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Checking the Stability Criteria of Multi-Storied Building by Varying Opening Area Percentages in Shear Wall Used in Periphery with Seismic Zone III

Mr. Prashant Sharma[1], Dr. A. K. Dwivedi[2]
[1]*P. G. Student, Department of Civil Engineering, University Department, Rajasthan Technical University, Kota, (Rajasthan), India*
[2]*Professor, Department of Civil Engineering, University Department, Rajasthan Technical University, Kota, (Rajasthan), India*

Abstract: ***To decrease the overall cost of the project, it is highly recommended dropping the cost in different manners. To make economic structure, structure without losing the stiffness standards and the cost cutting should be done at every construction stages. The dual systems in building structure consist of structural walls and moment resisting frames. The walls are made up of RCC, which is expensive material. The purpose of current study is to discover the effect of reducing shear wall area in multi-storey building to decrease cost. The buildings are provided with shear walls to improve the lateral load resistance. Post parametric analysis results shows that, the reduction in shear wall area should be modified to a certain limit up to 20 % for cost cutting. But in this study, the opening areas of shear wall are increased above 20% to 36.75% and verify the results of post analysis. In this study 8 cases are analysed with 0%, 11%, 14.20%, 20%, 33.20%, 29.05%, 35%, & 36.75% opening in shear wall and analysis is perform by Response Analysis Method of dynamic analysis using Staad.pro V8i software in Zone III of multi-storey building (G+18). The effects of opening in the wall are studied by considering the moments, shear, and torsion, and axial forces in the beams and columns. It is observed that after a certain percentage of shear opening in walls the building fails in the drift at a certain height. To resolve this problem the flared area of height 0.5 m at the height of failure is provided to counteract the effect of drift. It was observed that by the introduction of shear belt the drift reduces which made the structure stable. Finally in this study, the opening of shear wall area is increased up to 35% and concrete area is reduced 1170.20 m^2, which is 534.2m^2 more than the previous studies.***

Keywords: Shear Wall, Opening Area, Multi-storeyed Building, Seismic effects, Response Spectrum Method

I. INTRODUCTION TO SHEAR WALL

The shear wall will devour shear forces and prevents the location-position of construction from changing and consequently destruction. But one thing must be given importance that the shear wall arrangement must be supremely accurate, if not the resultant will give a negative effect instead. The shear wall is made up of braced panels (shear panels) to counteract the effects of lateral loading acting on a structure.

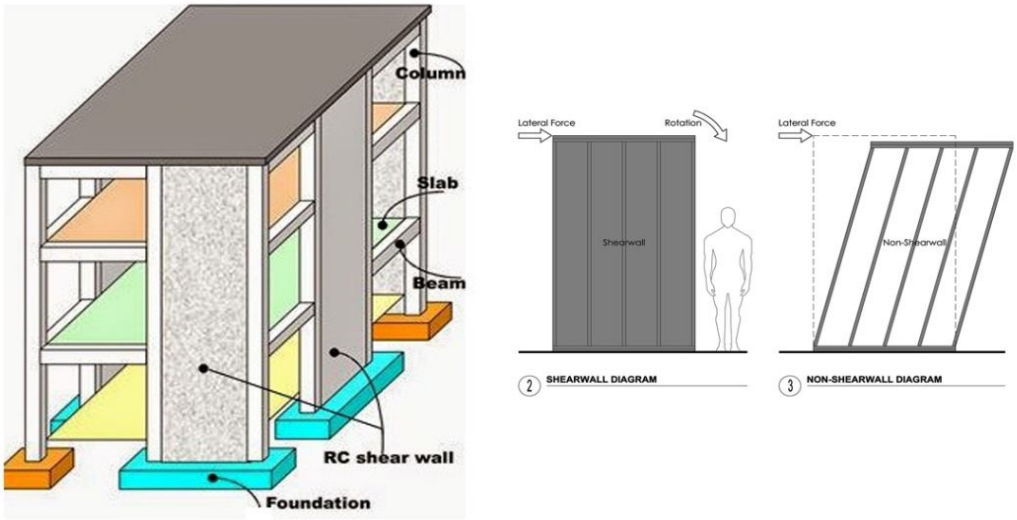

Fig. 1: Shear wall in Building

Seismic loads and wind are among the most common loads that shear walls can withstand. When a shear wall is built, it is created in the form of a line of heavily braced, reinforced panels. This is why they are also known as braced wall lines in some region. The wall seamlessly connects two exterior walls and reinforces other shear walls in the structure. Bracing is accomplished with heavy beams and metal brackets or support beams that keep the wall firm and strong. Shear walls are now a vital part of mid and tall buildings. For a building to be an earthquake resistant design, these walls are placed in the planes of the building which reduces lateral displacements under seismic loads. In this way shear wall frame structures are achieved. The shear wall is taken in different forms and types under reinforced materials such as Simple rectangular, Coupled, Rigid frame, Framed walls with infill frame, Column supported, Core type shear wall.

II. OPENING CONCEPT OF SHEAR WALL

Cantilever shear walls always act as coupled shear walls consist of openings and have connected with coupling beams. Multi-storeyed buildings may have openings in rows which is essential for doors, ventilations, openings and windows in both internal and external walls. As per architectural point of view, the opening has provided. This opening has to be decided within the limit to secure the structural resisting components by adverse seismic effects.

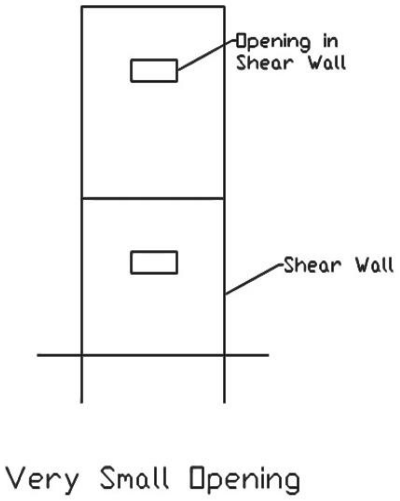

Fig. 2: Frame having very small opening of Shear wall

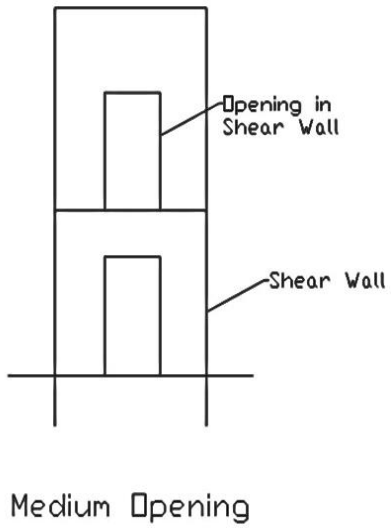

Fig. 3: Frame having medium opening of Shear wall

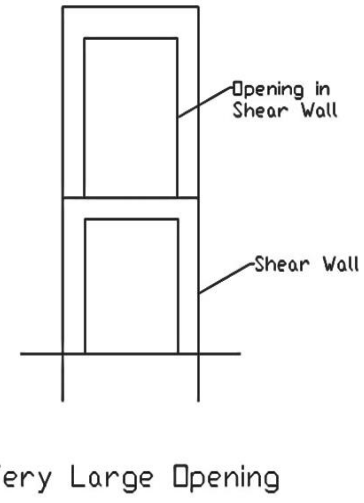

Fig. 4: Frame having very large opening of Shear wall

III. OBJECTIVES

To check the stability criteria of multistorey building, following objectives have been selected:-

A. To study the various cases of opening in shear wall and comparing them by using Response Spectrum Method of dynamic analysis using Staad.pro software.
B. To calculate Maximum displacement, Base Shear and Drift values and then comparing all the cases.
C. To explore the possibilities of overall structural resistance by minimal use of shear wall area.
D. To determine maximum Axial Forces in columns at ground level for various cases.
E. To study the variation of maximum Bending Moments & Shear Forces in columns of all cases for multi-storeyed buildings.
F. To study and compare maximum Bending Moments & Shear Forces in beams along X and Z direction.
G. To evaluate maximum Torsional Moments in beams along X and Z directions.

IV. METHODOLOGY AND MODELLING

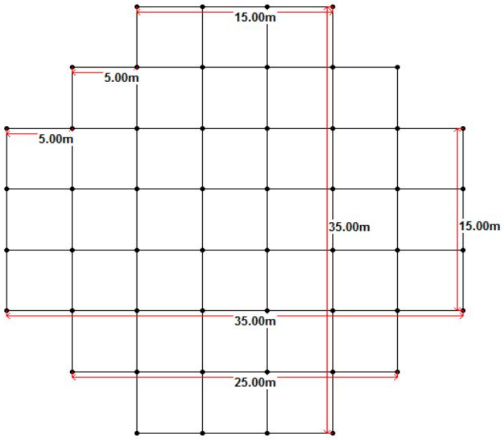

Fig. 5: Plan of all structures

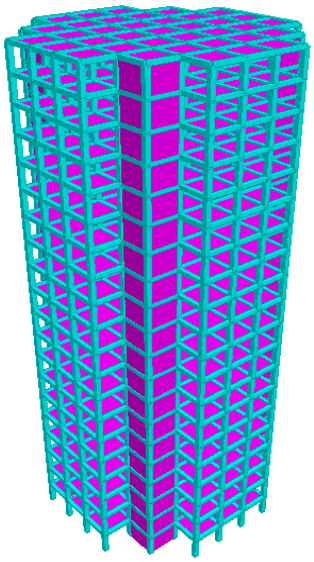

Fig. 6: Case WO1: - (Bay size = 5 m x 4 m & shear wall opening area = 0%)

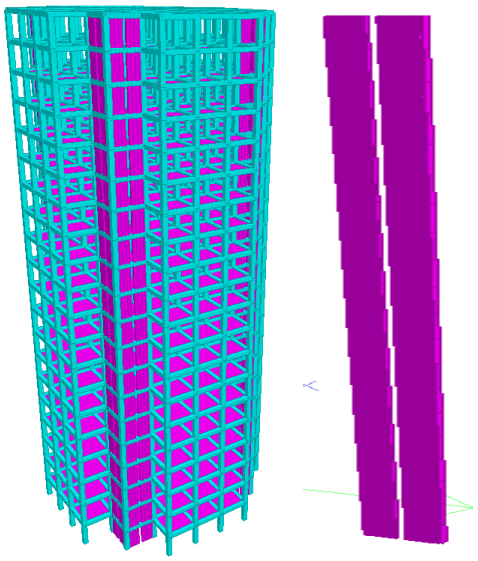

Fig. 7: Case WO2: - (Bay size = 5 m x 4 m & shear wall opening area = 0.55 m x 4 m (11%))

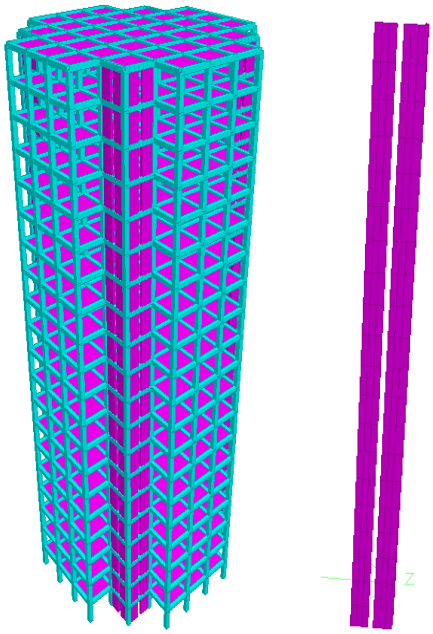

Fig. 8: Case WO3: - (Bay size = 5 m x 4 m & shear wall opening area = 0.71 m x 4 m (14.2%))

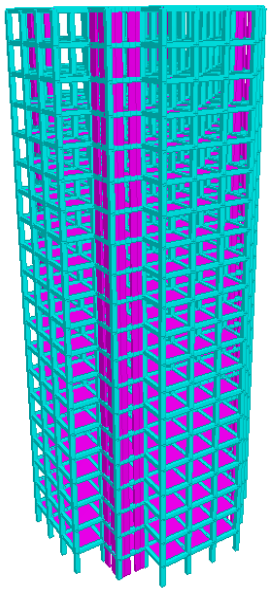

Fig. 9: Case WO4: - (Bay size = 5 m x 4 m & shear wall opening area = 1 m x 4 m (20%))

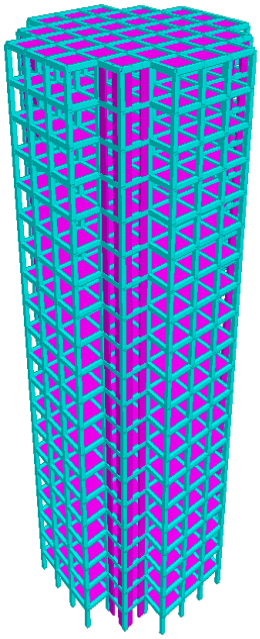

Fig. 10: Case WO5: - (Bay size = 5 m x 4 m & shear wall opening area = 1.66 m x 4 m (33.20%))

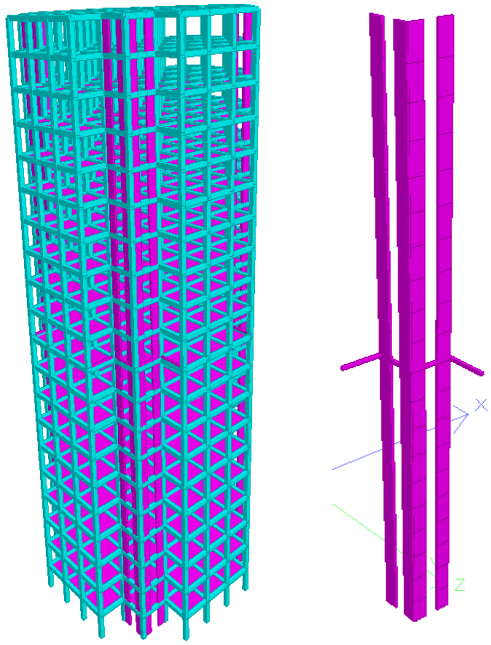

Fig. 11: Case WO5a: - (Bay size = 5 m x 4 m & shear wall opening area = 1.66 m x 3.5 m (29.05%))

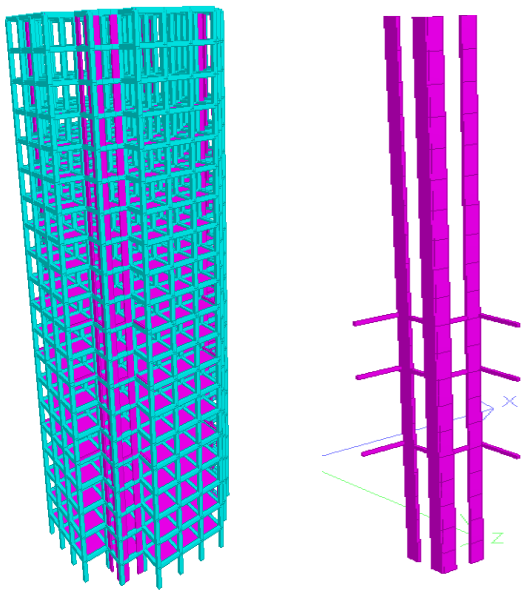

Fig. 12: Case WO6: - (Bay size = 5 m x 4 m & shear wall opening area = 2 m x 3.5 m (35%))

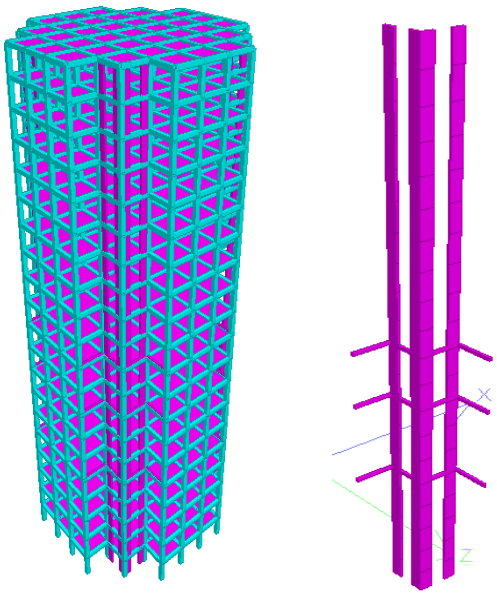

Fig. 13: Case WO7: - (Bay size = 5 m x 4 m & shear wall opening area = 2.10 m x 3.5 m (36.75%))

Table 1: Data taken for analysis of structure

Constraint	Assumed data for all buildings
Soil type	Medium Soil
Seismic Zone	III
Response reduction factor (Ordinary shear wall with SMRF)	4
Importance factor (For all semi Commercial & Residential building)	1.2
Damping ratio	5%
Fundamental natural time period of vibration (Ta)	0.09*h/(d)0.5
Plinth area of building 925 sq. m	925 sq. m
Floors configuration	G + 18
Height of building	79.50 m
Floor to floor height	4 m
Depth of foundation	3.5 m
Beam Size	550 mm x 600 mm
Column Size	650 mm x 700mm
Slab thickness	180 mm
Shear wall thickness	280 mm
Material properties	M 30 Concrete
Method used for Seismic Analysis	Response Spectrum Method
Moment of Inertia Reduction Factor	For Columns 70% (0.70) For Beams 35% (0.35)

V. RESULT ANALYSIS

The result parameters obtained by the application of loads and their combinations on various cases as per Indian Standard 1893: 2016 code of practice. Result of each parameter has discussed with its representation in graphical form below:-

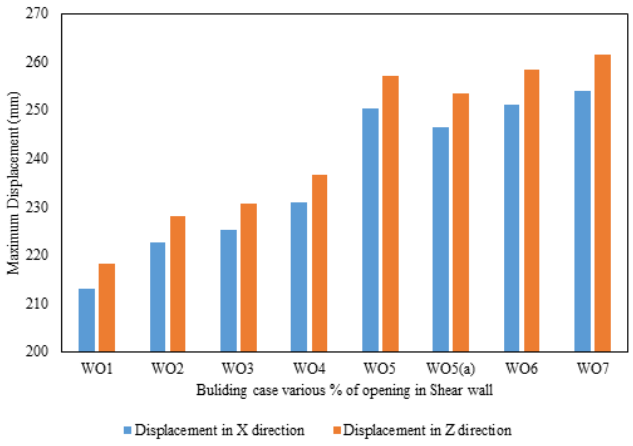

Fig. 14: Bar Chart for Displacement in X and Z directions

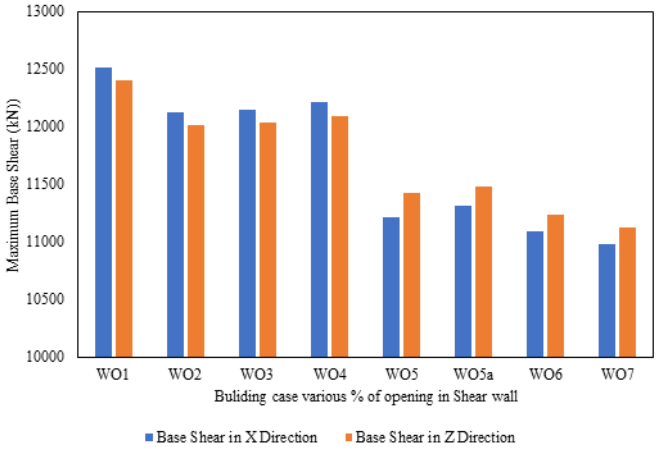

Fig. 15: Bar Chart for Base Shear in X and Z direction

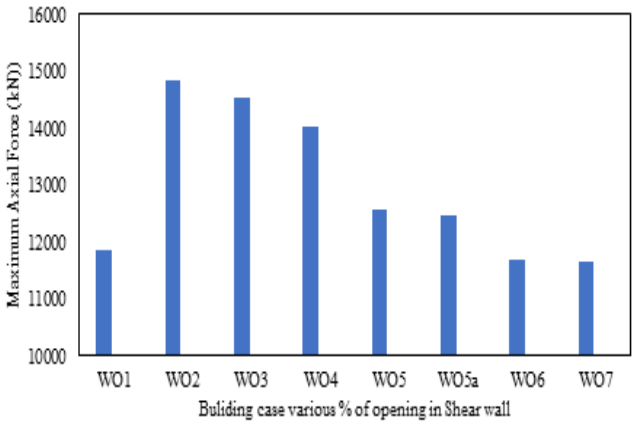

Fig. 16: Bar Chart for Maximum Axial force in Column

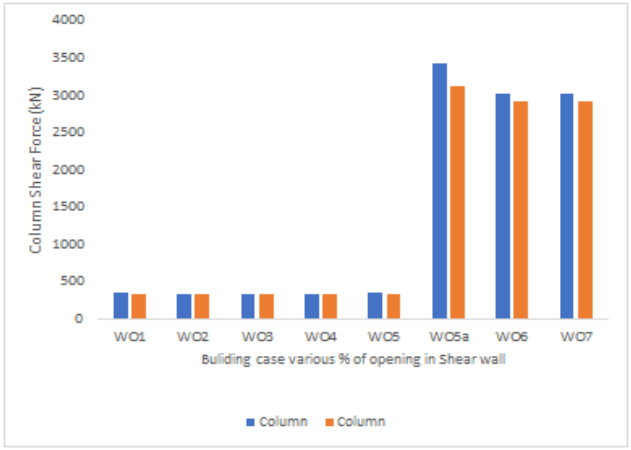

Fig. 17: Bar Chart for Maximum Shear force in Column

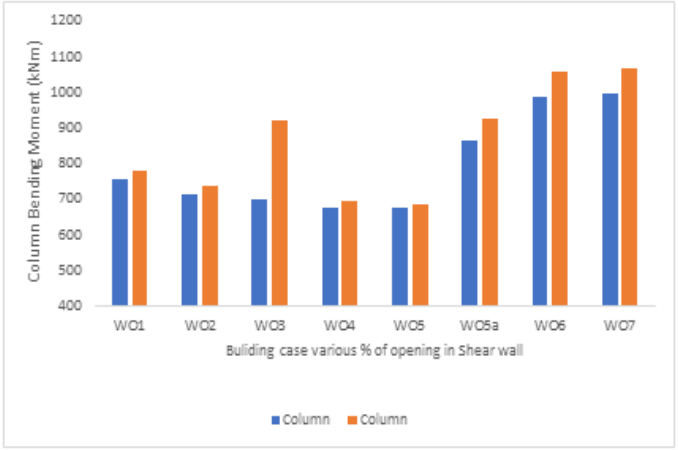

Fig. 18: Bar Chart for Maximum Bending moment in Column

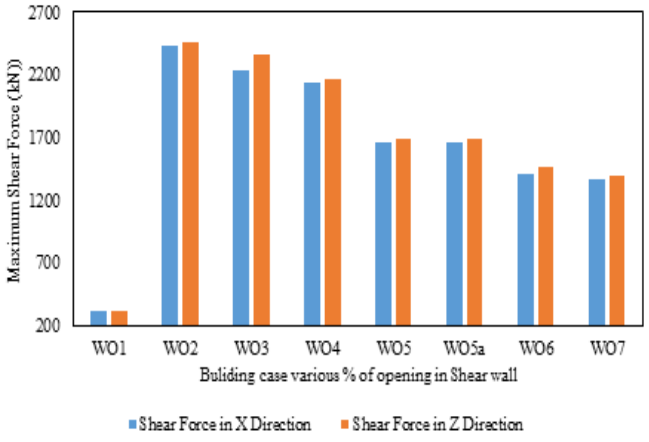

Fig. 19: Bar Chart for Maximum Shear force in Beam

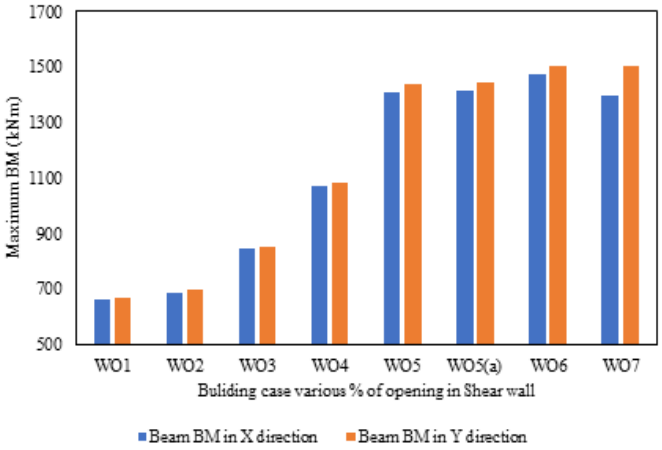

Fig. 20: Bar Chart for Maximum BM in Beam

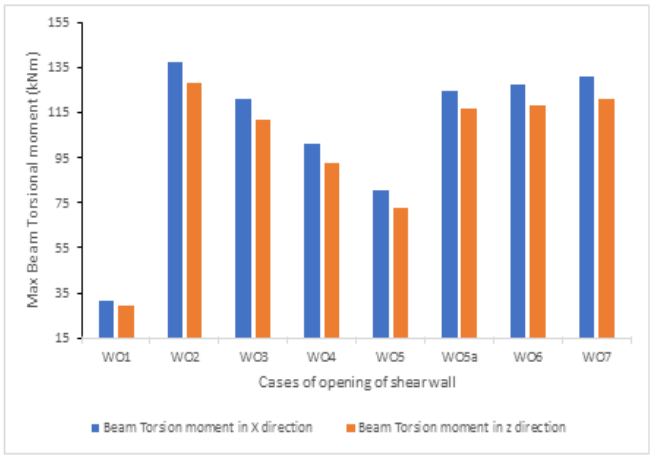

Fig. 21: Bar Chart for Beam Max Torsion Moment

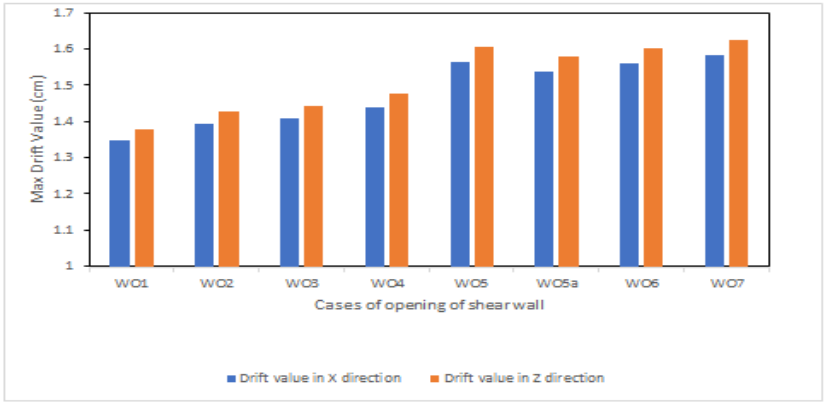

Fig. 22: Bar Chart for Max Drift Value

A. Discussions

After analysis perform on all cases then conclusion is following below:

1) The Displacement values increase proportionally with shear wall opening area increases. In this study, the displacements continuously increases up to case 5 (WO5), after case 5 shear wall area is increases but the displacement comparatively decreases.

2) The Base Shear value decreases inversely with the shear wall opening area increases. The Base Shear value is maximum in case 1 and minimum in case 8. When the opening area of shear wall is increases then the Base Shear value decreased.

3) The Axial Force in column initially increases up to case 2. After that the value of Axial force decreases inversely with the shear wall opening area increases. When opening area of shear wall is increased then the Axial Force in column is decreased.

4) The Shear Force in column is not vary up to case 5. But when the flared area used (in case 6-8) then the Shear Forces in Column rapidly increases.

5) The Bending Moment in column is mostly constant up to case 5 (minor variation shows). But in case 6 to 8 the Bending Moment in column increases.

6) The Maximum Shear force in Beam is initially increases in case 1 & case 2. After that the Maximum Shear Force in beam are decreased continuously.

7) The maximum Bending Moment in Beam increases proportionally with the shear wall area is increased. The Maximum Bending Moment in Beam values are increasing with the shear wall opening area.

8) The Maximum Torsional Moment in Beam initially increases in case 1 & case 2 and after that decrease up to case 5 and again increases with shear wall opening is increased. The Maximum Storey Drift increases proportionally to the shear wall opening area.

VI. CONCLUSION

In this research work, various percentage openings in shear wall are used to reduce the cost for making the economic structure. Based on which following conclusions are made.

1) The case WO5 fails in drift (according to IS L/250) at 39.5 m height when 33.20% opening in shear wall is provided then the flared area (shear belt) of height 0.5 m at a height of 39.5 m is provided to counteract the effect of drift in case WO5a.
In the cases WO6 & WO7, the flared area of height 0.5 m at height of 20 m, 31.5 m & 39.5 m are provided but the case WO7 fails in Drift. The opening in shear wall of 35% greater is not provided.

2) Displacement in both X and Z direction increases and when it cross the limit of 35%, the structural components fails and it needs increase in dimension. Building WO6 will be economical.

3) Base shear values decreases as the weight of the structure decreases when cutting the percentage area of shear wall. For this, in both X and Z directions, building WO6 shows the best parametric values at 35 % shear wall opening.

4) Shear forces in column in both Y and Z direction increase with reduction in Shear wall area, the members fail beyond building WO6 values. Hence building SD shows the safest values for shear forces in column.

5) The Moment values in column decreases from building WO1 to WO7 and beyond building WO6, the member fails. Hence building WO6 shows the safest values for bending moment in columns.

6) Beam in both X and Z direction shows least values of shear forces in building WO6 and beyond this, the beam fails.

A. Scope of the Future Work

The future scope of this research work, the flared area similarly used where the lateral force acting more efficiency in high earthquake zone. The shear wall constructed at the lift core where use the flared area (shear belt) for providing more stiffness and reducing the concrete area.

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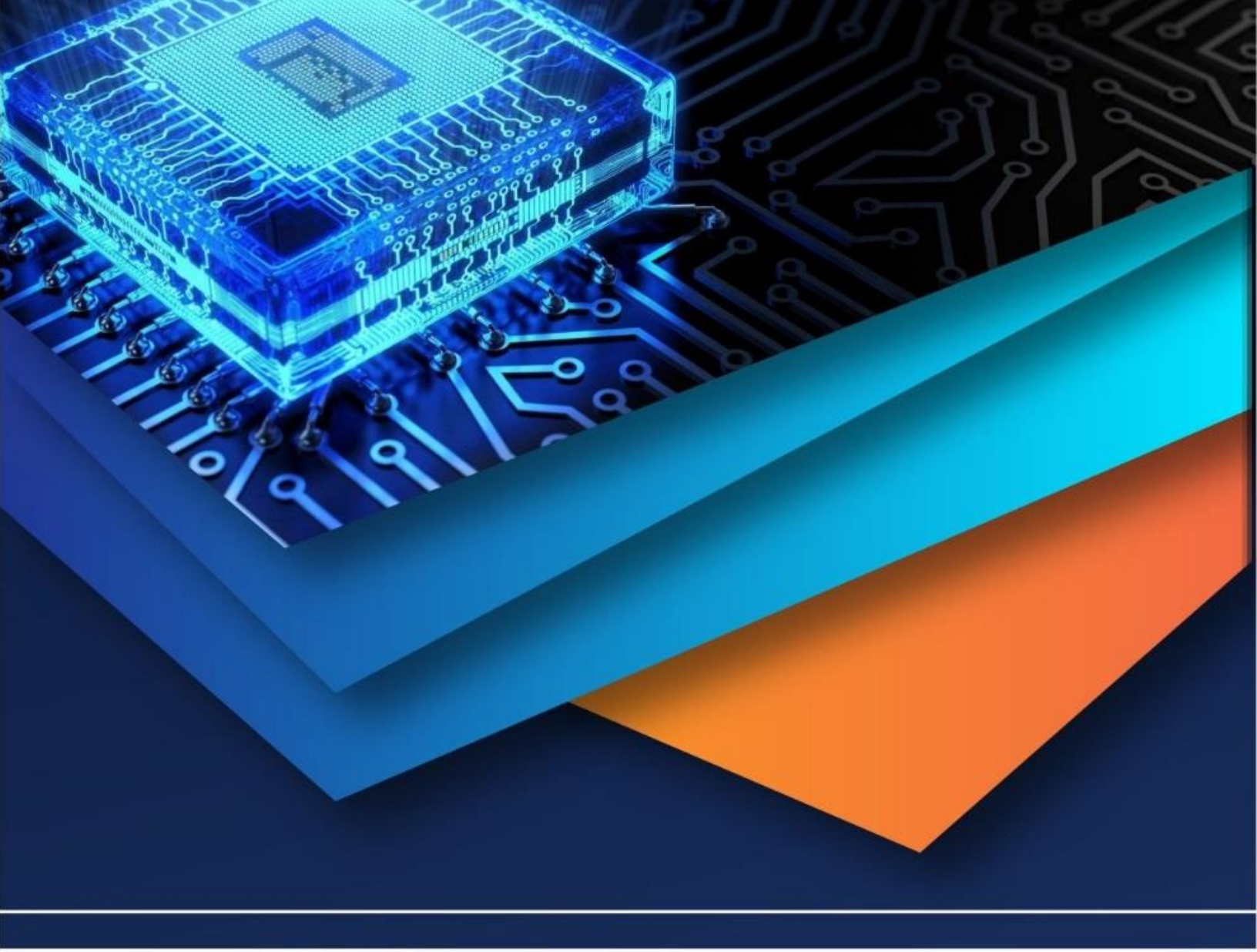

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