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Performance of Different Shear Wall Positions in Building using Pushover Analysis

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Abstract—*Earlier the buildings used, were designed mainly to resist gravity loads and check the structure for safety to withstand the lateral loads. Many existing buildings located in various seismic zones are not able to resist earthquake. The reasons for this deficiency in seismic performance are poor detailing in reinforcement, material degradation and poor lateral resistance. There are various lateral load resisting systems and the use of shear walls is the most common amongst all the available systems. Shear walls are used to resist lateral loads as well as gravity loads due to their high strength and stiffness.*

The main objective of this research is to determine the best suitable location of shear wall in multi-storey building. To achieve this aim five models of eleven storeyed building are considered. The five models taken for comparison are as follows first building without shear wall, second with shear wall at outer corners, third shear wall at exterior of the building, fourth shear wall at the interior of the building and fifth with shear wall at the core of the building. The building is located in seismic zone iv. All the loads considered are as per Indian standard. The software used for modelling and analysing in SAP 2000 v. 20.2.0.

Nonlinear static (pushover) analysis is done for all the five models with different positions of shear walls and the pushover curve is obtained. By the help of the pushover curve the comparison between the displacement and base shear is made. And subsequently the best location of shear wall is determined.

Keywords: *pushover analysis, shear wall, non-linear hinge properties, SAP 2000.*

1. INTRODUCTION

Shear wall is a vertical member which resist lateral loads and also supports gravity loads. They resist different types of lateral loads like earthquake load and wind load. Shear walls are provided because they help in increasing the strength and stiffness of the building. Shear walls provide earthquake resistance to multistorey building. Shear walls are provided to reduce the earthquake effects in the buildings. In multistorey buildings the size of beams and columns increases resulting increase in self weight and large displacement. By providing shear walls the size of the beams and columns can be reduced and also the displacement is reduced. The prime criteria these days in designing of reinforced concrete structures in earthquake prone zones is to regulate lateral displacement occurring due to lateral forces. The nonlinear static analysis of a building has become important to study behaviour of concrete including the crack pattern and also load deflection pattern. It helps in providing more realistic results.

1.1. Shear Wall

Shear walls are provided in high rise buildings subjected to wind forces and earthquake forces. In high-rise buildings, shear walls are used as vertical component to resist lateral load which may occur due to the effect of earthquake and winds which there by may cause structure failure. The resistance provided by the shear wall is due to the cantilever action. Shear walls vary according to their shapes. The different types of shear walls are rectangular, channel, T shape, L shape, box shape, etc. When shear walls are provided in the core of the building, then it can be used for elevator.

2. PUSHOVER ANALYSIS

Pushover analysis is a non linear static analysis method in which the lateral loads are applied incrementally increasing along the height of the building. It is an approximate method of analysis. Pushover analysis can find out the maximum roof displacement and the corresponding base shear. The analysis is done until the frame reaches the target displacement or mechanism is formed. It gives the graph between the displacement of roof and base shear.

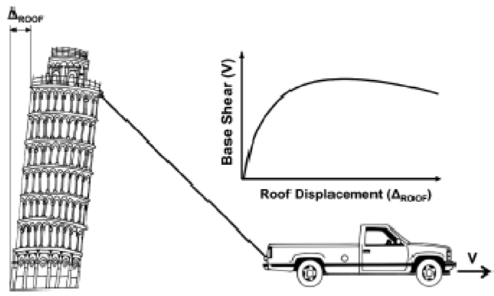

Figure 1: Pushover Curve

Earthquake generated forces are represented by equivalent static lateral loads. The graph which is obtained by pushover analysis is between the top displacement versus base shear, which indicate any weakness or failure. The analysis is done up to mechanism formation or target displacement value. The mechanism so formed represent the weakness or failure in structure. This kind of analysis method helps in identifying the weakness in the components of the structure. This helps in retrofitting of the structures.

2.1. Capacity Spectrum Method

The capacity spectrum method determines capacity and demand of structure in terms of spectral acceleration & spectral displacement therefore the name is capacity spectrum.

The analysis gives base shear vs. roof displacement curve. When the demand spectrum is plotted along with the capacity spectrum in an Acceleration Displacement Response Spectrum(ADRS) format, the two curves may meet to give a performance point.

Capacity- It refers to behaviour of structure due to seismic loading and how much load a structure can resist before collapse take place.

Demand- It depends upon the ground acceleration, location of structure and soil condition there. It is determined first, and capacity should be designed on the basis of demand. It is represented by response spectrum.

Performance point- The intersection of capacity curve and demand curve gives performance point. If the performance point does not exist that means structure fails to meet the demand.

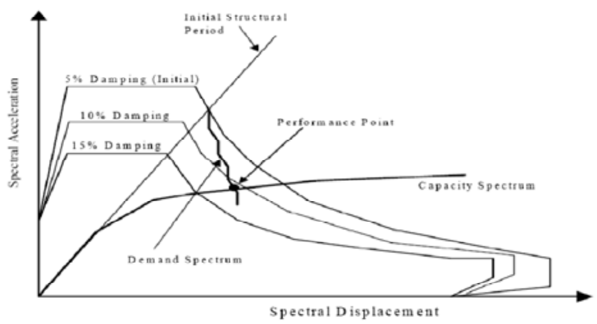

Figure 2: Capacity Spectrum Curve

3. METHODOLOGY

A multistorey building is modelled and analysed using SAP 2000 software. The five models of the building with different position of shear walls and also without shear walls are considered. The pushover analysis is done in both X and Y directions. The direction considered are positive directions. Two load cases Push X for x direction and Push Y for y direction.

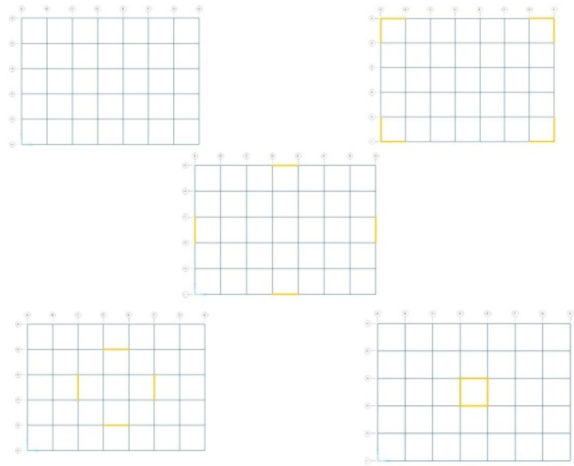

Figure 3: Plan of building with different shear wall positions

4. MODELLING AND ANALYSIS

For the analysis a G+10 storey building is considered. The details of structure are below:

Table -1: Detail of building

Total number of storey	G+10
Height of each storey	3.2m
Plan Area	28m*20m X direction 7@4m Y direction 5@4m
Size of Columns	300*600mm^2
Size of Beams	300*450mm^2
Thickness of Slab	150mm
Thickness of Shear Wall	230mm
Grade of Concrete	M25
Grade of Steel	Fe415
Seismic Zone	IV
Dead Load	1.5KN/m^2
Live Load	3KN/m^2
Type of Soil	Medium
Response Spectra	Acc. To IS 1893 (part I: 2002)
Importance Factor	I=1
Response Reduction Factor	R=5
Damping Ratio	5%
Pushover Load Cases	X direction- Push X Y direction- Push Y
Software	SAP 2000 V 20.2.0

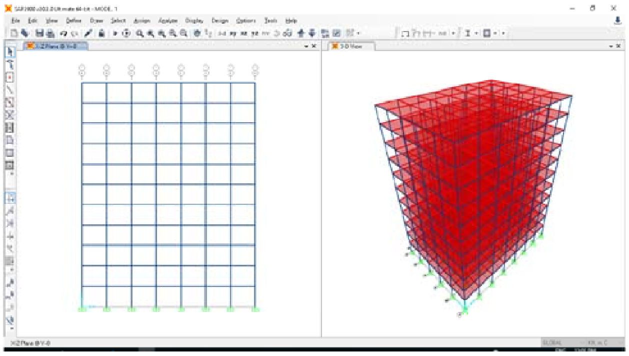

Figure 4: Model 1 without shear wall

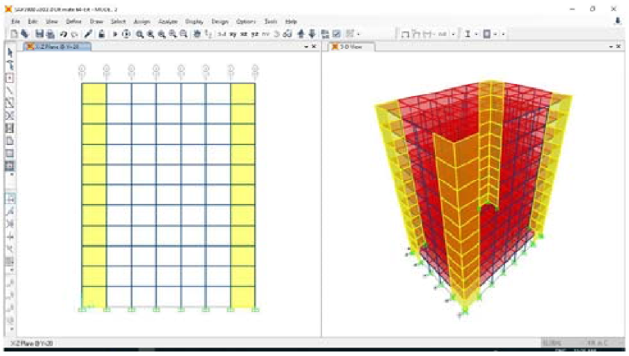

Figure 5: Model 2 with shear wall at corners

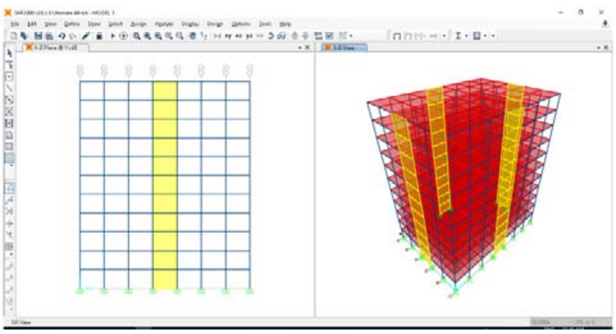

Figure 6: Model 3 with shear wall at exterior walls

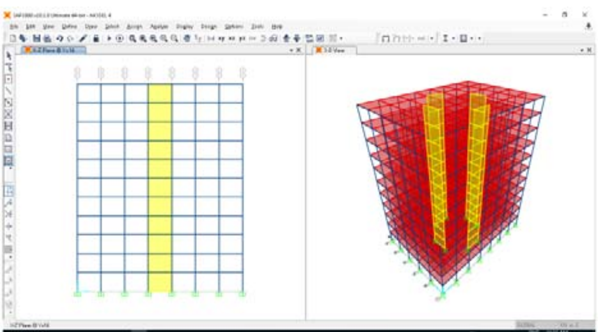

Figure 7: Model 4 with shear wall at interior walls

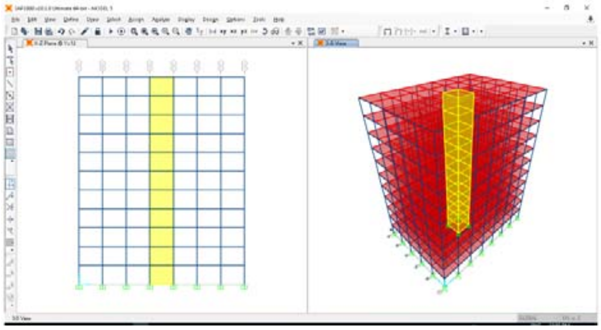

Figure 8: Model 5 with shear wall at corners

5. RESULTS AND DISCUSSION

After the analysis the pushover curves obtained are:

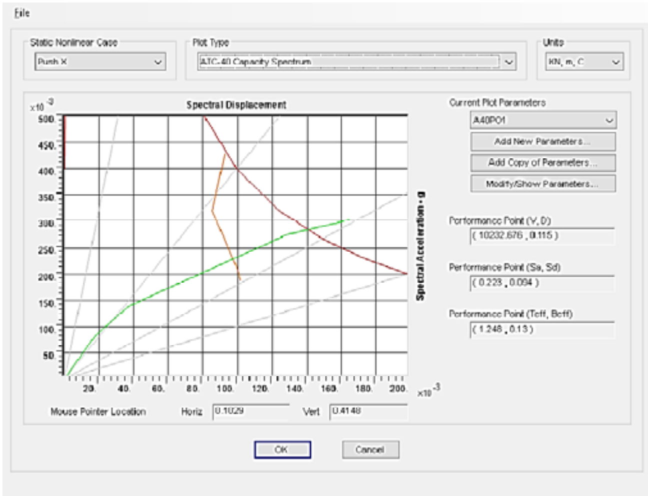

Figure 9: Pushover curve for model 1 in X direction

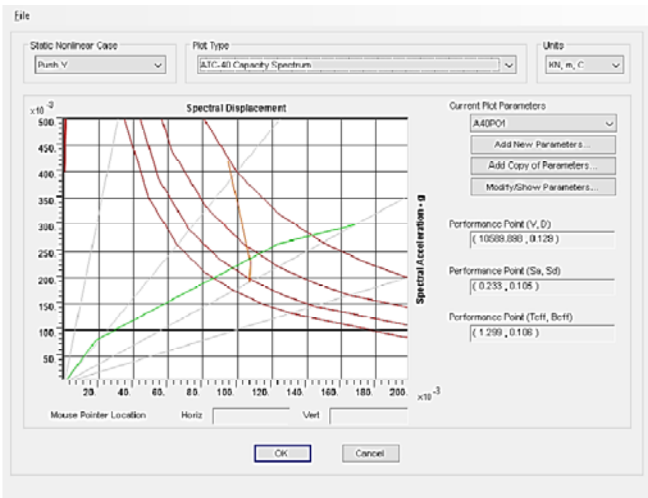

Figure 10: Pushover curve for model 1 in Y direction

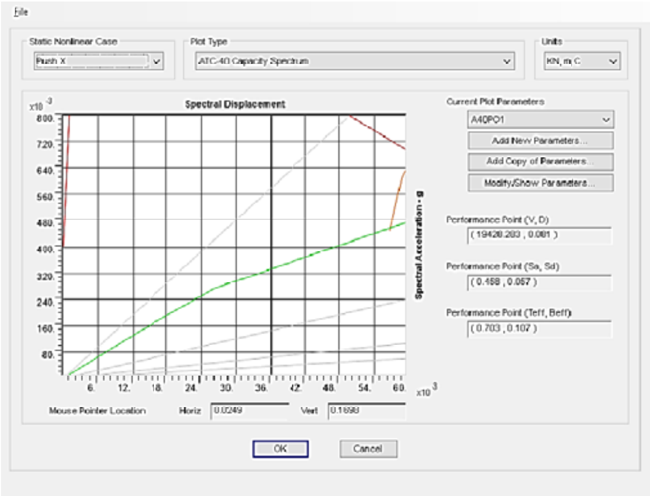

Figure 11: Pushover curve for model 2 in X direction

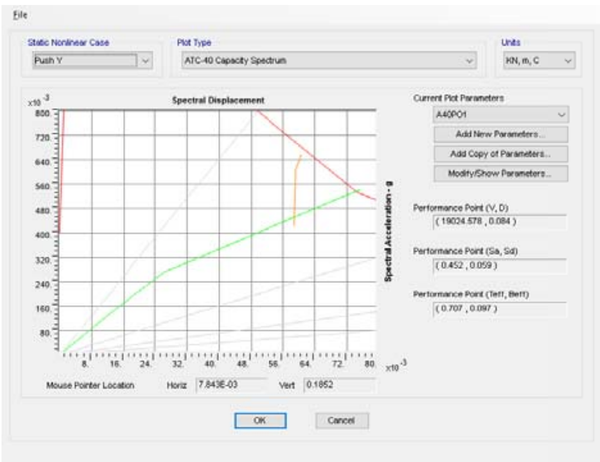

Figure 12: Pushover curve for model 2 in Y direction

Like this the pushover curves are obtained for other three models.

Table -2: Performance point in X direction

	V (KN)	D (m)
Model 1- Without SW	10232.6	0.115
Model 2- SW at corners	19428.283	0.081
Model 3- SW at external wall	15449.93	0.093
Model 4- SW at internal wall	15293.906	0.094
Model 5-SW at core	15531.217	0.087

Table -3: Performance point in Y direction

	V (KN)	D (m)
Model 1- Without SW	10589	0.129
Model 2- SW at corners	19024.57	0.084
Model 3- SW at external wall	13849.019	0.087
Model 4- SW at internal wall	14608.81	0.099
Model 5-SW at core	15292.234	0.090

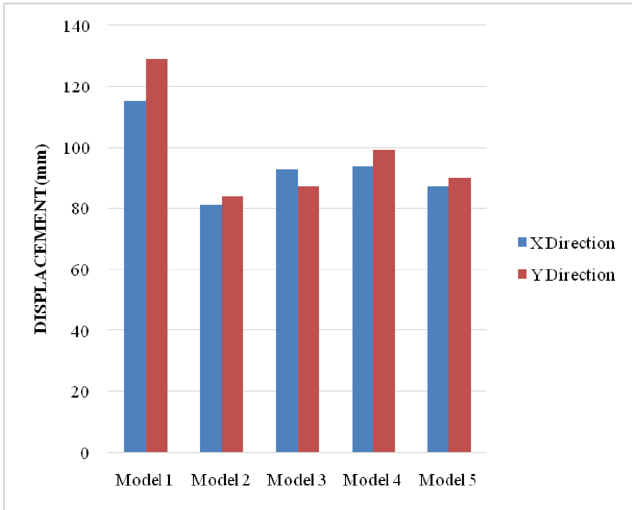

Chart 1: Displacement comparison for different models in X and Y direction

6. CONCLUSIONS

1. From the pushover curves it is observed that the displacement is reduced by providing shear wall.
2. The frames with shear walls are able to resist more base shear in comparison to bare frame.
3. The time period is reduced which shows that by providing shear wall stiffness of frame increases.
4. All the hinges formed are within permissible limits.
5. On comparing the displacement, shear wall at corners (model 2) has minimum displacement both in X and Y direction.
6. On comparing the base shear, shear wall at corners (model 2) is able to resist maximum base shear.
7. From the performance points of different models it can be concluded that the shear wall at corners is the most effective location of providing shear walls.

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