Effect of Change in Shear Wall Location with Uniform and Varying Thickness in High Rise Building

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Abstract: Shear wall are one of the excellent means of providing earthquake resistance to multistorey reinforced concrete building. They are usually provided in tall buildings and have been found to be immense use to avoid total collapse of building under seismic forces. It is very necessary to determine effective, efficient and ideal location of shear wall. In this paper, study of 25 storeys building in zone IV is presented with some preliminary investigation to reduce the effect of earthquake reinforced concrete shear walls are used in the building. These can be used for improving seismic response of buildings. The provision of shear wall in building to achieve rigidity has been found effective and economical. Shear walls are easy to construct and are efficient, both in terms of construction cost and effectiveness in minimizing earthquake damage in structural and non structural elements (like glass windows and building contents). This study aims to work on effect of addition of shear wall at different location and configuration, also study have been done with varying thickness of shear wall. The results are tabulated by performing pushover analysis using ETABS v 9.7.1 in the form of displacements and storey drift.

Keywords: Shear Wall, Storey Displacement, Storey Drift, Lateral Loading, Nonlinear Static Analysis

1. Introduction

Shear wall may be defined as structural elements, which provide strength, stiffness and stability against lateral loads deriving strength and stiffness mainly their shape in many cases, high rise buildings are designed as a framed structure with shear walls that can effectively resist horizontal forces. Lateral forces generated either due to wind blowing against the building or due to the inertia forces induced by ground shaking tend to snap the building in shear and push it over in bending. This type of forces can be resisted by the use of a shear wall system which is one of the most efficient methods of ensuring the lateral stability of tall buildings [1]. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. Shear walls in high seismic regions require special detailing [2].

1.1 Objectives of Study

The principal objectives of the study are as follows:
1) To study the Optimum location of shear wall having uniform thickness throughout the building.
2) To study the Performance of the building with shear wall having varying thickness at certain levels of building for different locations.

2. Methodology

This chapter explains the methodology used in the study. It explains the methodology in detail, various assumptions made, and details of the structures used in the study.

2.1 Description of Frame Buildings

The building consists of Twenty five stories. All columns in all models are assumed to be fixed at the base for simplicity. The floor to floor height is 3.5 m. Slab is modeled as rigid diaphragm element of 0.15m for all stories considered. Live load on floor is taken as 4 kN/m² and on roof is 1.5 kN/m². Floor finish on the floor is 1kN/m². Weathering course on roof is 1.5 kN/m². Wall thickness is of 230mm on all the beams. The seismic weight is calculated conforming to IS 1893-2002(part-I). The unit weight of concrete is taken as 24 kN/m³. The grade of concrete for column is M-40 and for beam and slab M-30. The building is special moment resisting frame considered to be situated in seismic zone IV having medium soil and intended for residential use.
2.2 Models Considered for the Analysis

2.2.1. Building with shear wall of uniform thickness
a) Building with shear wall at corner with uniform thickness.
b) Building with shear wall at mid span with uniform thickness.
c) Building with Shear wall at middle mid span with uniform thickness.
d) Building with shear wall at middle mid span channel type with uniform thickness.

2.2.2 Building with shear wall of varying thickness
a) Building with shear wall at corner with varying thickness.
b) Building with shear wall at mid span with varying thickness.
c) Building with Shear wall at middle mid span with varying thickness.
d) Building with shear wall at middle mid span channel type with varying thickness.

Table 1: shows the dimensions of beams and columns of buildings

<table>
<thead>
<tr>
<th>Storeys</th>
<th>No of bays in X direction</th>
<th>No of bays in Y direction</th>
<th>X direction bays in m</th>
<th>Y direction bays in m</th>
<th>Outer Column sizes in mm</th>
<th>Inner Column sizes in mm</th>
<th>All Beam sizes in mm</th>
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</thead>
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<td>25</td>
<td>6</td>
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Shear wall thickness = 300mm for uniform thickness models
Shear wall thickness for varying thickness models:
Base to storey 6 = 300mm
Storey 7 to storey 12 = 250mm
Storey 13 to storey 18 = 200mm
Storey 19 to storey 25 = 150mm

3. Results and Discussion

The results in the form of storey displacement and storey drift are presented in this chapter and variation of these results has been discussed. The analysis of buildings considered is carried out by nonlinear static method.

The variation of storey displacement and storey drift with respect to number of storey of the buildings with shear wall having uniform and varying thickness located in seismic zone IV are studied in this chapter.

The results obtained from analysis are tabulated as follows:

3.1 Displacement

As it can be seen from below figures, the displacement of the stories of structures is reduced by developing a T2-B model. In addition to the results of all models the maximum displacement is in T2-A model and minimum displacement is in T2-B model. Furthermore the graph shows that there has been steady increase in the amount of displacement of stories over the height.

According to this work, the reduction of displacement of stories is due to increase of stiffness of structure as well as...
decrease of velocity and acceleration of structure. In other words by creating the T2-B model, the response of structure such as velocity and acceleration can be reduced and it is the cause of reduction of displacement.

On Observing, displacements at all the storey in the TYPE 2B model is less than those in TYPE 2A. Here as one can see displacements lowest in bottom stories, very high at the upper stories.

The displacement is of interest with regard to structural stability, strength and human comfort. The displacement of T2-B model is less than the other model. It means that the T2B, Structure is more stable Chance of Structural Strength reduction is less. Human comfort is good.

Table 2: Storey wise displacement of type1 model

<table>
<thead>
<tr>
<th>STOREY</th>
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<th>T1BUX</th>
<th>T1CUX</th>
<th>T1DUX</th>
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Figure 7: storey wise displacement of Type1 Model

Table 3: Storey wise displacement of type 2 model

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</table>
3.2 Storey Drift Ratio

Storey drift is the displacement of one level relative to the other level above or below. In Software value of story drift is given in ratio.

Storey drift ratio = difference between displacement of two stories / height of one story

The building may collapse due to different response quantities. For example at local levels such as strains, curvatures, rotations and at global levels such as interior story drifts.

Individual stories may exhibit excessive lateral displacement. Therefore it can be concluded that by decreasing the story drifts of structure, the probability of collapse of the building can be reduced. To do that, as it is mentioned, T2-B model can play a significant role to reduce response of structure.

On observing, storey drift ratios at all the stories in the TYPE 2B model are less than those in TYPE 2A model. Here as one can see the storey drift ratio is very low in bottom stories, very high at the middle stories and finally decreases towards the upper stories.

After observing all the graphs, it can be generally said that drift ratio in upper storey is generally more, less in lower stories and maximum being middle storey.

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<thead>
<tr>
<th>STOREY</th>
<th>Drift-T1A-X</th>
<th>Drift-T1B-X</th>
<th>Drift-T1C-X</th>
<th>Drift-T1D-X</th>
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Table 4: storey drift ratio of type 1 model

<table>
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<tr>
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Table 5: Storey drift ratio of type 2 Model
4. Conclusions

The present study has been carried out the earthquake response of tall building by using varying thickness shear wall and its position. The main objectives of the study are stated in the chapter one. The purpose of the study is to investigate whether the TYPE 2 model provides adequate performance. The following conclusions were drawn from the analysis:

1. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake, percentage of lateral drift and displacement also depends on the location of shear wall and its thickness.
2. Model with shear wall at mid span having varying thickness achieves highest reduction in displacement with base shear in elastic region, so that the building acts well within the elastic region.
3. On Observing, storey drift ratios at all the stories in the TYPE 2 model are less than those in TYPE 1 model. Here the storey drift ratio is very low in bottom stories, very high at the middle stories and finally decreases towards the upper stories.

5. Recommendations for further work

It is recommended that further research be undertaken in following areas;
1. Determining the earthquake response of tall building structures by doing non linear dynamic analysis to assess the exact response of TYPE 2 model.
2. Study of foundation for various systems taking shear wall as major element.
3. Performance of building taking different heights of shear wall.

References