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Dynamic Response of High Rise Structure Having Varying Location of Shear Wall

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***Abstract*: The past few years have witnessed a boom in the construction scenario in Pondicherry. The paucity of land in our state necessitates the construction of multi-storied complexes to cater to the increasing housing apartments and commercial needs of society. The present project aims to check and compare the dynamic response of multi-storied building for different location of shear wall, so that one can choose the best alternative for construction in earthquake-prone area. Shear wall is a structural element used to resist horizontal forces parallel to the plane of the wall. Shear wall has highly in plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads. Shear Walls are specially designed structural walls include in the buildings to resist horizontal forces that are induces in the plane of the wall due to wind, earthquake and other forces. They are mainly flexural members and usually provided in high rise buildings to avoid the total collapse of the high rise buildings under seismic forces. In this project, study of G+ 12 storey's building in zone II is presented with some investigation which is analyzed by changing various location of shear wall for determining parameters like storey drift, storey shear, storey displacement, base shear, Time periods is done by using standard package E-TAB. Creation of 3D building model for both linear static and linear dynamic method of analysis. Limit state designs which conforms to the Indian Standard code of practice is the design method that is used by the E-TAB software. The structure modeled in E-TAB is subjected to Dead load, super dead, live load, wind load, and Earthquake load of the structure. The wind load values at different heights varies and it is given in conformation with specification of IS 875 (part-3). The building will be modeled and designed depending on the specifications given in the IS code. Complicated and high rise structures need very time taking and cumbersome calculations using conventional manual methods. E-TAB provides fast, efficient, easy to use and accurate platform for analyzing and designing structures subjected to both gravity and lateral loading.**

***Keywords*: Shear wall, Wind & earthquake forces, E-TAB software.**

1. Introduction

The Reinforced concrete multi storey buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, beam and column sizes are quite heavy and there is problem at these joint. It is congested to place and vibrate concrete at these places. The displacement is quite heavy which induces heavy forces in building member. Shear wall may become essential from the point of view of economy and control of horizontal displacement. There has been a considerable increase in the construction of tall buildings both residential and commercial and the modern trend is towards more tall and slender structure. Thus the effects of lateral loads like wind load, earthquake loads and blast forces are attaining increasing importance and almost every designer is faced with the problems of providing adequate strength and stability against lateral loads. Shear wall system is one of the most commonly used lateral load resisting in high rise building. Shear wall has high in plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads. It also significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in building. When shear walls are situated in advantageous positions in the building, they can form an efficient lateral force resisting system by reducing lateral displacements under earthquake loads. Therefore, it is necessary to determine effective, efficient and ideal location of shear wall.

The present work deals with study of effect of seismic loading on placement of different shapes of shear walls in multi storey building, say G+12 storied at different locations. The residential multi storey building is analyzed for earthquake force by considering two types of structural systems like frame system and dual system. The effectiveness of shear wall has been studied with the help of five different shapes of shear walls. Model one is bare frame structural system and other five models are dual type structural systems. The five shapes of shear walls are placed at different locations separately. The analysis is carried out by using standard package ETABS 9.7.4 and the comparison of these models for different parameters like storey displacement, storey drift, base shear, storey shear, Time periods, etc.

2. Objectives

The objective of study is seismic analysis and design of buildings has traditionally focused on reducing the risk of loss of life in the largest earthquake. To reduce the effects caused by these earth quakes and wind loads different lateral loading systems are introduced in the structures. Shear walls are one of the lateral loading systems commonly constructed in multi

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storey building below 35 stories. Position of shear walls in symmetrical buildings has due considerations. It is very necessary to determine efficient and ideal location of shear wall in symmetrical buildings. The following works are carried out,

1. The study behavior of multi storey building of G+12 storeys for various location of shear wall with seismic and wind loading has been done.
2. Both Equivalent static analysis and Response spectrum analysis are carried out.
3. The variation of displacement of the models has been studied.
4. The variation of storey drift of the models has been studied.
5. The variation of base shear of the models has been studied.
6. The variation of storey shear of the models has been studied.
7. The variation of time periods of the models has been studied.

3. Literature Review

Effect of change in shear wall location on storey drift of multistorey building subjected to lateral loads

Shahzad Jamil Sardar and Umesh. N. Karadi, International journal of innovative research in science, Vol. 2, Issue 9, September 2013.

RC multi-storey buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, beam and column sizes are quite heavy and there is problem arises at these joint and it is congested to place and vibrate concrete at these places and displacement is quite heavy which induces heavy forces in building member. Shear wall may become essential from the point of view of economy and control of horizontal displacement. Kasliwal Sagar K.et al considered two multi storey buildings, both are sixteen storey's have been modeled using software package ETABS for earthquake V zone in India. Different position and location of shear walls are considered for studying their effectiveness in resisting lateral forces. This paper also deals with the Dynamic linear Response spectra method and static method on multi-storey shear wall building with variation in number and position of shear wall. Based on the analysis results they found that as per the analysis storey drift in the Model M2 is less than Model M1. For earth quake forces in X and Y direction i.e. EQX and EQY shows that Story Drift along Y is larger than along X for M2. Story drift in model M1 is larger than model M2, Story Drift due to SPECX and SPECY is along Y is larger than along X. also story drift in model M1 is larger than model M2 Story. Show that base shear obtained in response spectra in X is larger than Y i.e. (spec X > spec Y.) for both model M1 & M2 and also base shear obtain in response spectra for M2 is larger than M1. Thus shear walls are one of the most effective building elements in resisting lateral forces during earthquake. By providing shear walls in proper position can be minimized effect.

Damages due to earthquake and winds. P. S. Kumbhare, A. C. Saoji, the scope of present work is to study the effect of seismic loading on placement of shear wall in medium rise building at different alternative location. The residential medium rise building is analyzed for earthquake force by considering two type of structural system. i.e. Frame system and Dual system. Effectiveness of shear wall has been studied with the help of four different models. Model one is bare frame structural system and other four models are dual type structural system. Analysis is carried out by using standard package ETAB. The comparison of these models for different parameters like Displacement, Storey Drift and Story Shear has been presented by replacing column with shear wall. Based on the analysis results they found that from result observed that the displacement of Model II, Model V reduced up to 20-30 % as compared with bare frame model. Where as in model III and IV maximum displacement also reduced up to 30-50 % as compared with bare frame. From result observed that drift is increased as height of building increased and reduced at top floor. From above results it is clear that shear wall frame interaction systems are very effective in resisting lateral forces induced by earthquake. Placing shear wall away from center of gravity resulted in increase in the most of the member's forces. It follows that shear walls should be coinciding with the centroid of the building Anuj Chandiwala considered five different models of 10-storey RC residential building located in India in seismic zone III and founded on medium soil, which is the reference ground condition. The structural configuration and dimension of the building structure are shown in Figures 3 to7 and 9. In this case the earthquake force is predominant then the calculated wind pressure, hence the structure is analyzed & designed for the seismic loading only. Based on the analysis results they found that after the analysis of the different position of shear wall in the building configuration following is the comparison in maximum base shear in X & Y-direction. It is shown in the graph fig. 8 and the Values of the base shear is given. From the analysis of the building configuration, it is concluded that Option-I is best suited for the base shear during earthquake.

Effect of shear wall location in buildings subjected to seismic loads

Lakshmi K. O, Jayasree Ramanujan, Bindu Sunil, Laju Kottalli, Mercy Joseph Poweth, ISOI Journal of Engineering and Computer Science, Volume 1, Issue 1, No. 7-17, Dec. 2014.

Performance of structures under frequently occurring earth quake ground motions resulting in structural damages as well as failures have repeatedly demonstrated the seismic vulnerability of existing buildings, due to their design based on gravity loads only or inadequate levels of lateral forces. This necessitates the need for design based on seismic responses by suitable methods to ensure strength and stability of structures. Shear wall systems are one of the most commonly used lateral load resisting systems in high rise buildings. This study aims at comparing various parameters such as storey drift, storey shear, deflection, reinforcement requirement in columns etc. of a building under lateral loads based on strategic positioning of shear walls. Based on linear and nonlinear analysis procedures adopted, the effect of shear wall location on various parameters are to be compared. Pushover analysis is used to evaluate the expected performance of the structure by estimating its strength and deformation demands in design earthquakes by means of static inelastic analysis, and comparing these demands to available capacities at the performance levels of interest. The capacity spectrum method is used to obtain the overall performance level of a structure. The software used is ETABS 9.5 and SAP 2000.V.14.1

1) In medium high rise buildings (i.e. greater than 10storeys') provision of shear walls is found to be effective in enhancing the overall seismic capacity characteristics of the structure.
2) From the comparison of story drift values it can be observed that maximum reduction in drift values is obtained when shear walls are provided at corners of the building.
3) Lateral displacement values obtained from static method of analysis indicate that shear wall provision along longitudinal and transverse directions are effective in reducing the displacement values in the same directions. Response spectrum analysis results provides a more realistic behavior of structure response and hence it can be seen that the displacement values in both X and Y directions are least in model with shear wall in core and corners when compared to all other models.

Significance of shear wall in high-rise irregular buildings

Ravikanth Chittiprolu, Pradeep Kumar Ramancharla, International Journal of Education and Applied Research, Vol. 4, Issue Spl. 2, Jan.-June 2014.

The usefulness of shear walls in the structural planning of multistory buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Reinforced concrete framed buildings are adequate for resisting both vertical and horizontal loads acting on them. Extensive research has been done in the design and analysis of shear wall high-rise buildings. However, significance of shear wall in high-rise irregular structures is not much discussed in literature. A study on an irregular high-rise building with shear wall and without shear wall was studied 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.

Dynamic linear analysis using response spectrum method is performed and lateral load analysis is done for structure without shear wall and structure with shear wall. Results are compared for the frame lateral forces and story drifts of both the cases. It is also observed that lateral forces are reducing when the shear walls are added at the appropriate locations of frames having minimum lateral forces. Therefore, it is inferred that shear walls are more resistant to lateral loads in an irregular structure. Also they can be used to reduce the effects of torsion.

4. Methodology

A. *Various locations of shear wall models*

- Model 1: The model is vertical asymmetric in plan and is modeled with only column elements and no shear walls in layout.
- Model 2: Model consists of column in all position along with shear wall placed parallel to the X-axis (Longitudinal).
- Model 3: Model consists of column in all position along with shear wall placed parallel to the Y-axis (Transverse).
- Model 4: Model consists of shear wall provided in all four corners of the building.
- Model 5: Model consists of shear wall provided in lift core area and column in all other positions.
- Model 6: Model is assigned with shear walls at central lift core area as well as corners.

B. *Building Parameters*

Type of occupancy: Residential
Shape of building: Regular
Total height of the building: 45.26 m
Number of stories: G+12+Stair and Lift cabin
Height of typical storey: 3.2 m
Height of ground storey: 3.66 m
Grade of concrete: M 30
Grade of steel: Fe 500
Plan dimensions: 23.62 x 17.83 m
Ground floor parking facilities: 50 cars
Fixing units: KN. m

C. *Indian Standard Codes*

1. IS-456 2000plain and reinforced concrete code of practice.
2. IS 875 (Part 1): Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures. Part 1: Dead Loads--Unit Weights of Building Materials and Stored Materials (Second Revision)
3. IS: 875(Part3): Wind Loads on Buildings and Structures.

Table 1

Support Condition	Fixed at base
Density of Concrete	25 KN/m^3 (from clause 19.2.1 , IS 456 - 2000)
Grade of Concrete	M30
Grade of Steel	Fe 500
Characteristics Compressive Strength of Concrete (Fck) For M30 Grade.	30 N/mm^2 (from table - 2, IS 456 - 2000)
Modulus of Elasticity of Concrete	5000√fck (from clause 6.2.3.1, IS 456 - 2000) = 27 x 103 N/mm^2
Poisson's Ratio For Concrete	0.2
Density Of Steel	7850 kg/m^3
Modulus Of Elasticity Of Steel	2.1 x105 N/mm^2 (from clause 5.6.3, IS456 - 2000)
Poisson's Ratio For Concrete	0.3
Density Of Brick Work	2000 Kg/m^3
Coefficient Of Thermal Expansion	9.900 x 10^{-6}

4. IS: 875 (Part 2): code of practice for design loads (other than earthquake) for buildings and structures.
5. IS 1893 (Part I), 2002, Indian Standard Criteria for Earthquake Resistant Design of Structures (5th Revision).

D. Define material

A. Click the *Define menu* > *Materials* command to display the Define Materials tab.
B. Enter the *Material Name* as M25 and enter the properties of the material such as *Modulus of Elasticity, Poisons Ratio, and Shear Modulus of concrete.*

5. Conclusion and Future Scope

1. The reinforced concrete frame structure is analyzed by linear static and linear dynamic method to determine and compare the base shear and displacement, drift.
2. It has been found that maximum base shear occurs in model-6 along longitudinal and transverse direction as compared to the other models.
3. Linear static and dynamic analysis displacements are within the permissible limits (H/500).
4. In equivalent static analysis it has been found that model-6 has lesser displacement and storey drift as compared to other models in transverse direction. In response spectrum analysis model-6 is lesser displacement and storey drift as compared to other models in transverse direction.
5. The storey drift is within the permissible limit in all the frame models (0.004*3.2 = 12.8mm).
6. Model -2 and Model-3 are reduced displacement in one direction another direction reduced 2 to 3 %.
7. In equivalent static and Response spectrum analysis it has been found that model-6 has maximum storey shear as compared to other models in transverse direction. The shear wall models are gradually increases in storey shear when compared to Model-1.
8. The Model-4 and Model-6 has reduced displacement and drift around 45% to 60%.
9. Stiffness of the building is increased due to addition of shear walls.
10. It has been found that the model-4 and model-6 are better locations of shear wall. Because both are reducing displacement and drift drastically.

Further studies can be conducted that on sky scrapers, composite structures, Studies can be conducted by providing dual system, which consists of shear wall (or braced frame) and moment resisting frame such that the two systems are designed to resist the total design force in proportion to their lateral stiffness considering the interaction of dual system at all floor levels. The moment resisting frames may be designed to independently resist at least 25% of design seismic base shear. For better ductility beam-column junction study can also be made. Various damping mechanisms and its applications on structures can also be studied. Studies also on existing building can be considered for evaluation.

A. Future Scope

- Study of all the system without infill walls and its effect.
- Study of coupled shear wall.
- Study of different parameters like thickness, height and tapered section for shear wall.
- Study of foundation for various systems

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