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Impacts of Shear Wall During Seismic Analysis of High Rise Structures

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Abstract - *Due to space limitations and increasing the number of migrants from rural to urban areas, it is observed to be very necessary to build multi-storey structures. With the previous seismic experiences, it is very essential to consider the effects of earthquake for design of multi-storey structures. In such structures, the safety of the residents is questionable. The past studies concluded that the higher value of stiffness to the columns demand the larger sized columns and it is not possible to provide such columns due to land limitations. As a result, the shear walls are found to be very suitable way to impart the stiffness to the structure. Shear walls behave like wide columns which resist the imposed loads. These walls behave like structural resistant against earthquake forces. This present study is an attempt to determine the effectiveness of the shear wall in the structures.*

In this study, seven models are considered to have suitable various shear walls arrangements. These models are analyzed for Equivalent 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 – 2002 (Part 1) in the form various load combinations. Various parameters such as base shear, fundamental natural time period of vibrations are evaluated on the basis of both methods of analysis and the best arrangement of shear wall is suggested.

Key Words: *Shear Wall, Base Shear, Fundamental Time Period of Vibrations, Stiffness.*

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 design the most suitable shear wall by ETABS.
- To analysis and compare the base and fundamental natural time period for the frames with and without shear wall.
- To decrease the column size and beam size by using shear wall.
- Find out appropriate location of shear walls based on the elastic and inelastic analysis.

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 1 and table 2 represent the geometric parameters and the material used for the designing of the structural frame which does not constitute any shear wall. This frame models have been named as M-0, M-1, M-2, M-3, M-4, M-5, M-6.

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

Building plan	48m x 42m
No. of Storey	9
Storey ht.	3.2m
Thickness of slab	125 mm
Thickness of wall	230 mm
Column Size	400 mm x 400 mm (In model M-0 and model M-1)
Beam Size	350 mm x 550 mm (In model M-0 and model M-1)
Concrete grade	M25
Steel Grade	Fe 500
Live Load on floor	2.5 kN/m2
Floor finish	1 kN/m2
Uniformly distributed load on beams	17.5 kN/m2
Response Reduction factor	5
Importance Factor	1
Seismic Zone	IV
Zone factor	0.24
Soil type	Medium
Joint Restraint	Fixed

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	350mm x 350mm (In model M-2 to model M-6)

3. RESULTS AND DISCUSSIONS

3.1 EQUIVALENT LINEAR STATIC ANALYSIS

The equivalent static analysis always assumes the structure to be a type of discrete structure that consists of concentrated loads at the floor levels in the form of self-weight of walls, columns, etc. These loads should be uniformly distributed to floors below and above the storey. Moreover, some ample amount of imposed load is also considered at floor levels. During this analysis, the various load patterns and load cases are considered which have been shown in table 3 and table 4.

Table 3: Load Pattern considered During Equivalent Static Analysis

Name of the Load	Nature of the Load	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 Equivalent Static Analysis

Name	Type
Dead	Linear Static
Live	Linear Static
EQ X	Linear Static
EQ Y	Linear Static

3.1.1 BASE SHEAR

The base shear of the structure along X-direction and Y-direction are nearly found to be same. Although the maximum value of base shear is observed for model M-5 which is in the order of 9000 kN. The Minimum base has been observed in the model M-0 (Bare Frame Model) i.e., 2850 kN along X-direction and 2760 kN along Y-direction. The model M-2 and M-5 have almost same values of base shear and this value is exactly same along both the direction. Fig. 1 shows the values of base shear along the storey height for all the frame models.

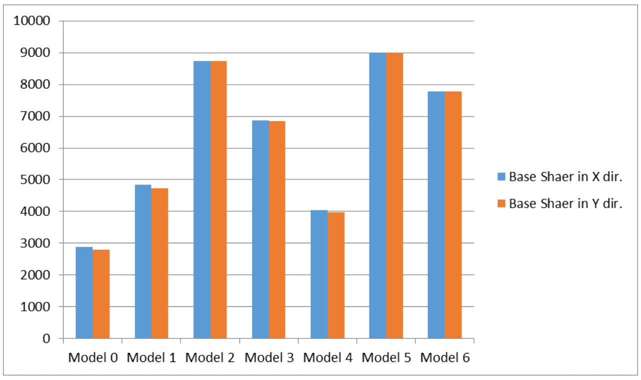

Fig. 1: Base Shear Values of the various Models [Equivalent Linear Static Analysis]

3.1.2 NATURAL TIME PERIOD

The approximate fundamental natural time period of vibrations for the various models is determined using IS: 1893 – 2002. This value is found to be maximum for the bare frame model M-0 and it is interesting to note that this value is slightly more along Y-direction as compared to X-direction. The models M-2 and M-5 have the minimum values of approximate fundamental natural time period of vibrations. It can also be said that these models have maximum value of fundamental natural frequency as it is inversely proportional to the fundamental natural time period of vibrations. Fig. 2 shows the values of fundamental natural time period of vibrations along the storey height for all the frame models.

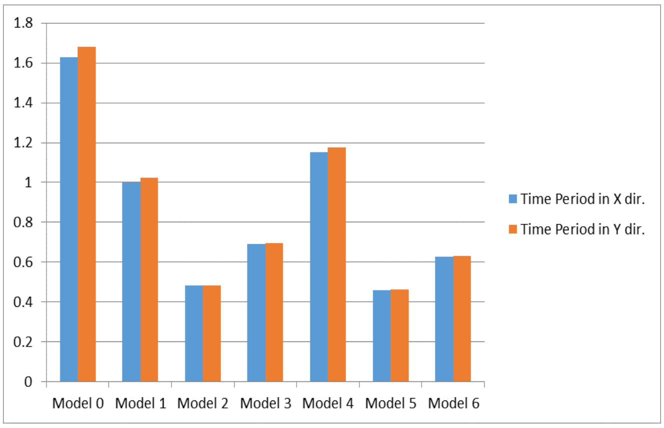

Fig. 2: Natural Time Period of Vibration of the various Models [Equivalent Linear Static Analysis]

3.2 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 5 and table 6.

Table 5: 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 6: 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

3.2.1 BASE SHEAR

The base shear of the structure along X-direction and Y-direction are nearly found to be same. Although the maximum value of base shear is observed for model M-5 and M-6 which is in the order of 3800 kN. It may be due to the effective, symmetrical and uniform distribution of shear walls. The Minimum base has been observed in the model M-0 (Bare Frame Model) i.e., 1750 kN along X-direction and 1700 kN along Y-direction. The model M-2 and M-3 have almost same values of base shear and this value is exactly same along both the direction. Fig. 3 shows the values of base shear along the storey height for all the frame models.

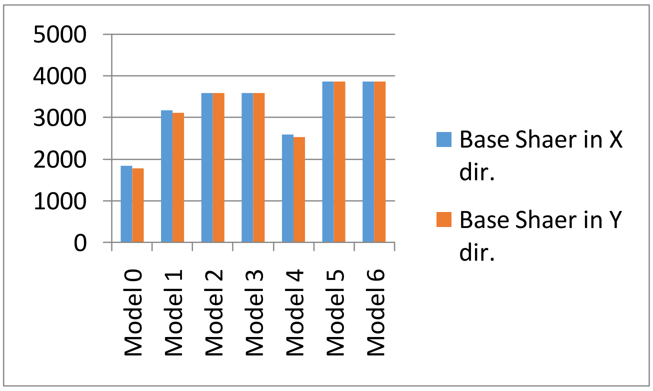

Fig. 3: Base Shear Variation in the Various Models along X-direction and Y-direction [Response Spectrum Analysis]

3.2.2. NATURAL TIME PERIOD

The approximate fundamental natural time period of vibrations for the various models are determined using IS: 1893 – 2002. This value is found to have maximum value for the bare frame model M-0 and it is interesting to note that this value is slightly more along Y-direction as compared to X-direction. The models M-2 and M-5 have the minimum values of approximate fundamental natural time period of vibrations. It can also be said that these models have maximum value of fundamental natural frequency as it is inversely proportional to the fundamental natural time period of vibrations. Fig. 4 shows the values of fundamental natural time period of vibrations along the storey height for all the frame models.

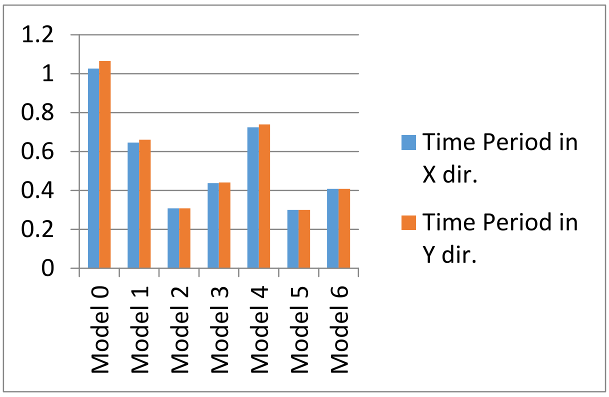

Fig. 4: Natural Time Period Variation in the Various Models along X-direction and Y-direction [Response Spectrum Analysis]

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 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.
3 From Both the methods of analysis, it has been concluded that models M-2 and M-5 have the minimum values of approximate fundamental natural time period of vibrations. It can also be said that these models have maximum value of fundamental natural frequency as it is inversely proportional to the fundamental natural time period.

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