IMPORTANCE OF SHEAR WALL IN MULTISTORY BUILDING WITH SEISMIC ANALYSIS USING ETABS

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Abstract - *Due to space restrictions and migration of people from rural to urban areas, it has become essential to construct high rise structures. With the past experiences of earthquake in the form of devastating effects, it has now become important to consider the seismic effects during designing of the medium to high rise structures. In these types of structures, their safety during earthquake is still objectionable. Moreover, the column stiffness must be so enough to resist the seismic vibrations. From the past studies, it has been observed that the high stiffness in the columns require the larger column sizes large and it is practically impossible to construct such large sized columns due to space restrictions. Hence, the shear walls are considered to be one of the alternatives to increase the structural stiffness. Shear wall acts as a wide column always. It supports the imposed loads and consists of high stiffness in plane. It acts as structural resistant against seismic forces. However, the shear walls cannot be provided at all the locations due to its impact on economy. This present study is an attempt to determine the effective of shear wall in terms of structural in symmetrical structures.*

In this study, seven frame models are considered having different arrangement of shear wall. These frame models are subjected to perform Equivalent Linear Static Analysis and Response Spectrum Analysis with the help of platform ETABS 16.2.1. Both the analysis are carried out under the guidelines of IS: 1893 (Part— 1)-2002 in the form various load combinations. Various parameters such as maximum lateral displacement, storey drift and storey shear are evaluated from the both analyses and best arrangement of shear wall is suggested.

Keywords: *Shear Wall, Stiffness, Equivalent Linear Static Analysis, Response Spectrum Analysis*

1. INTRODUCTION

In past earthquakes, many structures especially Reinforced Concrete structures have been undergone the various kinds of damage or collapse. The buildings which were subjected to collapse during earthquakes are investigated in the form their performances. Strong beam - weak column behaviour, the use of poor quality concrete, insufficient bond between the end supports, insufficient length of slices provided, behaviour of short columns and the partial or improper design consideration are found to be major deficiencies to the structures. Based on these structural deficiencies, several codes have been revised so far. The required ductility of the structure, their lateral stiffness and the strength are comparatively less than those which are designed by the modern codes of building designs. Due to lower level of the ductility values of the structures, their stiffness and strength, these are more susceptible to the large amount of lateral displacement. Meanwhile in the present time, the global strengthening techniques are frequently considered as the strength imparting strategies. In these techniques, the transformation of global behaviour of the structure when subjected to external loading is required to be considered. This method results in the increase in the value of lateral load capacity of structure as well its strength. This method involves shear walls installation along all the sides of the structure. This method of external strengthening is found to be more beneficial in terms of their cost and easiness to the construction.

1.1 Shear Wall

Shear walls are the type of structural system which is formed by the use of braced panels (shear panels) which resist the effects of lateral load when subjected to the structure. Shear wall are primarily designed to resist the wind and seismic load.

1.2 Research Objectives

The main objective of the provision of the shear wall is to design the existing structure more strong and to study the various ways in which the structures can be made more stable against the effects of strong seismic loading. Moreover, the following aspects may also be covered:

- To analysis and compare the results of story drift and story displacement for with and without shear wall models.
- To reduce the size of column and beam by using shear wall.
- Find out appropriate location of shear walls based on the elastic and inelastic analysis.
- The most suitable model of shear wall is design by ETABS.
- To reduce the area of structure and increase the carpet area of structure by provision of the shear walls in place of RCC frames.
- To prepare all the structural details of element of structure by using AUTO CADD and E-TABS.

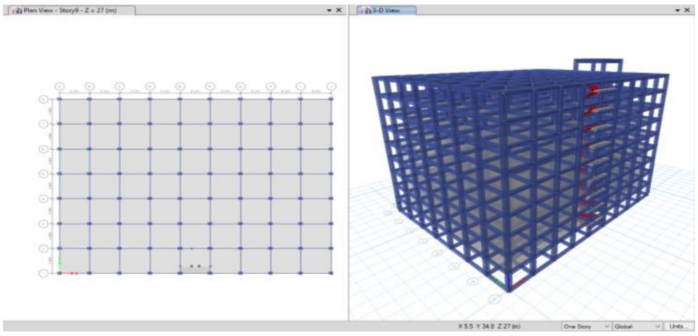
2. METHODOLOGY

In this present study, the modelling of the structure has been classified into two sections viz., the structural frame without any shear wall and the structural frame with shear walls having different dimensions, positions and shapes. The table no. 1 represents the geometric parameters and the material used for the designing of the structural frame which does not constitute any shear wall. This frame model has been named as Model – M 0.

Table -1: Geometric Parameters and Material Used for Design of Frame M-0

Building plan	36m x 32m
No. of Storey	9
Storey ht.	3m
Thickness of slab	150 mm
Thickness of wall	230 mm
Column Size	450mm x 450mm (In model M-0 and model M-1)
Beam Size	300mm x 400mm (In model M-0 and model M-1)
Concrete grade	M30
Steel Grade	Fe 500
Live Load on floor	2 kN/m^2
Floor finish	1 kN/m^2
Uniformly distributed load on beams	14 kN/m^2
Response Reduction factor	5
Importance Factor	1
Seismic Zone	IV
Zone factor	0.24
Soil type	Medium
Joint Restraint	Fixed

By the use of the data provided in the Table No. 1, the frame M-0 has been designed on the platform ETABS. The figure no. 1 shows the plan view and three dimensional view of the designed frame.



(Plan View) **(3-D View)**

Fig 1: Plan View and Three Dimensional View of the Frame M-0

2.1 Modelling of the Structure with Shear Wall

The modelling of structure having shear wall is done with same geometric parameters that have been considered in table no. 2. In this case, total six frames have been considered and designed having various shapes and positions of the shear walls. However, for frame M-1, the size of beams and columns is assumed to be same as that of frame M-0 but for the other frames the size of beams and columns is assumed to be different. These considered sizes and geometric parameters of shear walls are shown in the Table no. 2. The geometric plan view of the frames from frame M-1 and frame M-6 are shown in the figure no. 2.

Table-2: Geometric Parameters of Shear Walls and Size of beams & Columns

Thickness of Shear Wall	230mm
Wall Grade Concrete	M 30
Size of Beam	300mm x 300mm (In model M-2 to model M-6)
Size of Column	400mm x 400mm (In model M-2 to model M-6)

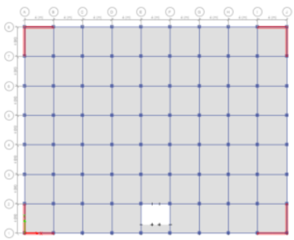


Fig. 2 (a): Model M-1

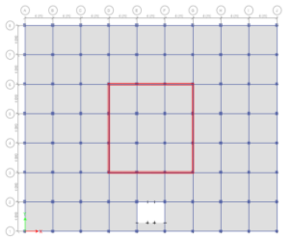


Fig. 2 (b): Model M-2

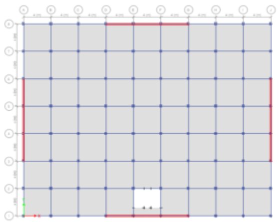


Fig. 2 (c): Model M-3

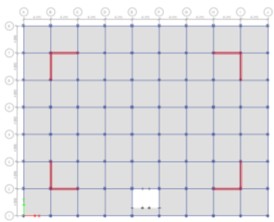


Fig. 2 (d): Model M-4

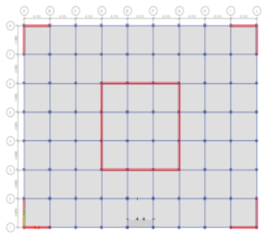


Fig. 2 (e): Model M-5

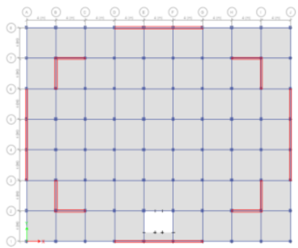


Fig. 2 (f): Model M-6

Fig. 2: Plan View of the Various Models having Different Positions of Shear Wall

3. RESULTS AND DISCUSSIONS

3.1 MAXIMUM LATERAL DISPLACEMENT

Due to rise in the height of building, the rise in lateral displacement of the structure is observed but fall in the value of lateral stiffness of the building is observed.

Maximum Lateral Displacement in X - Direction

From the analysis, the maximum lateral displacement is observed at each floor level of each frame model. It is observed that the maximum lateral displacement is reduced by 24 % in model M-1, 67.8 % in model M-2, 44.5 % in model M-3, 8.3 % in model M-4, 67.9 % in model M-5 and 49.8% in model M-6 as compared to model M-0 (Base Model). The least value of maximum lateral displacement has been observed in model M-5 as this model M-5 consists of a concentric shear walls and the shear walls along each corners. The maximum value is observed in the model M-4, which consists of a shear walls in four equal and opposite parts. However, the maximum lateral displacement along X-direction is almost similar in both the Model M-1 and Model M-5 throughout its height. The individual values and the graphical variation of the lateral displacement for all the models may be observed from figure 3.

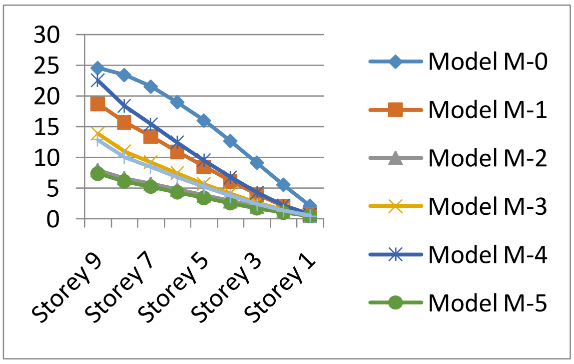


Fig. 3: Graphical variation of Maximum Displacement along the Height of the Structure in the X-Direction [Equivalent Linear Static Analysis]

Maximum Lateral Displacement in Y - Direction

From the analysis, the maximum lateral displacement is observed at each floor level of each frame model. It is observed that the maximum lateral displacement is reduced by 24.1 % in model M-1, 70.1 % in model M-2, 47.1 % in model M-3, 10.9 % in model M-4, 72.3 % in model M-5 and 51.3 % in model M-6 as compared to model M-0 (Base Model). The least value of maximum lateral displacement has been observed in model M-5 as this model consists of a concentric shear walls and the shear walls along each corners. The maximum value is observed in the model M-4, which consists of a shear walls in four equal and opposite parts. However, the maximum lateral displacement along X-direction is almost similar in both the Model M-1 and Model M-5 throughout its height. The individual values and the graphical variation of the lateral displacement for all the models may be observed from figure 4.

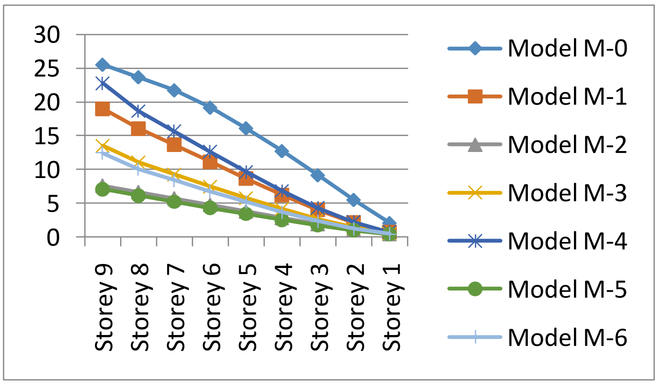


Fig. 4: Graphical variation of Maximum Displacement along the Height of the Structure in the Y-Direction [Equivalent Linear Static Analysis]

3.2 STOREY DRIFT

With increase in the height of the structure, the storey drift in the structure also gets increased up to certain height and then it decreases.

Storey Drift in X- Direction

The maximum storey drift is observed to be reduced by 68 % in the bare frame model M-0. However, if we consider the structure containing different arrangements of shear walls, the decrease in the value of maximum storey drift is observed to be very less as compared to the model M-0. The decrease in the storey drift is 8.9 % for model M-1, 13.7 % for model M-2, 5.7 % for model M-3, 5 % for model M-4, 6.9 % for model M-5, and 4.5 % for model M-6. The maximum decrement in the value was observed in model M-2. However, this decrease is very less in upper storey as compared to lower storey. It is due to the fact that the lower storey consists of higher value of lateral stiffness. Figure 5 represents the variation of storey drift with the height of each model.

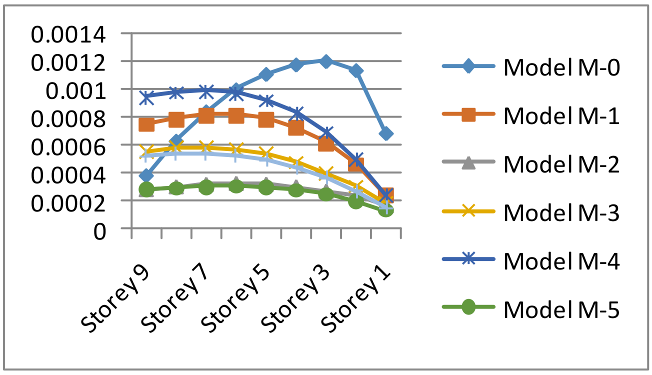


Fig. 5: Graphical variation of Storey Drift along the Height of the Structure in the X-Direction [Equivalent Linear Static Analysis]

Storey Drift in Y- Direction

The maximum storey drift along Y-direction is observed to be reduced by 67 % in the bare frame model M-0. However, if we consider the structure containing different arrangements of shear walls, the decrease in the value of maximum storey drift is observed to be very less as compared to the model M-0. The decrease in the storey drift is 8.9 % for model M-1, 16.3 % for model M-2, 7 % for model M-3, 4.8 % for model M-4, 6.5 % for model M-5, and 4.2 % for model M-6. The maximum decrement in the value was observed in model M-2. However, this decrease is very less. Moreover, the variation of storey drift along X - direction and Y – direction is almost similar. Figure 6 represents the variation of storey drift with the height of each model.

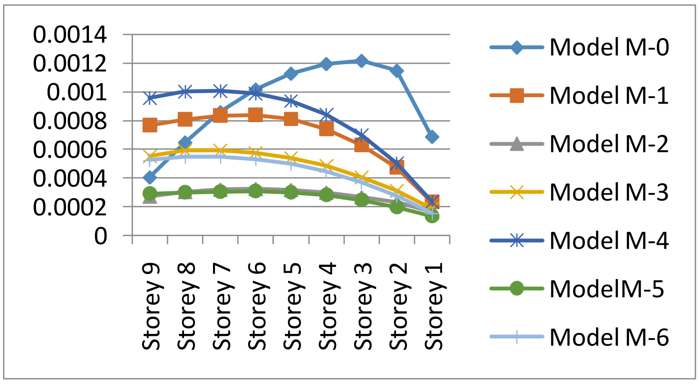


Fig. 6: Graphical variation of Storey Drift along the Height of the Structure in the Y-Direction [Equivalent Linear Static Analysis]

3.3 STOREY SHEAR

With increase in the height of the structure, the value of storey shear is observed to be decreases. It is due to the increase in the value of dead load of the structure from upper floor level to the bottom floor level.

Storey Shear in X-Direction

The pattern of variation of shear force along the storey increases from upper floor level to bottom floor level. It is interesting to note that value of shear force becomes almost constant at the lowermost floor level for each individual frame model. Fig. 7 shows the variation in the values of the storey shear force at the various floor levels of the structure having different models.

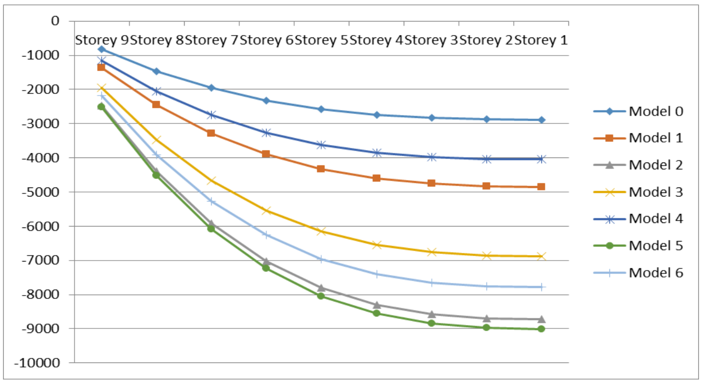


Fig. 7: Graphical variation of Storey Shear along the Height of the Structure in the X-Direction [Equivalent Linear Static Analysis]

Storey Shear in Y-Direction

The pattern of variation of shear force along the storey increases from upper floor level to bottom floor level. It is interesting to note that value of shear force becomes almost constant at the lowermost floor level for each individual frame model. Fig. 8 shows the variation in the values of the storey shear force at the various floor levels of the structure having different models.

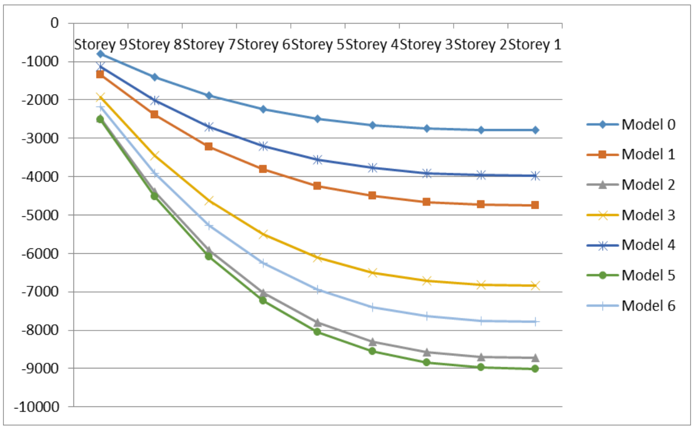


Fig. 8: Graphical variation of Storey Shear along the Height of the Structure in the Y-Direction [Equivalent Linear Static Analysis]

3.4 RESPONSE SPECTRUM ANALYSIS METHOD

This method is an approximate linear method which is based on the modal analysis and on the definition of response spectrum. It should be noted that this procedure results in the maximum response of the structure. The maximum response may be established for each and every mode of loading by the means of some sufficient response spectrum. During this analysis, the various load patterns and load cases are considered which have been shown in table no. 3 and table no.4.

Table - 3: Load Pattern considered During Response Spectrum Analysis

Name	Type	Self Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
EQ X	Seismic	0	IS: 1893 - 2002
EQ Y	Seismic	0	IS: 1893 - 2002

Table - 4: Load Cases considered During Response Spectrum Analysis

Name	Type
Dead	Linear Static
Live	Linear Static
EQ X	Linear Static
EQ Y	Linear Static
RS-X	Response Spectrum
RS-Y	Response Spectrum

3.5 MAXIMUM LATERAL DISPLACEMENT

With increase in the height of building, the increase in lateral displacement of the structure is observed but decrease in the value of lateral stiffness of the building.

Maximum Lateral Displacement in X - Direction

From the analysis, the maximum lateral displacement is observed at each floor level of each frame model. It is observed that the maximum lateral displacement is reduced by 22 % in model M-1, 80 % in model M-2, 54.2 % in model M-3, 8.9 % in model M-4, 80.1 % in model M-5 and 60 % in model M-6 as compared to model M-0 (Base Model). The least value of maximum lateral displacement has been observed in model M-5 as this model M-5 consists of a concentric shear walls and the shear walls along each corners. The maximum value is observed in the model M-4, which consists of a shear walls in four equal and opposite parts. However, the maximum lateral displacement along X-direction is almost similar in both the Model M-1 and Model M-5 throughout its height. The individual values and the graphical variation of the lateral displacement for all the models may be observed from figure 9 respectively.

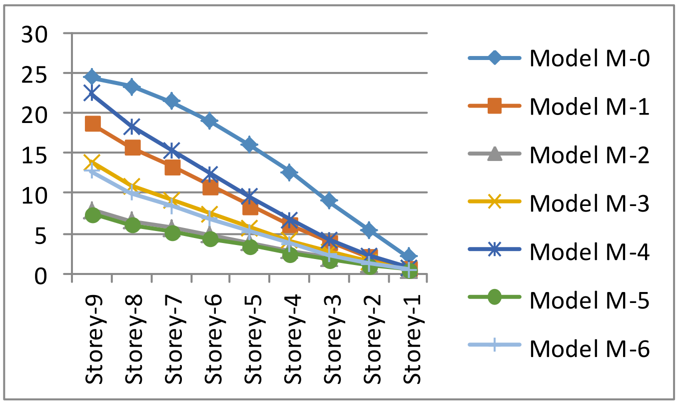


Fig. 9: Graphical variation of Maximum Displacement along the Height of the Structure in the X-Direction [Response Spectrum Analysis]

Maximum Lateral Displacement in Y - Direction

From the analysis, the maximum lateral displacement is observed at each floor level of each frame model. It is observed that the maximum lateral displacement is reduced by 23.44 % in model M-1, 80.9 % in model M-2, 54.2 % in model M-3, 8.9 % in model M-4, 80.1 % in model M-5 and 60 % in model M-6 as compared to model M-0 (Base Model). The least value of maximum lateral displacement has been observed in model M-5 as this model consists of a concentric shear walls and the shear walls along each corners. The maximum value is observed in the model M-4, which consists of a shear walls in four equal and opposite parts. However, the maximum lateral displacement along X-direction is almost similar in both the Model M-1 and Model M-5 throughout its height. The individual values and the graphical variation of the lateral displacement for all the models may be observed from figure 10 respectively.

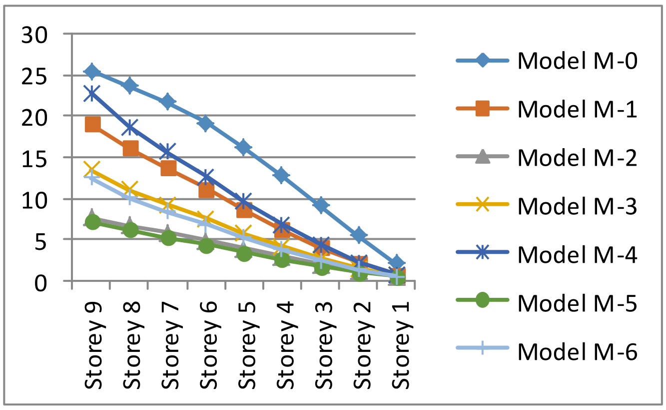


Fig. 10: Graphical variation of Maximum Displacement along the Height of the Structure in the Y-Direction [Response Spectrum Analysis]

3.6 STOREY DRIFT

With increase in the height of the structure, the storey drift in the structure also gets increased up to certain height and then it decreases.

Storey Drift along X- Direction

The maximum storey drift is observed to be reduced by 69 % in the bare frame model M-0. However, if we consider the structure containing different arrangements of shear walls, the decrease in the value of maximum storey drift is observed to be very less as compared to the model M-0. The decrease in the storey drift is 10 % for model M-1, 85.4 % for model M-2, 6.3 % for model M-3, 6.3 % for model M-4, 7.8 % for model M-5, and 4.2 % for model M-6. The maximum decrement in the value was observed in model M-2. However, this decrease is very less in upper storey as compared to lower storey. It is due to the fact that the lower storey consists of higher value of lateral stiffness Figure 11 represents the variation of storey drift with the height of each model.

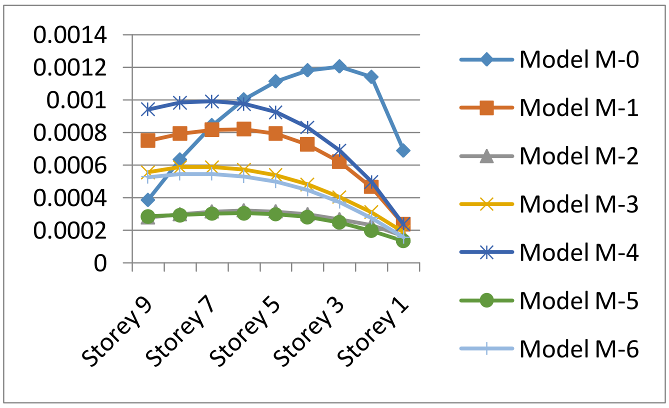


Fig. 11: Graphical variation of Storey Drift along the Height of the Structure in the X-Direction [Response Spectrum Analysis]

Storey Drift along Y- Direction

The maximum storey drift along Y-direction is observed to be reduced by 68 % in the bare frame model M-0. However, if we consider the structure containing different arrangements of shear walls, the decrease in the value of maximum storey drift is observed to be very less as compared to the model M-0. The decrease in the storey drift is 9 % for model M-1, 85.2 % for model M-2, 7.5 % for model M-3, 4.9 % for model M-4, 6.52 % for model M-5, and 4.3 % for model M-6. The maximum decrement in the value was observed in model M-2. However, this decrease is very less.

Moreover, the variation of storey drift along X - direction and Y – direction is almost similar. Figure 4.12 represents the variation of storey drift with the height of each model.

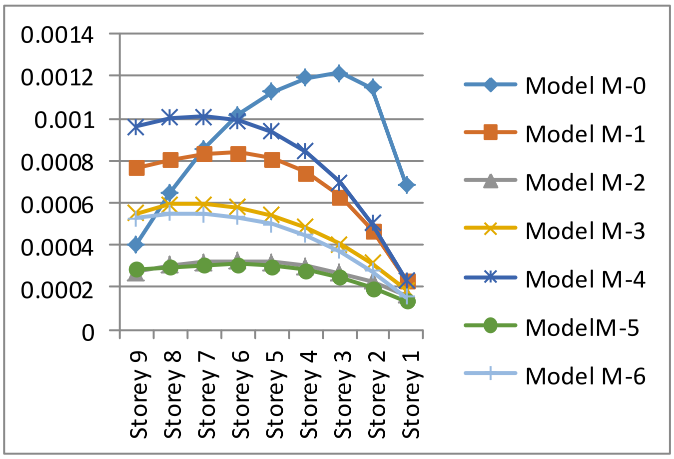


Fig. 12: Graphical variation of Storey Drift along the Height of the Structure in the Y-Direction [Response Spectrum Analysis]

STOREY SHEAR

With increase in the height of the structure, the value of storey shear is observed to be decreases. It is due to the increase in the value of dead load of the structure from upper floor level to the bottom floor level.

Storey Shear along X-Direction

The pattern of variation of shear force along the storey increases from upper floor level to bottom floor level. It is interesting to note that value of shear force becomes almost constant at the lowermost floor level for each individual frame model. Fig. 4.13 shows the variation in the values of the storey shear force at the various floor levels of the structure having different models.

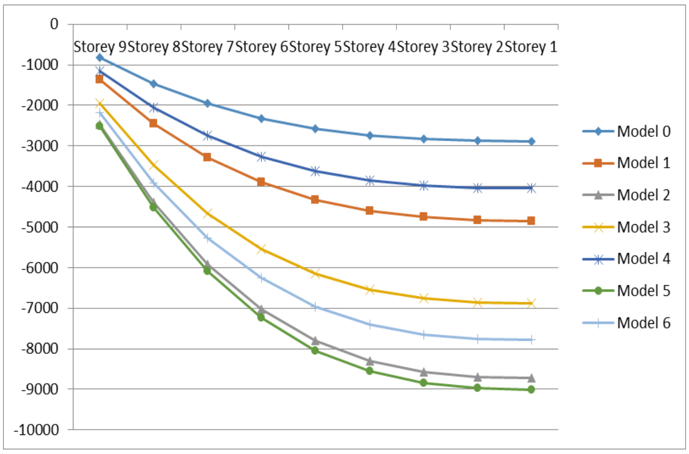


Fig. 13: Graphical variation of Storey Shear along the Height of the Structure in the X-Direction [Response Spectrum Analysis]

Storey Shear along Y-Direction

The pattern of variation of shear force along the storey increases from upper floor level to bottom floor level. It is interesting to note that value of shear force becomes almost constant at the lowermost floor level for each individual frame model. Table 4.18 shows the individual values of the shear force at the various floor levels of the structure having different models along Y-direction. Fig. 14 shows the variation in the values of the storey shear force at the various floor levels of the structure having different models.

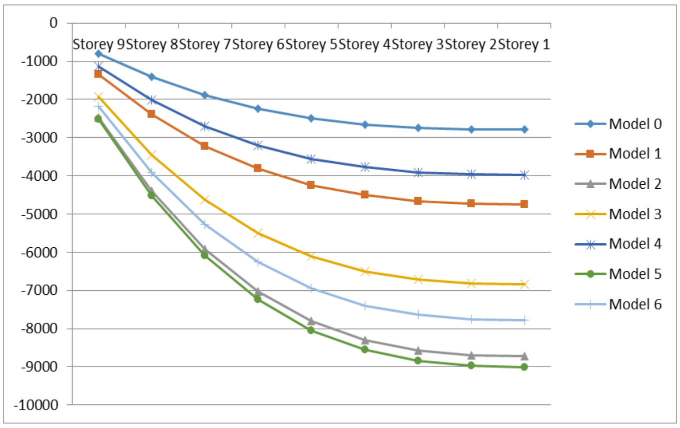


Fig. 14: Graphical variation of Storey Shear along the Height of the Structure in the Y-Direction [Response Spectrum Analysis]

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4. CONCLUSIONS

The following are the salient conclusion drawn from the present study:

1. In both equivalent static analysis and response spectrum analysis method, it has been observed that model having box shaped shear walls at the centroid of the building, M-5 shows the least value of maximum lateral displacement X-direction and Y-direction both.
2. With increase in the height of the structure, the storey drift in the structure also gets increased up to certain height and then it decreases. The minimum value of the storey drift is observed in the both frame model M-2 and M-5. Both the models have a similarity of having the shear walls in the form a concentric square box at the centroid of the structure.
3. The provision of the shear wall in a structure can change structural performance during earthquake vibrations to a very large extent as it imparts the lateral strength & stiffness to the structure. It is observed that the models having shear walls at the centroid of the structure in the shape of square box results in the better location of shear wall as the value of storey drift and maximum lateral displacement are comparatively less to the other models.
4. It is interesting to note that the effect of shear walls become insignificant after the almost 80% height of the building as the shear force increases initially up to its 80% height and then decreases along both the directions.
5. The most effective distribution of base shear has been observed in the model M-5 in both the methods of analysis. It is due the effective uniform distribution of shear wall provided concentrically in the form of square box.

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