1]PG Student, Department of Civil Engineering, FIT, SPPU, Pune, Maharashtra, India
[3]Assistant Professor, Department of Civil Engineering, FIT, SPPU, Pune, Maharashtra, India

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Abstract - Earthquakes Reinforced concrete framed buildings are capable for resisting both the vertical and horizontal load acting on them. However, when buildings are tall, it is difficult to workout sizes of beams and columns. There is lot of clogging at these joint and it is difficult to place and vibrate concrete at these places which does not contribute the safety of building. These practical difficulties call for introduction of shear wall. Shear wall has system is one of the most commonly used internal load resisting system in high rise buildings. Shear wall has very high in plane strength and stiffness which can be used to simultaneously resist large horizontal loads and supports gravity loads.Therefore incorporation of shear wall has become assured in multi-storey buildings built in region likely to experienced earthquake of high intensity or high winds. There are lots of literatures available to design and analyze the shear wall. However, the decision about an arrangement of shear wall in multi-storey building is not much discussed in any literatures, in this study; therefore main objective is to determine the position of shear walls in multi-storey building. An earthquake load is applied to a building of twenty sixth storied located in zone III. The analysis is performed using ETABS software. Axial forces, shear force, bending moment, storey displacement and time period are computed and location of shear walls is established.

Key Words: ETABS2013, Response Spectrum Analysis, Seismic Responses and Shear wall

1.INTRODUCTION

RC multi-storey building is adequate for resisting both vertical and horizontal load. When such building is designed without shear wall, beam and column sizes are considerably heavy and there is lot of clogging at these joint and it is challenging to place and vibrate concrete at these places and displacement is quite more which induces heavy forces in member. Shear wall may become crucial from the economy point of view and control of lateral deflection. In RC multi-storey building lift well or shear wall are frequent requirement. Centre of mass stiffness of the building is absolute for a structure. However, many times the design has to be based on the off centre position of lift and stair case wall with respect to centre of mass which results into an excessive forces in most of the structural members.

Reddy and Tupat [1] analyzed multi-storied building for earthquake loads in various zones based on IS 1893 and for wind load IS 875 code used. The wind loads are estimated based on the design wind speed of that zone with a variation of 20%. The wind loads so obtained on the building have been compared with that of earthquake loads. Finally it was found the wind loads are more critical than the earthquake loads in most of the cases.

Chandurkar and Pajgade [2] analyzed 10 storied RC building for all four zone using ETABS v 9.5.0, it was observed that constructing building with shear wall in short span at corner was economical as compared with other models. From this it was concluded that large dimension of shear wall was not effective in 10 storied building. It was observed that changing the position of shear wall affect the attraction of forces, so that wall must be in proper position. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall. Providing shear walls at adequate locations substantially reduces the displacement due to earthquake.

Agrawal and Charkha [3] analyzed 25 storied RC building zone V considering different positions and shapes of shear wall using ETABS. It was determined different parameters such as storey drift, axial load, displacement, etc. It was concluded that location of shear wall affects on static and dynamic axial load on column. In case of zero eccentricity for seismic loading, the displacement of building was unidirectional and uniform for all grids.

Chandiwala [4] analyzed 10 storied RC residential building for Zone III using software SAP2000. It was tried to get moment at a particular column including the seismic load by taking different lateral load resisting structural systems, different number of floors, with various positions of shear wall. It was found that among different location of shear wall, shear wall at the end of "L" section gives best results. It reduced overall bending moment of building.

Romy and Prabha [5] modeled two multi-storey buildings along with variation in building height, one of six and other of eleven storey using SAP 2000 software for earthquake zone V in India. Six different types of shear walls with its variation in shape studying for their response in resisting lateral forces. Dynamic responses under prominent earthquake, El-Centro earthquake have been investigated. Finally highlighted the accuracy and exactness of time history analysis in comparison with the most commonly adopted response spectrum analysis and equivalent static analysis was done.

Anand *et al.* [6] analyzed one to fifteen storied space frame with and without RC shear wall to understand the behavior of RC shear wall subjected to seismic forces for different soil conditions using ETABS software. It was found that up to three storey's, the base shear values increase when the soil type changes from hard to medium and medium to soft. The lateral displacement values increase when the type of soil changes from hard to medium and medium to soft for all the building frames. The axial force and moment in column increase when the type of soil changes from hard to medium and medium to soft. Since the base shear, axial force, column moment and lateral displacements increases as the soil type changes, soil structure interaction must be suitably considered while designing frames for seismic forces.

Esmaili *et al.* [7] analyzed 56 stories RC tall building with shear wall with irregular openings. They have done non linear analysis and verified results with FEMA356. They found that main walls which are RC shear walls not only carry seismic loads but also bear significant percentage of gravity loads.

1.2 Objective of studies

1. To study the effect of different position of shear walls on axial force, shear force, bending moment, story displacement and time period.
2. To analyze RC building with best position of shear wall for seismic zones II, III, IV and V in India.
3. To evaluate dynamic response of RC building for specific position of shear wall.
4. Recommendation of effective position of shear walls for RC framed structure.

2. METHODS OF ANALYSIS

For better performance of building during earthquake, it is necessary to know how the building behaves during earthquake and for that seismic analysis of building is required. The seismic analysis of building is done by two methods-static analysis and dynamic analysis. Static analysis does not give us clear idea of how structure is going to behave during earthquake but gives approximate forces and displacements. Dynamic analysis gives somewhat accurate results.

2.1 Equivalent Static Analysis

All design against seismic loads must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is insufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings. This procedure doesn't require dynamic analysis, however, it account for the dynamics of building in comparative manner. The static method is the simplest one-it requires less computational efforts and is based on formulae given in the code of practice. First, the design base shear is computed for the whole building, and it is then distributed along the height of the building. The lateral forces at each floor levels thus obtained are distributed to characteristic lateral load resisting elements.

2.2 Response Spectrum Method

Response spectrum method is the linear dynamic analysis method. In this method the summit structural responses of a structure during an earthquake is obtained directly from the earthquake responses spectrum. The representation of the maximum responses of idealized SDOF systems having certain period and damping, while earthquake ground motion. The maximum response is plotted against the undamped natural period and for different damping values, and can be expressed in terms of maximum relative velocity or maximum relative displacement

2.3 Structural modeling and analysis

The G+25 RC multistory framed building considered for analysis to know the realistic behavior during earthquake with the general form of plan shown in fig. Plan dimensions in X and Y direction are 24.05m and 28.10m respectively. The buildings are consisting of columns with dimension 230mm x 1000mm for all stories and beam with dimension 230mm x 600mm. The floor slabs are taken as 150mm thick. The thickness of shear wall is taken as 230 mm. In case of design of shear wall it is necessary to assign pier and spandrel label to obtain the longitudinal reinforcement. The height of all floors is 3.0m. Foundation height is 1.5m considered soil type is hard. Modal damping 5% is considered with SMRF and I=1. The columns are assumed to be fixed at the ground level. Material concrete grade is M30 and at the same time steel Fe 500 is used.

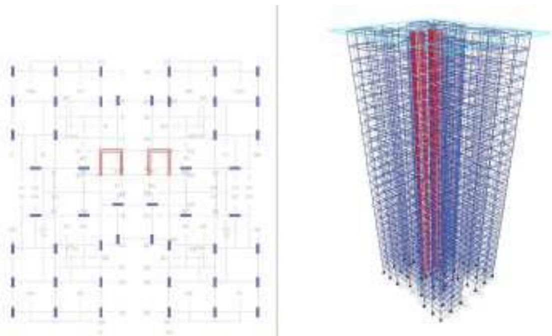

Fig -1: Plan and Elevation of G+25 RC multistoried framed Building in ETABS2013

The building is analyzed for different position of shear walls. To find the effective position of shear walls different models are prepared and analyzed. First model is solid RC multistoried frame building while second model consist of shear wall arrangement at corner of the building that is L shaped. Third model in which framed Building with Shear wall in X and Y Direction and fourth model in which framed Building with Shear wall in X and Y Direction and shear wall placed at centre of the building. For analysis these four model are analysis by using ETABS2013software.

3. RESULTS AND DISCUSSION

The parametric study of Critical Axial Force in column, storey displacement, Shear force, and Bending Moment Variation of building in different stories by response spectrum analysis for G+25 Floor RC structure is performed here. The results achieved from analysis are listed below and compared by graphical representation.

2.1 Critical Axial Force in column

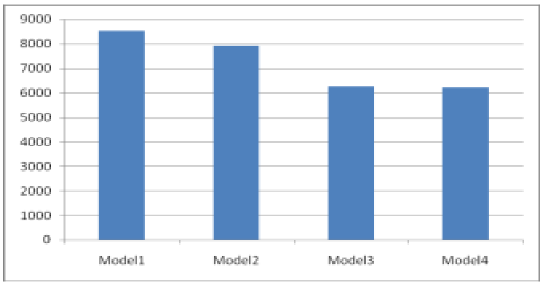

Fig -2: Comparison of Axial Force in Column

From above graph it is seen that the value of critical axial force in column for model 2, 3 and 4 decreases by 6.95%, 26.52%, and 27.17% respectively than model 1.

2.2 Critical Shear Force

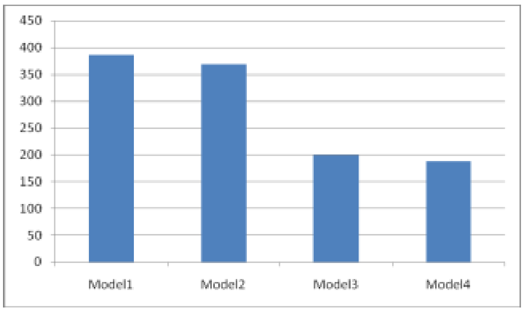

Fig -3: Comparison of Shear Force

From above graph it is seen that the critical value for shear force in column is maximum for model 1. It is respectively 4.68%, 48.49% and 51.47% less for model 2,3and 4.

2.3 Critical Bending Moment

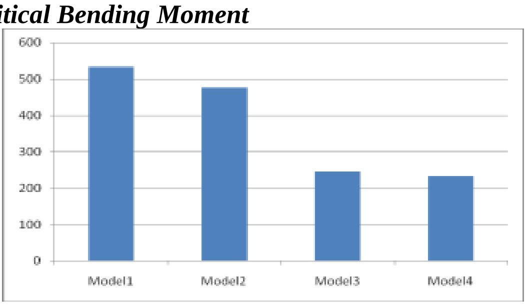

Fig -4: Comparison of Bending Moment

From above graph it is seen that the critical value for bending moment in column is maximum for model 1. It is respectively 10.53%, 53.89% and 56.3% for model 2,3and 4 than model 1.

2.4 Lateral Displacement

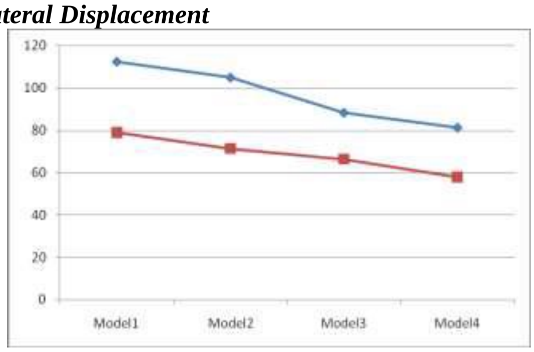

Fig -5: Comparison of Storey Displacement

The top storey displacement is maximum for model 1 and minimum for model 4 it is reduced by 6.64%, 21.41% and 27.67% for X direction and 9.62%, 16.06% and 26.86% for Y direction for model 2, 3 and 4 respectively than model 1.

2.5 Time Period

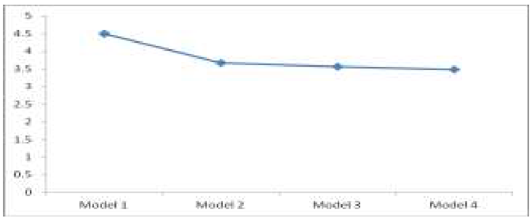

Fig -6: Comparison of Time period

The time period of model 2, 3 and 4 decreases by 16.66%, 19.01% and 20.92% than model 1.

4. CONCLUSIONS

From all the above study, it is observed that in multi-storied RC building, constructing building with different position of shear wall affects on different parameters such as storey displacement, axial force, shear force, bending moment and time period etc. Therefore model 4 gives effective better results as compared to other models. That is shear wall located at the centre of building gives effective results as compared to other location. Also observed that-

1. Changing the position of shear walls affects the attraction of forces, so that wall must be in proper location.
2. Providing shear walls at adequate locations essentially reduces the displacements due to earthquake.
3. For building with frame and shear walls model 4 that is shear wall located at the centre of building gives considerable percentage reduction in axial force, shear force, bending moment, storey displacement and time period. Therefore wall located at the centre of building is effective as compared to the other location of shear walls.

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