Opening Area Effect of Shear Wall in Multistorey Building under Seismic Loading

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Abstract— *To reduce the overall cost of the project, it is highly recommend reducing the cost in different manner. To make economic structure, the cost cutting should be done in 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 a costly material used. The purpose of current study is to explore the reduction in shear wall area in multistorey building to reduce cost. Total 5 buildings framed in Staad pro software abbreviated as SA, SB, SC, SD, SE supposed to be situated at Seismic Zone III. Post parametric analysis results shows that, the reduction in shear wall area should be adapted to a certain limit up to 20 % for cost cutting.*

Keywords— *Deduction Area, Earthquake Effects, Opening Area, Shear Wall, Response spectrum, Wall Area Reduction, Wall Deduction Ratio.*

I. INTRODUCTION TO SHEAR WALL

The shear walls are designed not only to stand firm against gravity or vertical loads (loads due to its self-weight and other living/ moving loads), but also from lateral loads of winds and earthquakes. The walls are structurally incorporated with floors/roofs and other lateral walls running crossways at right angles, thereby giving all the three dimensional stability to the building.

The walls have to resist the uplift forces due to the pull of wind. It has to resist the force that aim to push the walls over. The walls also have to resist lateral forces of wind that try to push the walls in and drag them away from the building. Shear walls are quick to build as the method implemented for construction is concreting the members using the formwork. The walls do not need extra finishing or plastering.

II. CLASSIFICATION OF SHEAR WALL

There are many types of reinforced concrete shear walls:-
1. Simple rectangular type shear wall
2. Coupled shear wall
3. Rigid frame shear wall
4. Framed walls with infill frame
5. Column supported shear wall
6. Core type shear wall

III. CONCEPT OF OPENING IN SHEAR WALL

Cantilever shear walls always act as coupled shear walls consist of openings and have connected with coupling beams.

Multistoried buildings may have openings in rows which are essential for doors, ventilations, openings and windows in both internal and external walls.

As per architectural point of view, the opening has provided.

As per structural engineering point of view, the opening has to be decided within the limit to secure the structural resisting components by adverse seismic effects.

Shear walls are especially important in high-rise buildings subject to lateral wind and seismic forces. Generally, shear walls are either plane or flanged in section, while core walls consist of channel sections.

Opening in shear wall can be provided in:-
1. Structure generally provided with any type of shear walls.
2. Structure generally provided with Shear walls around lift areas.
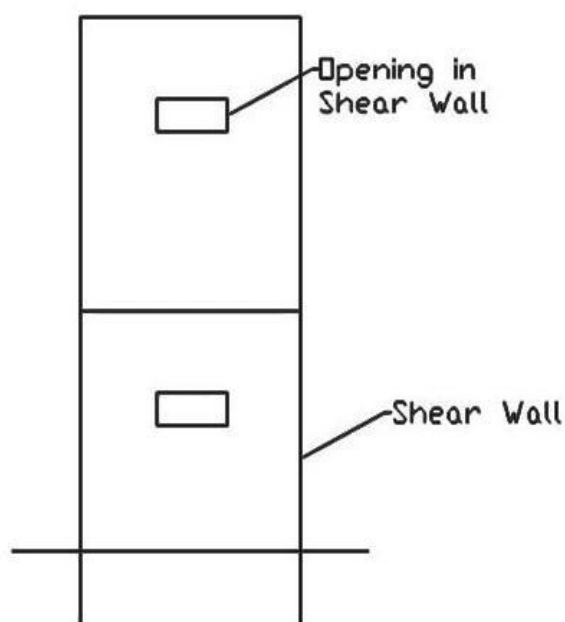3. Shear wall components in Dual System buildings.

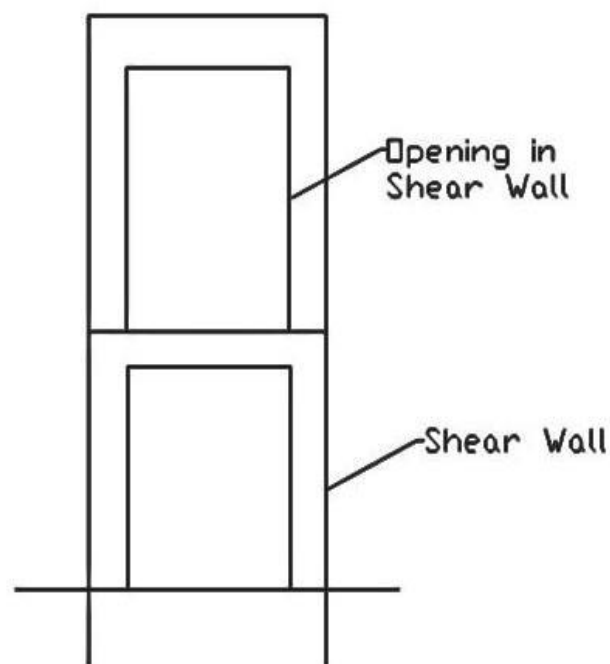*Fig. 1: Frame having very small opening of Shear wall*
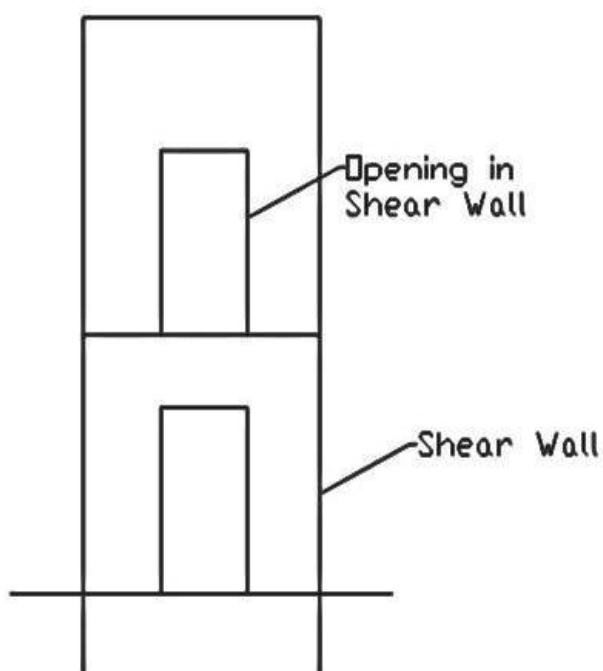

Fig. 2: Frame having medium opening of Shear wall

Fig. 3: Frame having very large opening of Shear wall

To counteract the seismic forces and to maintain the rigidness of the structure, outriggers and belt supported system is used.

IV.   OBJECTIVES OF THE PRESENT STUDY

1. Use of response spectrum method in with and without opening dual configuration multistoried structure.
2. To take five different buildings, comparing them among each other by using Response Spectrum Method of dynamic analysis using Staad pro software.
3. To calculate maximum displacement and drift values and then comparing all the 5 buildings.
4. To compare base shear, time period along with mass participation factor shows dynamic response result of the 5 dual configuration buildings.
5. To explore the possibilities of overall structural resistance by minimal use of shear wall area.
6. To determine maximum Axial Forces and Shear Forces in columns at ground level for various buildings.
7. To show the variation of maximum Bending Moments in columns for all five multistoried buildings.
8. To investigate maximum Shear Forces in beams parallel to X and Z direction.
9. To study and compare maximum Bending Moments in beams along X and Z direction.

10. To evaluate maximum Torsional Moments in beams along X and Z directions.

To obtain the best building with opening threshold criteria, all buildings are thoroughly observed and compared their parametric values.

V.   LIST OF MODELS FRAMED FOR ANALYSIS OF STRUCTURE

Various models are framed for analysis and assessment of structure to accomplish the aforesaid objectives of the current study.

Table 1: List of buildings framed with assigned abbreviation

S. No.	Buildings framed for analysis when Shear Wall used at corners	Abbreviation
1.	Building with 100 % shear wall area used	SA
2.	Building with 88.88 % shear wall area used	SB
3.	Building with 85.80 % shear wall area used	SC
4.	Building with 80 % shear wall area used	SD
5.	Building with 66.66 % shear wall area used	SE

Table 2: List of buildings with used and deducted Shear Wall area

S. No.	Abbrev-iation	Wall Deduction Ratio	Bay Size	Deduction Area (L x B)	Percentage Deduction
1.	SA	-	5 m x 4 m	0 m x 0 m	0 %
2.	SB	5 / 9	5 m x 4 m	0.55 m x 4 m	11.11 %
3.	SC	5 / 7	5 m x 4 m	0.71 m x 4 m	14.28 %
4.	SD	5 / 5	5 m x 4 m	1 m x 4 m	20 %
5.	SE	5 / 3	5 m x 4 m	1.66 m x 4 m	33.33 %

VI.   DESCRIPTION OF SEISMIC PARAMETERS TAKEN FOR ANALYSIS

Table 3: Data assumed 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 building)	1.2
Damping ratio	5%
Fundamental natural period of vibration (Ta)	$0.09*h/(d)^{0.5}$
Plinth area of building	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 sizes	550mm X 600mm
Column sizes	650mm X 700mm
Slab thickness	180 mm (0.18 m)
Shear wall thickness	280 mm (0.28 m)
Material properties	M 30 Concrete
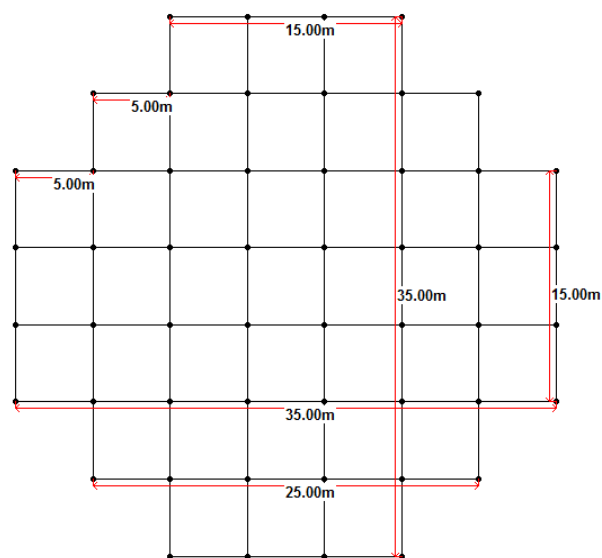
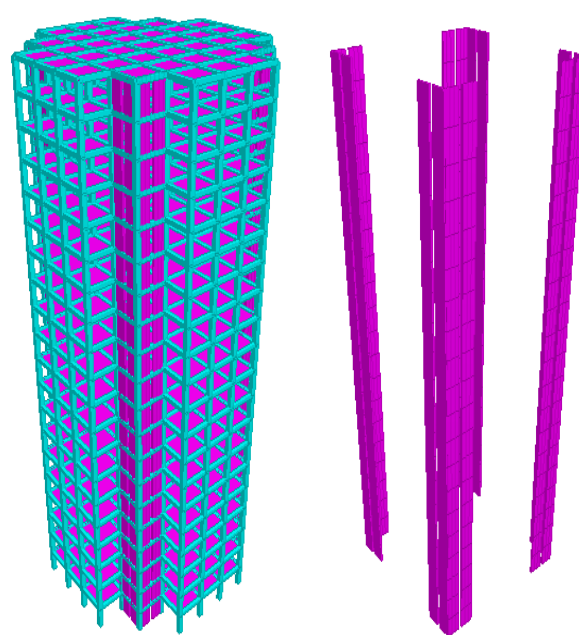*Fig. 4: Plan of all buildings*
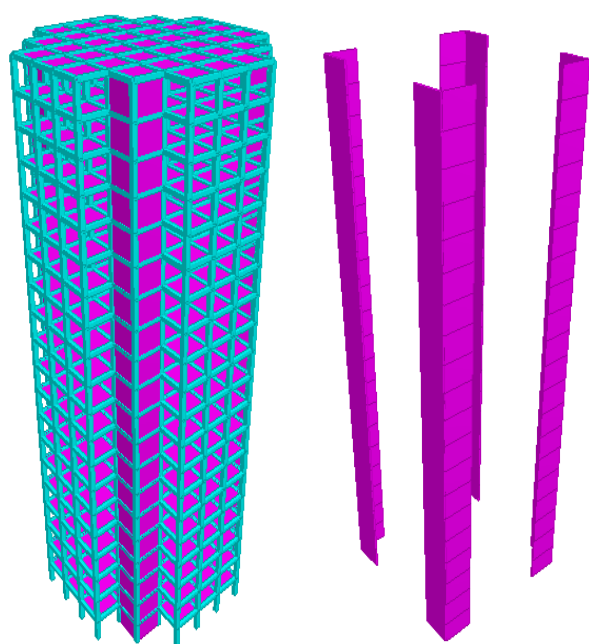
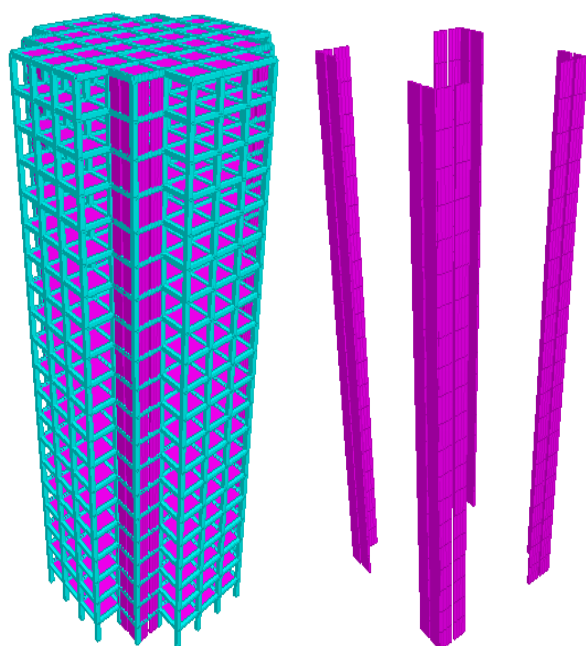(a)   (b)

Fig. 5: (a) 3- D view of building SA: Shear wall with no opening
(b) Shear wall without opening

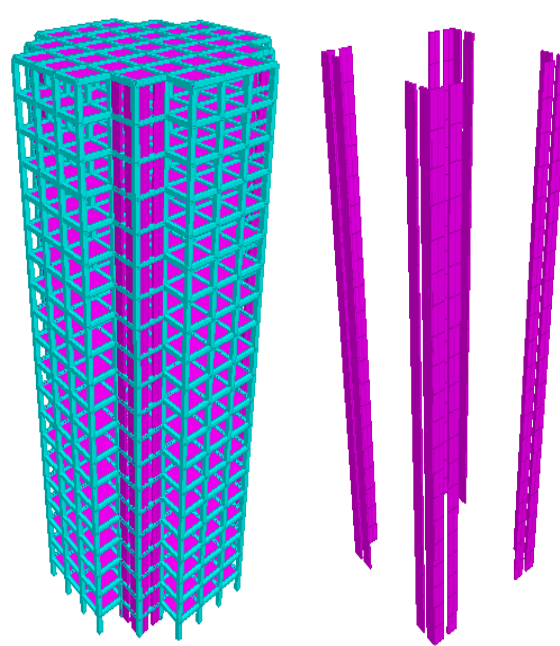(a)   (b)

Fig. 7: (a) 3- D view of building SC: Shear wall with no opening
(b) Shear wall with 14.28 % opening

(a)   (b)

Fig. 6: (a) 3- D view of building SB: Shear wall with opening
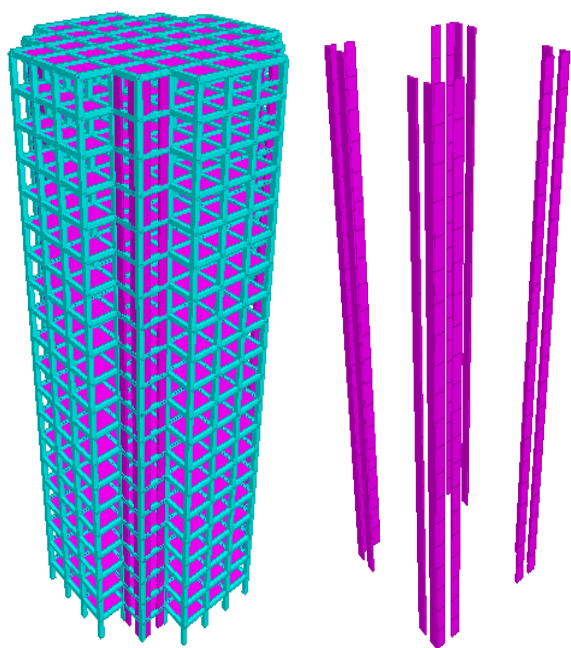*(b) Shear wall with 11.11 % opening*

(a)   (b)

Fig. 8: (a) 3- D view of building SB: Shear wall with opening
*(b) Shear wall with 20 % opening*

Fig. 9: (a) 3- D view of building SB: Shear wall with opening
(b) Shear wall with 33.33 % opening

VII.   RESULTS ANALYSIS

For the stability of the structure, parameters such as the nodal displacement in both seismic directions, storey drift in both seismic directions, beam stress values, time period and mass participation factors obtained by application of loads and their combinations on various cases of the multistorey building. Tabular result of each parameters and its optimal case is discussed with its graphical form below:-
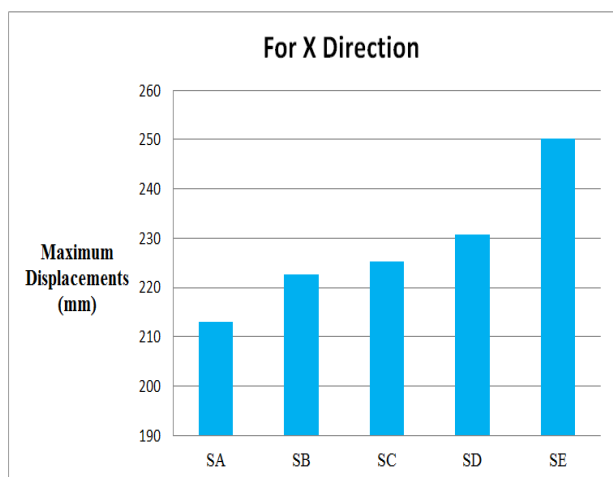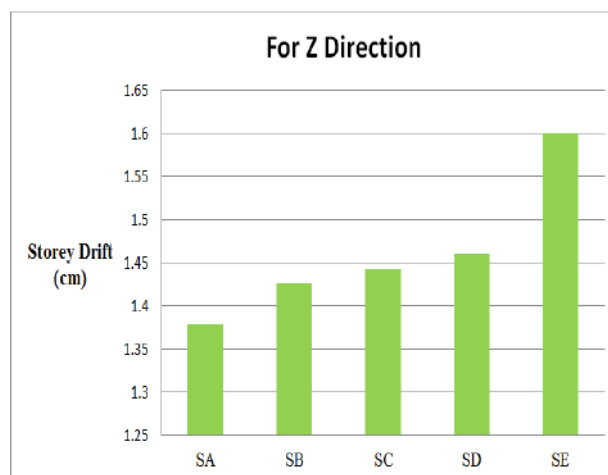

Graph 1: Maximum Displacement in X direction for all 5 Buildings in Zone III
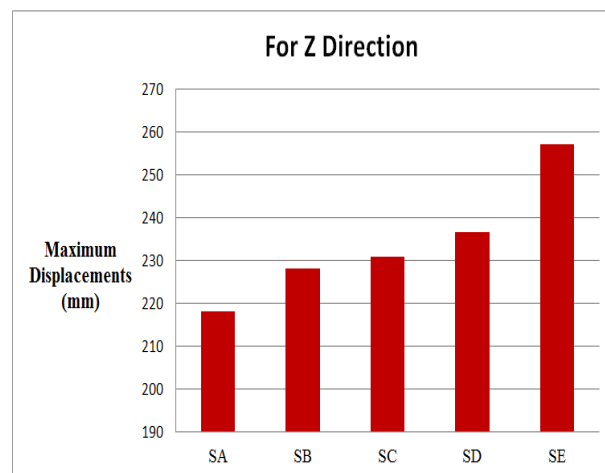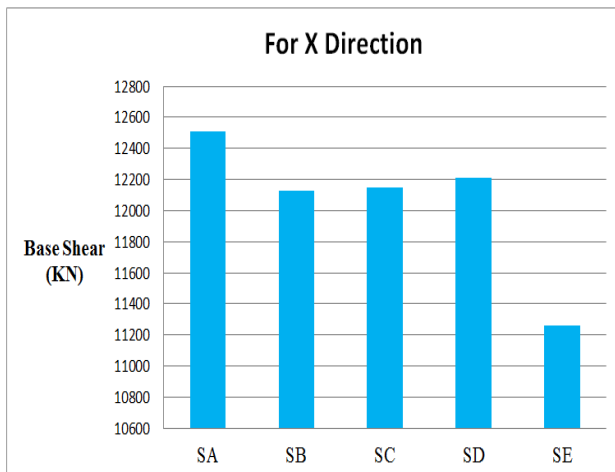

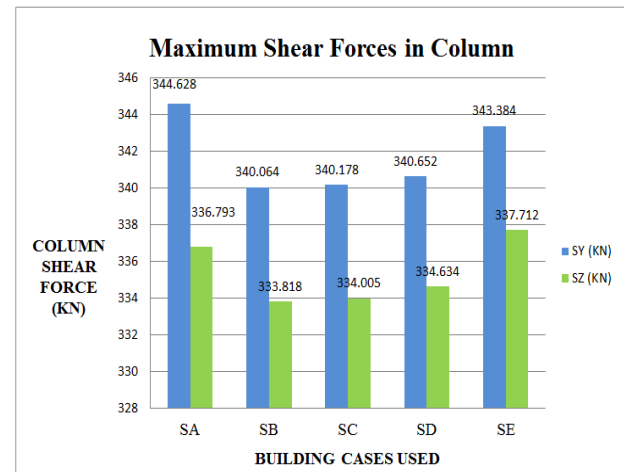*Graph 2: Maximum Displacement in Z direction for all 5 Buildings in Zone III*
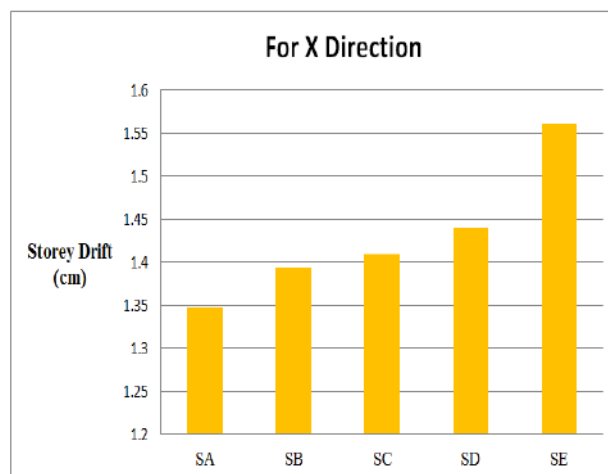
Graph 3: Storey Drift in X direction for all 5 Buildings in Zone III
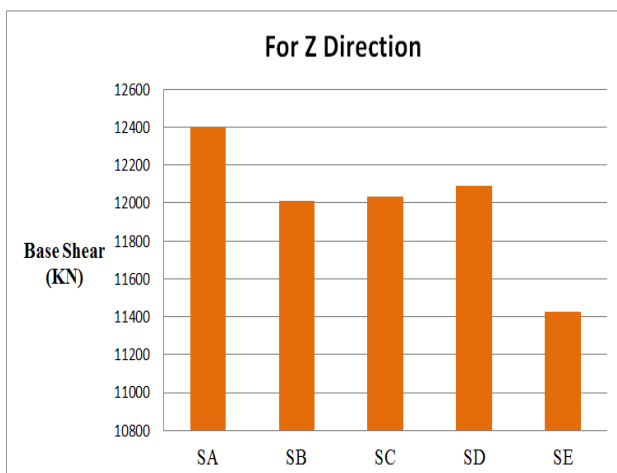

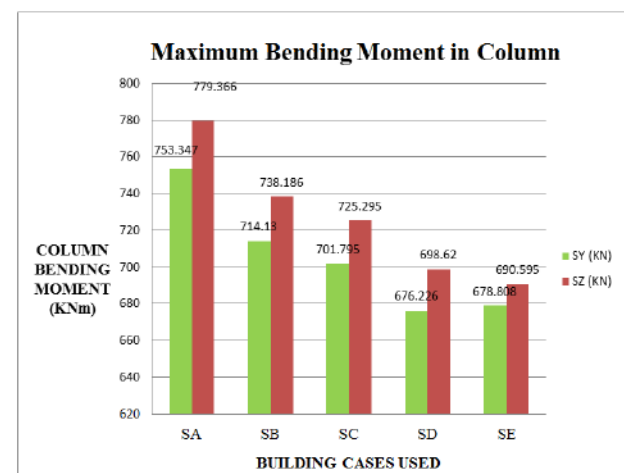*Graph 4: Storey Drift in Z for all 5 Buildings in Zone III*

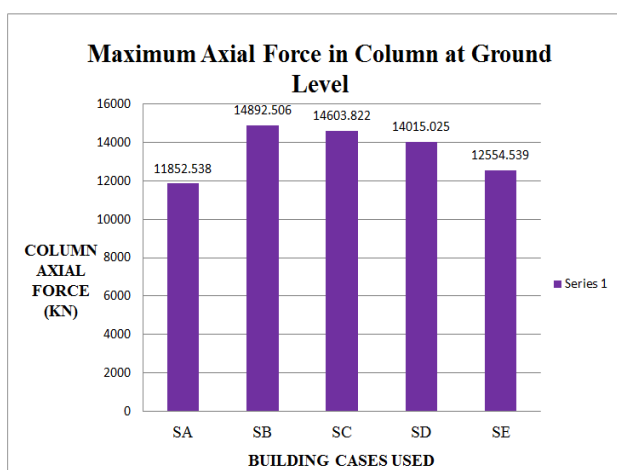*Graph 5: Base Shear in X direction for all 5 Buildings in Zone III*

Graph 8: Maximum Shear Forces in Columns for all 5 Buildings in Zone III
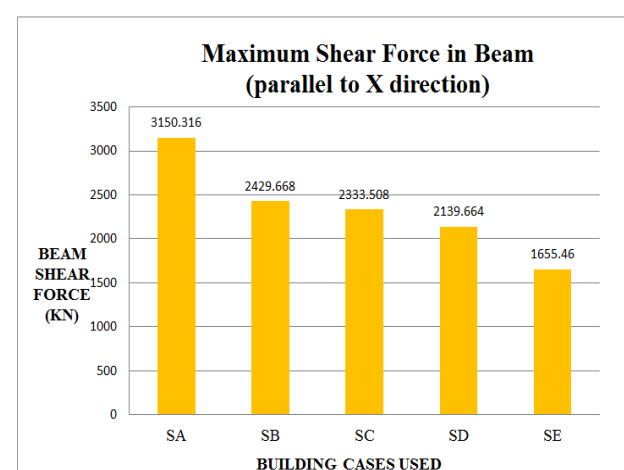

Graph 6: Base Shear in Z direction for all 5 Buildings in Zone III
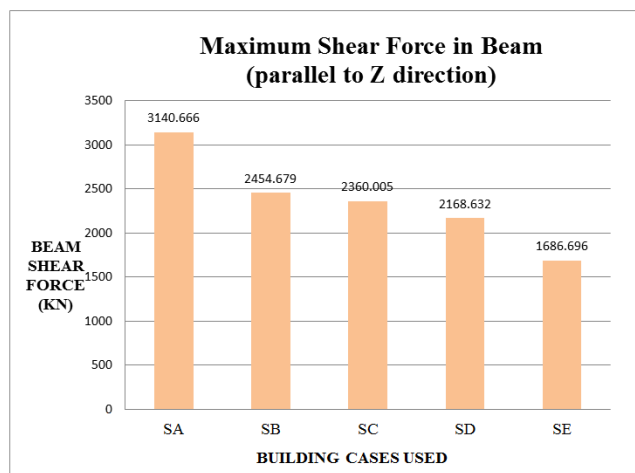

Graph 9: Maximum Bending Moment in Columns for all 5 Buildings in Zone III
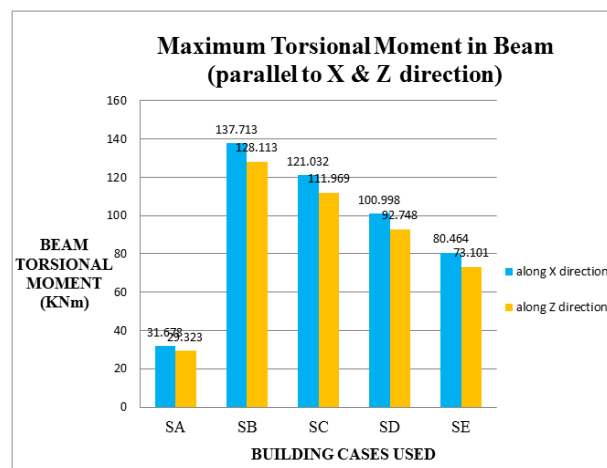

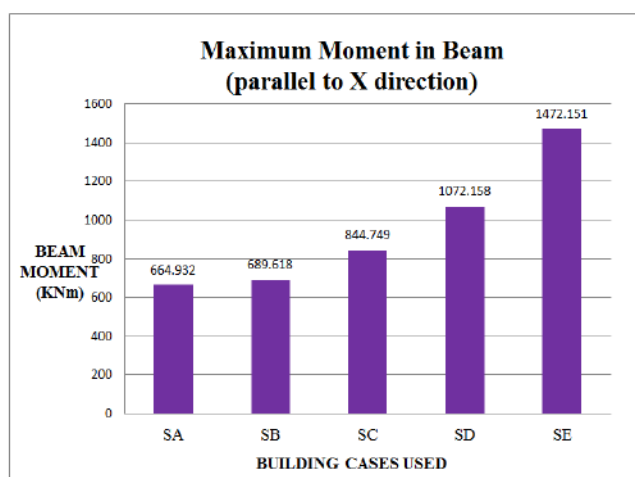*Graph 7: Maximum Axial Forces in Column at ground level for all 5 Buildings in Zone III*

Graph 10: Maximum Shear Forces in beams parallel to X direction for all 5 Buildings in Zone III
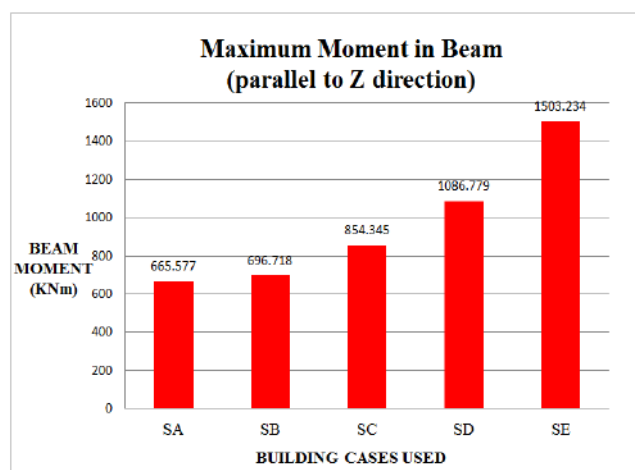
Graph 11: Maximum Shear Forces in beams parallel to Z direction for all 5 Buildings in Zone III

Graph 12: Maximum Bending Moment in beams parallel to X direction for all 5 Buildings in Zone III

Graph 13: Maximum Bending Moment in beams parallel to Z direction for all 5 Buildings in Zone III

Graph 14: Maximum Torsional Moment in beams parallel to X & Z direction for all 5 Buildings in Zone III

VIII.   CONCLUSION

1. Displacement in X direction and Z direction increases and when it crosses the limit of 20 %, the structural components fails and it needs increase in dimension. Building SD will be economical.

2. The Storey Drift will behave same as displacements in both X and Z directions, first it shows incremental values and at certain height, it again decreases. Indian Standardization limit is L/250 i.e. 0.004, when applied to the structure, all buildings behaves safe except SE, fails from 35.5 m height. For this parameter, building SD will be safe and efficient.

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 SD shows the best parametric values at 20 % shear wall opening.

4. Values of Maximum Axial forces in column decreases when shear wall area decreases, but column fails when axial force values are lower beyond 14015.025 KN limit and therefore building SD shows the safest value for axial forces.

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

6. The Moment values in column decreases from building SA to SE and beyond building SD, the member fails. Hence building SD shows the safest values for bending moment in columns.

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

8. For moments in beam in both X and Z direction, the values increases gradually and beyond the limit, it seems that up to building SD, the structural components are safe and beyond this, the beam fails.

9. Torsion in beam shows limiting parametric values up to building SD when there will be deduction in shear wall area.

Total 5 different buildings used in this work. The main focus in this work is to show how the values differ from each other when decreasing the shear wall area.

It is found from above study that when there will be excess use of opening beyond the 20 % limit, the stiffness of the structure will be less and the structural components will fail. Due to load transfer criteria of the members 20 % wall deduction is sufficient. Building SD with 80% coverage performs best of all.

ACKNOWLEDGEMENT

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