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Effect of Location of Shear Wall on Buildings Subjected to Seismic Loading

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Abstract— **Earthquake is a phenomenon which causes shaking of the earth, resulting from the sudden release of an enormous amount of energy in a short time. As earthquake acts laterally on a structure, lateral load resisting systems are used. Shear walls can be defined as the vertical structural elements which resist the horizontal forces acting on a building structure. Shear walls have very large in-plane stiffness and therefore resist lateral load and control deflection very effectively. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. The behavior of shear walls is influenced by their proportion as well as the support condition. They are usually provided in high rise buildings to avoid total collapse of the building under seismic force. In this study, an analysis of a twenty story building, irregular in plan, in zone IV is performed by changing the location of the shear wall and the effects of the parameters like story drift and displacement are determined using standard package ETABS. Four different models have been considered and analysis is performed using time history analysis method, by considering different earthquakes.**

Index Terms— **Shear wall, Non-linear dynamic analysis, Time history method of analysis**

I. INTRODUCTION

Many researchers have studied the behaviour and response of multi-storied reinforced concrete buildings under earthquake and the importance of shear wall in the seismic resistance of the buildings.

Dahesh et al. (2015) Studied the influence of shear wall in controlling the lateral response of building by varying the thickness, height, configuration and opening of shear walls. In the study, a multi-story RC building, square in plan and assumed to be located in a seismically active city of the Kingdom of Saudi Arabia, was laterally stiffened with the shear walls of different thickness, height, configuration, and opening location. The building was then subjected to seismic forces, and the influence of shear walls in controlling the lateral response of the building was studied by varying the above parameters. Results are useful for obtaining optimum amount and arrangement of shear walls.

Surana et al. (2015) Observed that the shear-wall and shear-wall cores are the most commonly used lateral load resisting elements in mid-rise to high-rise RC buildings. In the journal performance of shear-wall and shear-wall core buildings for design basic earthquake and maximum considered earthquake is studied using non-linear pushover analysis. The various modelling techniques for shear-walls and shear-wall cores have been discussed with their limitations.

Tuken and Siddiqui (2013) Presented an analytical method to determine the amount of shear wall necessary to make RC buildings seismic resistant against moderate to severe earthquakes. Ratio of total area of shear wall to the floor plan has been obtained by equating the total design base shear to total shear resistance provided by all shear wall in one direction.

Ugalde and Lopez-Garcia (2017) Conducted a study on post seismic behaviour of high-rise buildings in the country of Chile, which is one of the most seismic countries in the world. In this country, RC walls have been the preferred system for virtually any residential building higher than five stories. Two buildings of 17 and 26 stories that undergone the 2010 Chile earthquake without damage were selected for analysis.

We have seen in the above study that the configuration and location of shear wall in plan considerably affect the seismic responses of the buildings. But sufficient studies have not been done to determine the effect of change in location of shear wall and its judicious distribution. The size, configuration and position of shear wall affect the behaviour of the building. When shear walls are provided in advantageous positions in the building, they can form an efficient lateral force resisting system by reducing lateral displacements under earthquake loads. So it is necessary to determine the effective, efficient and ideal location of shear wall, therefore the topic of the present study.

II. EARTHQUAKE DATA AND ANALYSIS

Time history analysis was performed in ETABS v.15.1.0 software. In the analysis time history function and a target response spectrum function are defined. The time history function is matched with the defined target response spectrum function. For this purpose a software named Seismo Match has been used.

For the purpose of analysis, ground motion data are required. In the present study, four different earthquakes that have been occurred at different locations across East Asian region with different intensities have been considered.

A. Chamoli Earthquake:

The Chamoli earthquake was occurred in 1999 in India. The earthquake was the strongest to hit the foothills of The Himalayas in more than ninety years. The magnitude of the earthquake was 6.6 on the Ritcher scale. The maximum intensity was VIII (Severe)

B. Bhuj Earthquake:

The Bhuj earthquake is also known as the Gujarat earthquake and was occurred in 2001 in India. The intra-plate earthquake reached 7 on the moment magnitude scale and had a maximum felt intensity of X (extreme) on the Mercalli intensity scale.

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C. Kobe Earthquake:

The Kobe or Great Hanshin earthquake was occurred in 1995 in Japan. It measured 6.9 on the moment magnitude scale and had a maximum intensity of 7 on the JMA Seismic intensity Scale, which is the highest of the level.

D. Chi Chi Earthquake:

The Chi Chi earthquake which is locally known as the 921 earthquake, was occurred in 1999 in Taiwan. It was the second deadliest quake in the recorded history in Taiwan. The magnitude recorded on the Ritcher scale was 6.3.
The earthquake data that has been used is tabulated as below; (data has been taken from COSMOS Virtual Data Center)

Table 1. Earthquake data

Earthquake Name	Region	Magnitude
Chamoli	India	6.6
Bhuj	India	7
Kobe	Japan	6.9
Chi Chi	Taiwan	6.3

III. DESCRIPTION OF THE MODEL

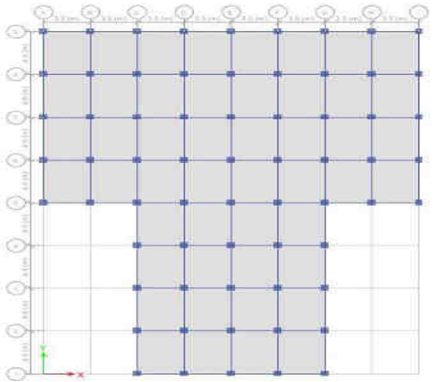


Fig. 1.1 Plan view of the model considered

A 20- storey building is considered for the analysis. Provided 8 bays along x- axis and 8 bays along y-axis. The spacing between the frames in given as 3.5m along x-axis and 4.5m along y-axis. Floor height is taken as 3.6m.

Table 2. Loads

Loads considered	Load Intensity
Live load on floor	4 KN/m^2
Floor finish	1 KN/m^2
Wall load	13.8 KN/m

Table 3. Section Properties

Section type	Size
Beam	400x500 mm
Column	500x500 mm
Slab	150 mm
Thickness of the wall	230 mm
Thickness of shear wall	230 mm

Considered M30 grade concrete and Fe 500 steel as reinforcement. Density of concrete is taken as 25 kN/m^3 and density of infill is taken as 20 kN/m^3.

Table 4. Factors considered for seismic analysis

Seismic Zone	IV
Zone factor	0.24
Type of soil	Hard
Importance factor of the building	1.5
Response reduction factor	5
Damping of structure	5%

Four models have been considered for the analysis. Shear walls are positioned at different locations in these models.
Model 1 - When shear walls are placed along all the corners of the building
Model 2- When shear walls are provided as inner walls
Model 3- When shear walls are provided as outer walls
Model 4- When shear walls are provided in the core of the building
The plan view of all the models are shown below:

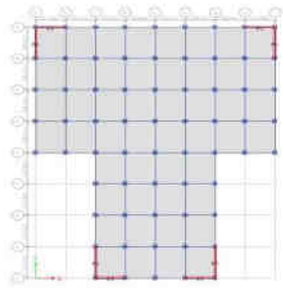


Fig. 1.2 Model 1

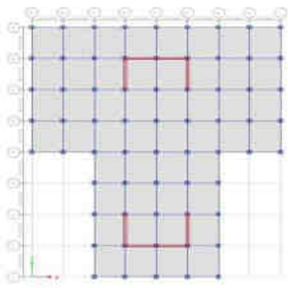


Fig. 1.3 Model 2

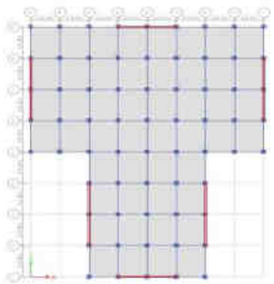


Fig. 1.4 Model 3

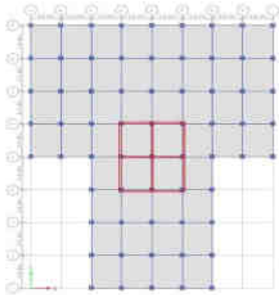


Fig. 1.5 Model 4

IV. RESULTS AND DISCUSSIONS

The results obtained from time history analysis performed in all the models for different earthquakes are tabulated below. The parameters used for the comparison and study are the lateral displacement and inter-storey drift.

a) Chamoli Earthquake:

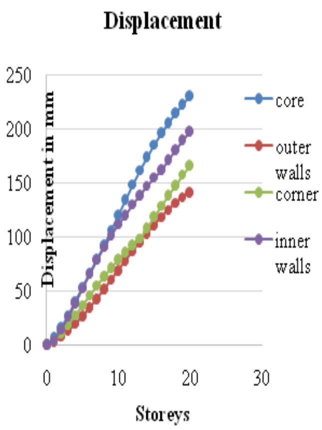


Fig. 2.1

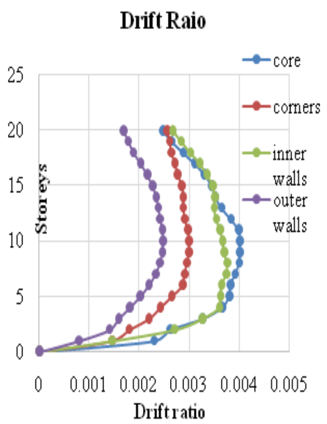
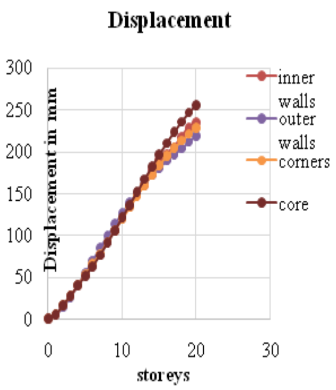


Fig. 2.2

Fig. 2.1 Storey-wise displacement
Fig. 2.2 Inter-storey drifts

b) Bhuj Earthquake:



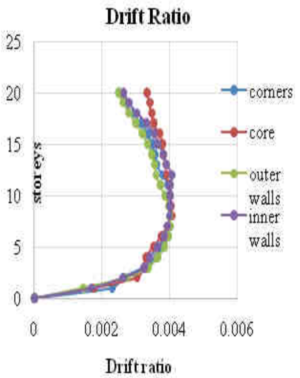
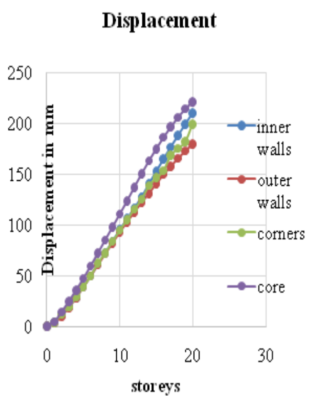


Fig. 2.3 **Fig. 2.4**

Fig. 2.3 Storey-wise displacement
Fig. 2.4 Inter-storey drifts

c) Kobe earthquake:



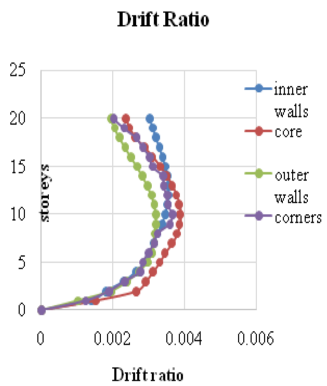
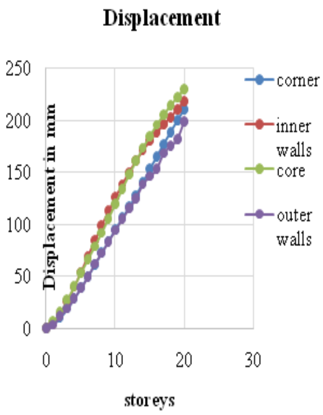


Fig. 2.5 **Fig. 2.6**

Fig. 2.5 Storey-wise displacement
Fig. 2.6 Inter-storey drifts

d) Chi Chi Earthquake:



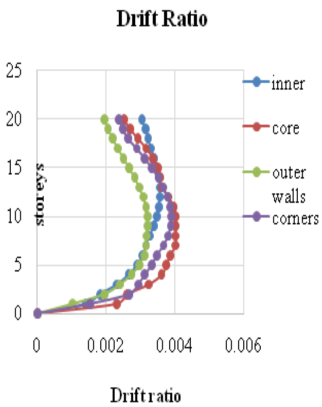


Fig. 2.7 **Fig. 2.8**

Fig. 2.7 Storey-wise displacement
Fig. 2.8 Inter-storey drifts

Storey drift can be defined as relative displacement between the floors or levels above or below the storey under consideration. As per Clause no. 7.11.1 of IS 1893 (Part I) : 2016, the storey drift in any storey due to specified design lateral force with partial load factor of 1.0, shall not exceed 0.004 times the storey height. Here, in the present study, the maximum drift permitted as per the codel provision is 0.004 x 3600 = 14.4 mm. In the study, the results have been presented as a ratio which is given as storey drift ratio i.e the ratio of difference between displacement of two storeys and height of one storey.

By analysing the drift values obtained for all the models obtained by performing time history analysis for each of the ground motions, it could be seen that the drift values are within the permissible limits. By comparing the drift values for all the models, obtained by both the methods , it could be found that in model with shear wall provided as the outer walls, the inter-storey drift has considerably been reduced when compared to the other models in which shear walls are provided as inner walls, along the corners and in the core.

Now, the lateral displacement of the building in both longitudinal and transverse directions are considered. The displacement is of interest with regard to structural stability, strength and human comfort. On comparing the results obtained, it could be seen that the lateral displacement values are less for the model 3, where shear walls are provided as the outer walls, than the other models considered.

CONCLUSION

Time History analysis by using four different earthquakes is carried out for the four models considered , which are having shear walls at different locations. Based on the analyses performed, the following conclusions can be drawn.

1. Providing shear walls at adequate locations substantially reduces the displacements and inter-storey drift due to earthquakes.
2. By performing time history analysis by considering different earthquakes, it has been found that model 3 shows lesser displacement as compared to the other models.
3. The inter-storey drift is found to be less in model 3 as compared to the other models, in both the methods
4. The presence of shear wall can affect the seismic behaviour of frame structure to a large extent, and the shear wall increases the strength and stiffness of the structure.
5. It has been found that the model 3, in which shear walls provided as the outer walls is the better location of shear wall.

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