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A Comparative Study on Behaviour of Shear Wall with and Without Openings in RC Framed Structure by Dynamic Analysis

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Abstract - *Nowadays, earthquake and wind are the major topics of study in structural engineering. In order to overcome the problem of population there is need for vertical development instead of horizontal development. Project work includes the modelling of G + 13 storeyed building with and without openings in the shear wall and, shear wall located at middle and edge of the structure. As per IS 1893 Part 1 (2016) codal provisions, the effect due to dynamic forces is analyzed by RSA in Zone II using ETABS software and the seismic parameters such as storey displacement, storey drift ratio, storey stiffness, storey shear and time period are obtained. From, the results observed for five modals, addition of shear wall at the central position(M3) reduces the storey displacement and storey drift ratios, and increases the storey stiffness and storey shear compared to the modals without shear wall and with openings in the shear wall, thus making the building safe and secure against the dynamic loads. Hence it is better to provide shear wall with or without openings at the central position than at the edges*

Key Words: **Earthquake, Wind, Storey Displacement, Storey Drift, Storey Stiffness, Storey Shear, Shear Wall, ETABS.**

1. INTRODUCTION

Nowadays, earthquake andiwind are the major topics of study in structuraluengineering. Throughout the lifetime, the structures are subjected to serious vibrations.Assymetrical configurations are observed in most of the buildings. Hence along the height of the building, there is irregularudistribution in mass, stiffness and strength. Reinforced concrete buildings resist both vertical and horizontal loads, but the size of beams and columns are quite heavy and large amount of steel quantity is required due to which there is lot of congestion at jointsand placing of the concrete becomes difficult inducing heavy forces in members. Thus building with shear wall, has greater lateral load resisting capacity and lesser damage compared to building without shear wall.

1.1 Shear Wall

In order to reduce lateral sway and increase the strength and stiffness the best earthquake resistance is observed when shear walls are properly designedandodetailed. Shear walls are provided from the foundationylevel and are continuousthroughout building height and acts as verticle cantilever. The factorsisuch as shapeyin plan, reinforcement and opening layout, dimension of the walls and openings, type ofearthquake, site condition andustrain rates are certain failure mechanisms of shear wall. Butishear walls placed inadvantageous position form anxefficient lateral forceiresisting system.

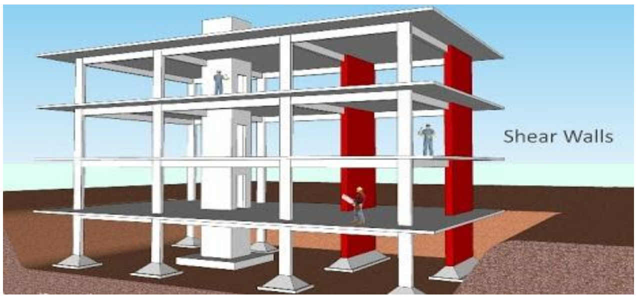

Fig -1: Typical view of shear walls in buildings

1.2 Shear Wall with Openings

Shear wall are perforated with openings. The sizehand location of opening depends on the function of thegbuilding. Windows, corridors and door openings are sufficient for residential buildings whereas for special buildings like, hotels, function hall, cinema theaters and community halls larger openings are required to meet their requirements and also to provide access of cables and pipelines, openings are provided in Shear Wall. Openings may be staggered or vertically arranged. Size of opening is also responsible for seismic response of the system. Stress distribution is critical around the opening.

2. LITERATURE REVIEW

Reddy and Kumari (2019)[12]: Analyzed a high rise building of G+20 storeys, is considered forjthe analysis by using finite elementysoftware ETABS resting in seismic Zone III through response spectrumuanalysis. Earthquake analysis is done as per IS 1893 (2002) using three models without shear wall, with shear wall and shear wall with opening.

Kodappana and Dilip (2017)[9]: Analyzed (G+15) storeyed building with regular and staggered openings in shear wallsiat corners and periphery with irregular plan shapes "L", "T" and "I" in seismic Zone V using structural software ETABS (V-15). The structure considered has plan area 50X50m with 10 bays in X and Yidirection of 5m each. The parameters such as storeyudrift, storey displacement, story shear and stress distribution were considered in this study. Response spectrumimethod is used for dynamic analysis as per IS 1893 (2002).

Aarthi and Senthil (2015)[8]: In this study seven storeyed building was modelled and meshing was done ineorder to increase theiaccuracy of results. Theumodel was analyzed using Finite Element software ETABS (v-13) with shearxwall having verticalgand staggeredmopenings by considering Zone II. Load combinations and earthquake load was calculated as periIS 1893 (2002)iand responsespectrum method was used for seismic analysis. The design was done as per IS 456 (2000) and detailing according to IS 13920 (1993). The building was analyzed for timeperiod, storydisplacement, storydrift, storyushear and stresshdistribution.

3. OBJECTIVES AND DEVELOPMENT OF MODELS

3.1 Objectives

The objectives are as follows,

1. To avoid the failure of buildings by providing shear walls.
2. To analyze the building using Response Spectrum seismic analysis by Finite Element software ETABS.
3. To study the structural parameters such as story displacement, story drift ratio, story stiffness, storey shear, base shear and timeiperiod of the building.
4. To determine the effect of building without shear wall under seismic loading.
5. To determine the effect of building with shear wall under seismic loading.
6. To determine the effectof shear walliwith and withoutvopening in the structure.
7. Comparing the performance of different building models.

3.2 Development of Models and Analysis

Table -1: Parameters Considered in Modelling

Sl No	Parameter	Remarks
1	Structural type	Residential
2	No of stories	G+13
3	Height of building	42.2m
4	Bays width in X-direction	3.734m, 6.655m
5	Bays width Y-direction	5.563m, 5.715m, 3.048m
6	Column size	400x750mm
7	Beam size	300x500mm
8	Slab thickness	150mm
9	Storey height	3m
10	Grade of concrete	M35
11	Steel grade	Fe550
12	Poison's ratio of concrete	0.2
13	Density of AACBLOCKS	7.45kN/m3
14	Concrete density	25kN/m3
15	Shear wall thickness	300mm
16	Size of openings	1.2x1.5 m
17	Live load on Floor	3kN/m2
18	Live load onbRoof	1.5kN/m2
19	Wall load	6kN/m
20	Damping ratio	5%
21	Type of soil	Medium
22	Zone factor	II
23	Importance factor	1.2
24	Response reduction factor	3

3.2.1 Different RC Framed Models Considered for Response Spectrum Analysis

M1: Regular RC Building
M2: RC Building without Openings in Shear Wall at Edges
M3: RC Building without Openings in Shear Wall at Middle
M4: RC Building with Openings in Shear Wall at Edges
M5: RC Building with Openings in Shear Wall at middle

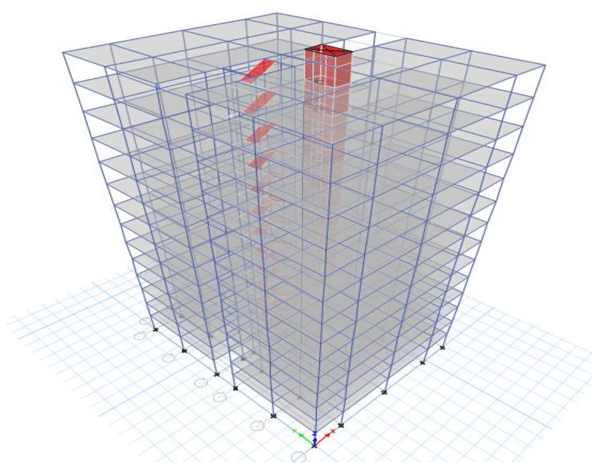

Fig -2: 3-D View for Model M1

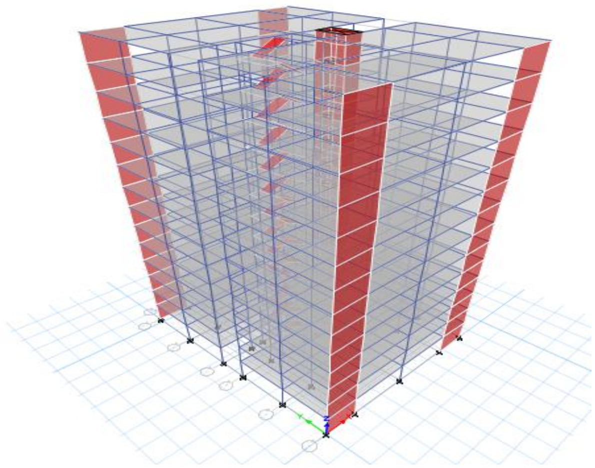

Fig -3: 3-D View for Model M2

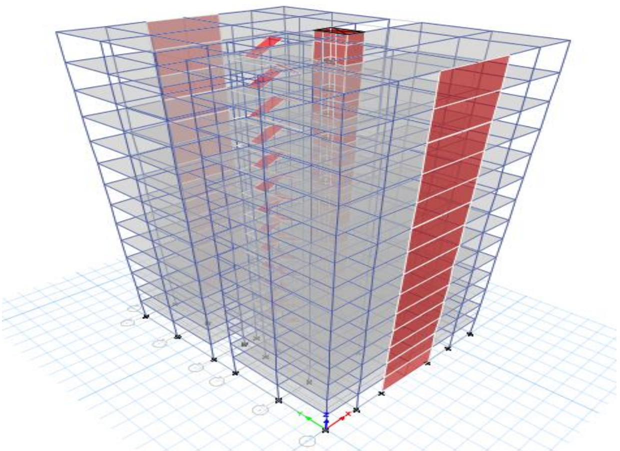

Fig -4: 3-D View for Model M3

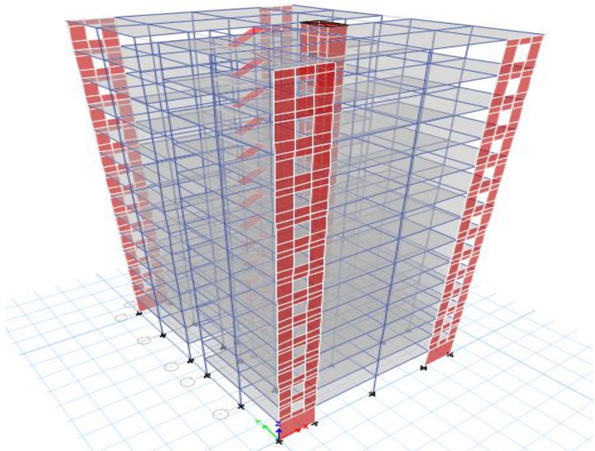

Fig -5: 3-D View for Model M4

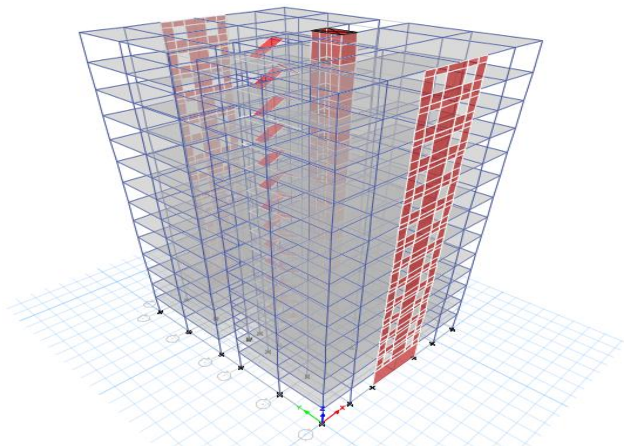

Fig -6: 3-D View for Model M5

4. RESULTS AND DISCUSSION

4.1 Storey Displacement

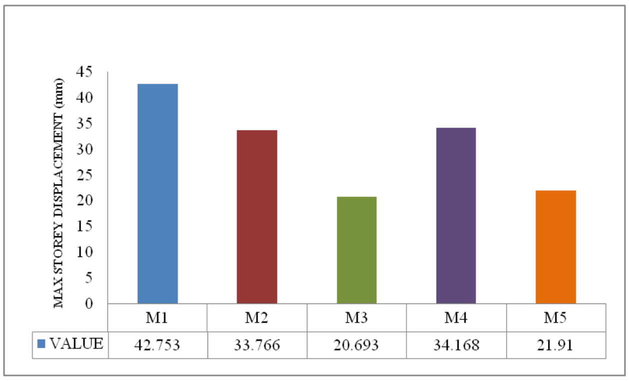

Chart -1: Maximum Storey Displacement in X direction

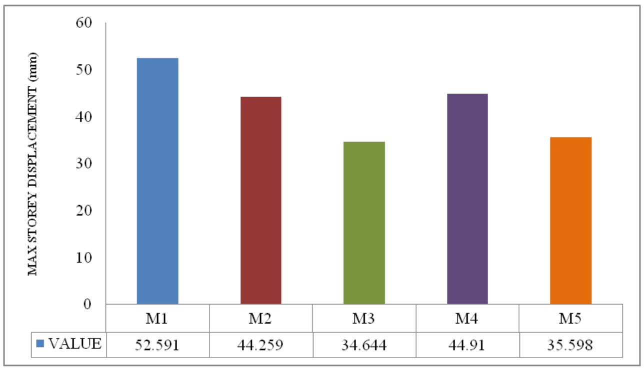

Chart -2: Maximum Storey Displacement in Y direction

From the above tables and figures, concluded that maximum displacement is observed from modal M1 and minimum displacement is observed from modal M3 in both X and Y directions.

4.2 Storey Drift

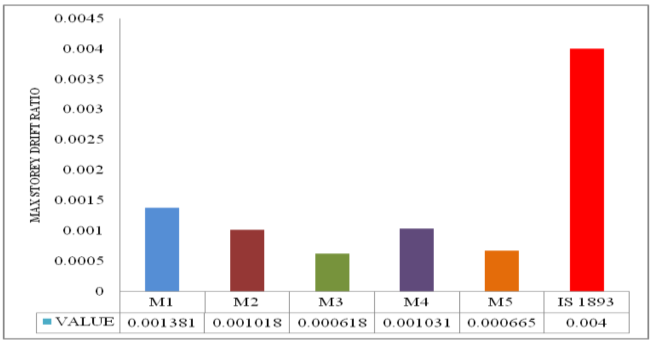

Chart -3: Maximum Storey Drift in X direction

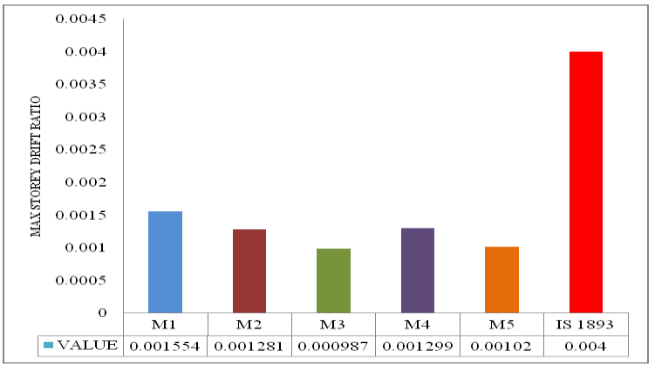

Chart -4: Maximum Storey Drift in Y direction

From the above tables and figures, concluded that drift ratio for all the modelsyis less than 0.004 which is the limiting value as per the cl.7.11.1.1 of IS 1893 Part 1 (2016).

4.3 Storey Stiffness

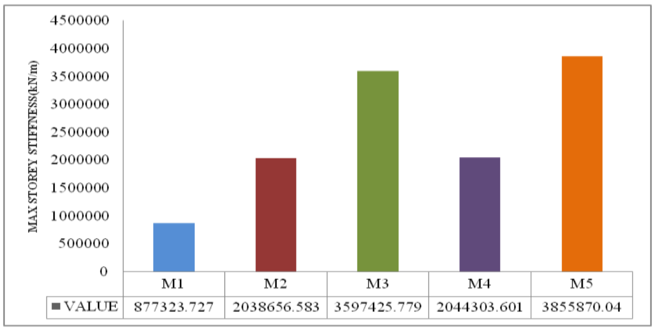

Chart -5: Maximum Storey Stiffness in X direction

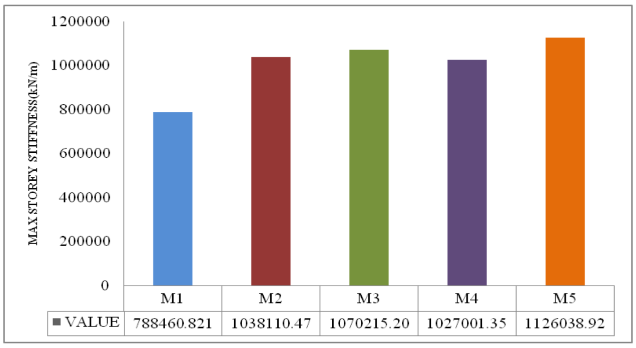

Chart -6: Maximum Storey Stiffness in Y direction

From the above tables and figures, concluded that maximum storey stiffness is observed for modal M5 in X direction and for modal M3 in Y direction, and minimum storey stiffness is observed for modal M1 in both X and Y directions.

4.4 Storey Shear

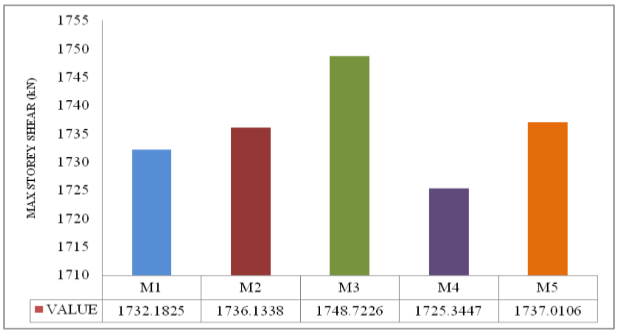

Chart -7: Maximum Storey Shear in X direction

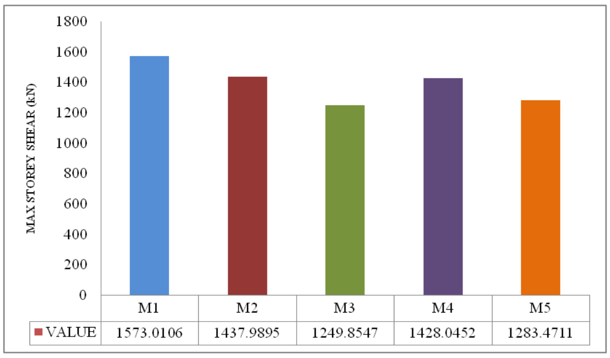

Chart -8: Maximum Storey Shear in Y direction

From the above tables and figures, concluded that maximum storey shear is observed for modal M3 in X direction and for modal M1 in Y direction, and minimum storey shear is observed for modal M4 in X direction and for modal M3 in Y directions

4.5 Time Period

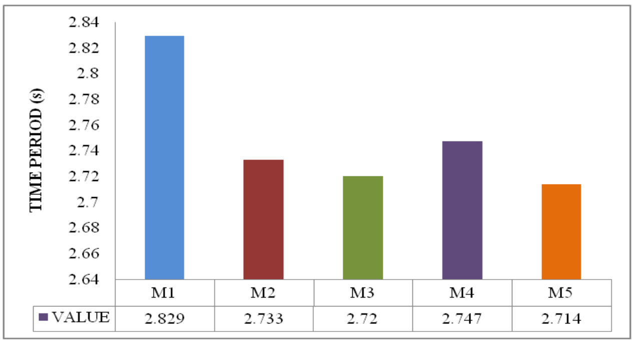

Chart -8: Maximum Time Period

From the table and figure it is observed that, modal M1 has maximum Time period and minimum time period value is observed for modal M5compared to all other models.

5. CONCLUSIONS

By observing the results obtained from RSA, the following are the main conclusions drawn.

1. Story displacement in model M3 is decreased by 51.6% in X direction and 34.12% in Y direction when compared to model M1. Storey displacement is maximum for modal M1 in both X and Y directions and displacement increases at successive storeys from base to the top storey.
2. Storey drift ratio for model M3 is decreased by 84.55% in X direction and 75.32% in Y direction compared to the limit specified in IS 1893 Part 1 (2016) i.e 0.004.
3. Different kinds of variation are observed in storey drift ratio in all the modals and in each storey. Maximum drift ratio is observed for modal M1.
4. Storey Stiffness in model M5 is increased by 339.50% in X direction and 42.81% in Y direction compared to the regular model M1. Storey stiffness decreases at successive storeys from base to the top storey.
5. Storey shear in model M3 is found to be increased by 0.95% in X direction and in Y direction there is 20.54% decrease in story shear compared to regular model M1. Storey shear decreases at successive storeys from base to the top storey.
6. Base shear value for model M3 is increased by 0.95% compared to regular modal M1 using RSA in X direction.
7. For all the models, base shear values are equal in both equivalent static analysis and RSA along X and Y directions.
8. For model M4, time period value is decreased by 2.9% compared to the regular modal M1.
9. Maximum time period value is observed for modal M1 and mode no.1 comparedzto all other models.

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