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Comparative Parametric Analysis of Opening Area Usage of Shear Wall in Different Percentages Relating to Wall Area Used for Multistorey Building

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***Abstract:** It is highly recommend that the structure should be efficient in terms of the cost in diverse manner. To reduce the overall cost of the project, 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 structural wall members are made up of RCC, which is a costly structural member. The purpose of current study is to explore the reduction in shear wall area in multi-storey building for reduction of overall project cost. Total 5 buildings abbreviated as SOA, SOB, SOC, SOD and SOE framed in analytical software supposed to be situated at Seismic Zone III. After the comparative result analysis, it proves that, the reduction in shear wall area should be adapted to a certain limit due to load transfer criteria of the members 20 % wall deduction is sufficient. Building SOD with 80% coverage performs best of all.*
***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.

II. CLASSIFICATION OF SHEAR WALL

There are many types of reinforced concrete shear walls:-

Table 1: Various types of shear wall as per current scenario

Type 1	Simple rectangular type shear wall
Type 2	Coupled shear wall
Type 3	Rigid frame shear wall
Type 4	Framed walls with infill frame
Type 5	Column supported shear wall
Type 6	Core type shear wall

III. CONCEPT OF OPENING IN SHEAR WALL

When provisions of opening in Shear wall has allotted, the Cantilever shear walls act as coupled shear walls and have connected with coupling beams. 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 is the first part. The second part consist of architectural point of view, the multi-storeyed buildings may consist of openings in rows which are essential for indoor lightening and with green building concepts in both internal and external walls.

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. The walls do not need extra finishing or plastering. Opening in shear wall can be provided in:-

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Table 2: Various concepts of building as per previous reviews

Concept 1	Structure generally provided with any type of shear walls.
Concept 2	Shear wall components in Dual System buildings.
Concept 3	Structure generally provided with Shear walls around lift areas.

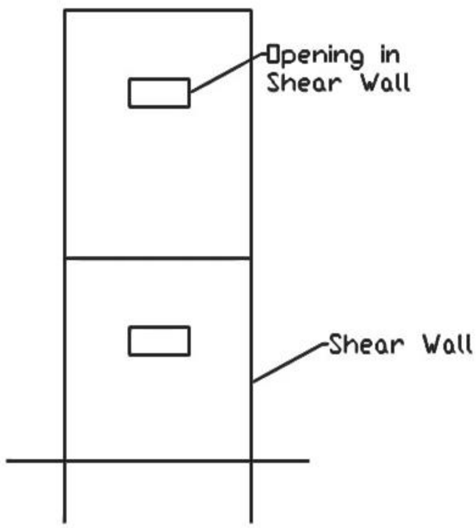

Fig. 1: Frame with Shear wall having very small opening

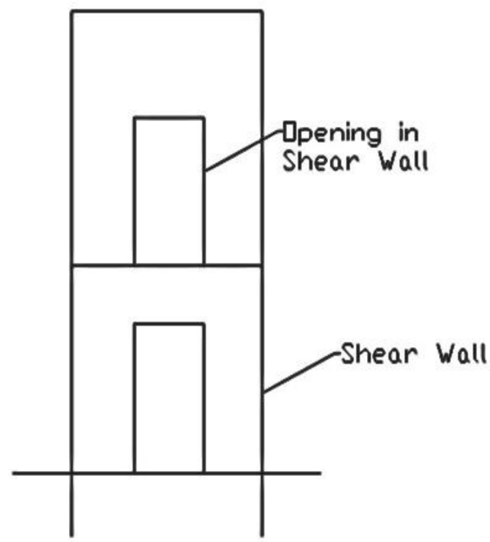

Fig. 2: Frame with Shear wall having medium opening

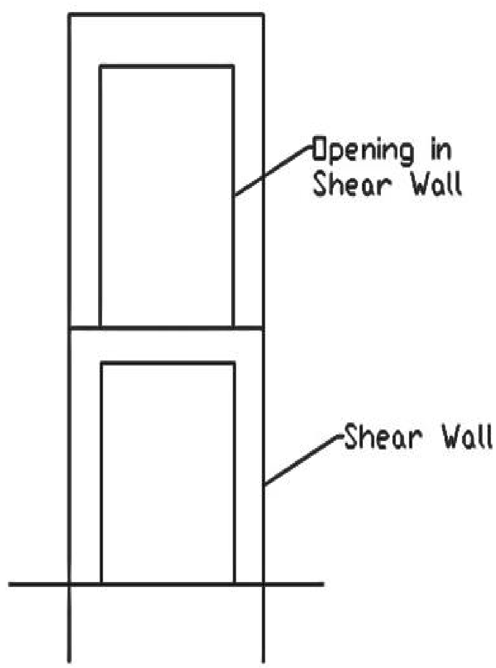

Fig. 3: Frame with Shear wall having very large opening

This study is totally based on maintaining the rigidness of the structure along with counteracting the seismic force effects, usage of Outriggers and Belt Supported System has been done.

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IV. OBJECTIVES OF THE PRESENT STUDY

Following heads shows the point of comparison of result parameters between various models during earthquake forces for building and its various cases. They are as follows:-

A. To take five different buildings, comparing them among each other by using Response Spectrum Method of dynamic analysis using Staad pro software.
B. To calculate maximum displacement and drift values and then comparing all the 5 buildings.
C. To compare base shear, that shows response result of the 5 dual configuration buildings.
D. To determine maximum Axial Forces and Shear Forces in columns at ground level for various buildings.
E. To show the variation of maximum Bending Moments in columns for all five multistorey buildings.
F. To investigate maximum Shear Forces in beams parallel to X and Z direction.
G. To study and compare maximum Bending Moments in beams along X and Z direction.
H. To evaluate maximum Torsional Moments in beams along X and Z directions.
I. Use of response spectrum method in with and without opening dual configuration multistorey structure.
J. To explore the possibilities of overall structural resistance by minimal use of shear wall area.

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 3: 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	SOA
2.	Building with 88.88 % shear wall area used	SOB
3.	Building with 85.80 % shear wall area used	SOC
4.	Building with 80 % shear wall area used	SOD
5.	Building with 66.66 % shear wall area used	SOE

Table 4: List of buildings with used and deducted Shear Wall area

S. No.	Abbreviation	Wall Deduction Ratio	Bay Size	Deduction Area (L x B)	Percentage Deduction
1.	SOA	-	5 m x 4 m	0 m x 0 m	0 %
2.	SOB	5 / 9	5 m x 4 m	0.55 m x 4 m	11.11 %
3.	SOC	5 / 7	5 m x 4 m	0.71 m x 4 m	14.28 %
4.	SOD	5 / 5	5 m x 4 m	1 m x 4 m	20 %
5.	SOE	5 / 3	5 m x 4 m	1.66 m x 4 m	33.33 %

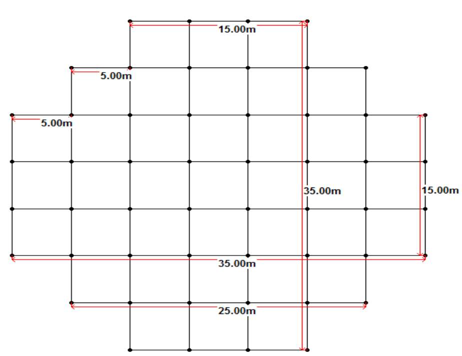

Fig. 4: Plan of all buildings

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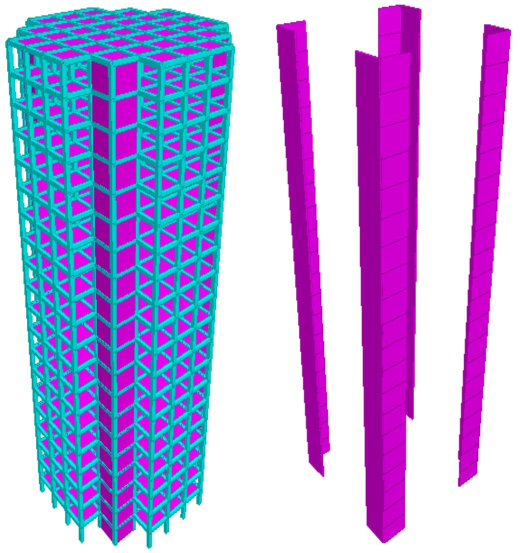

Fig. 5: Building SOA: Shear wall without opening

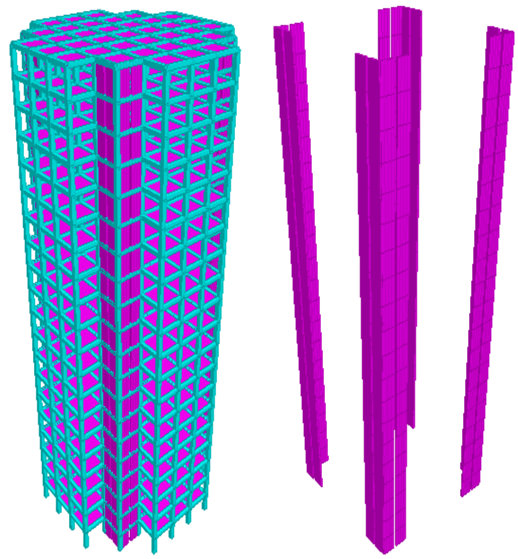

Fig. 6: Building SOB: Shear wall with 11.11 % opening

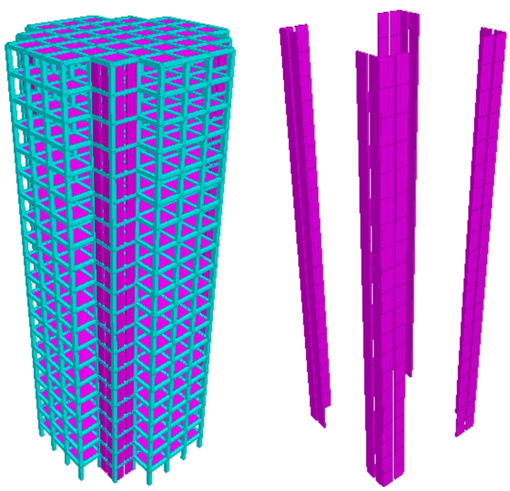

Fig. 7: Building SOC: Shear wall with 14.28 % opening

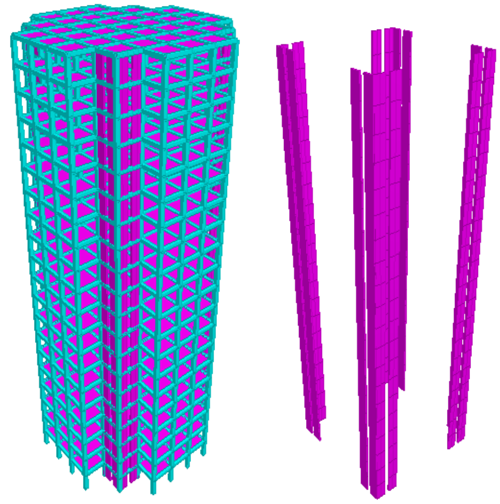

Fig. 8: Building SOD: Shear wall with 20 % opening

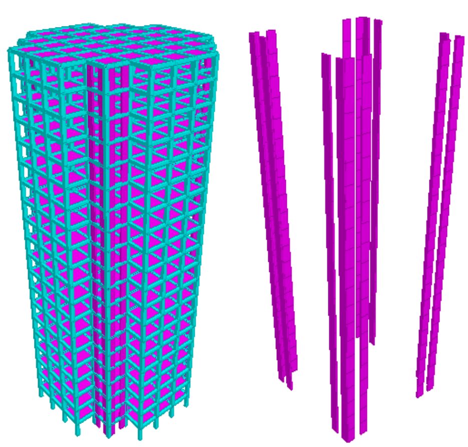

Fig. 9: Building SOE: Shear wall with 33.33 % opening

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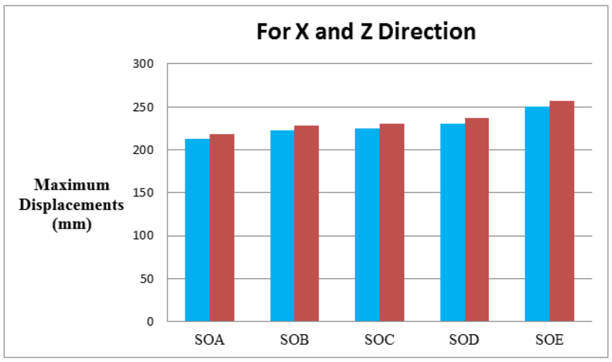
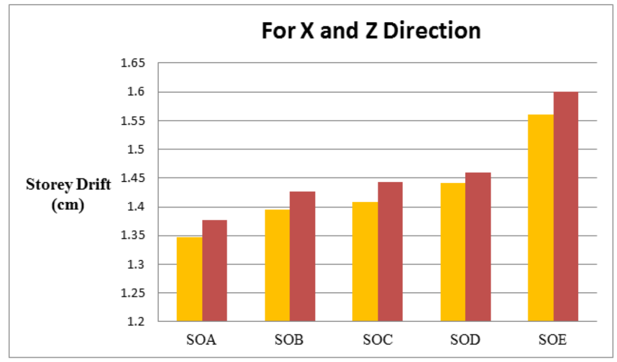
VI. RESULTS ANALYSIS

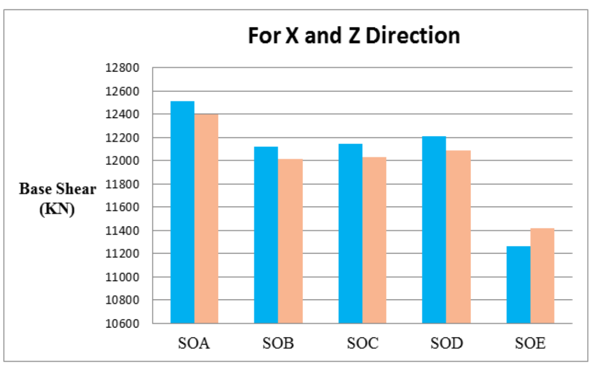
As per theme for increasing the stability of the structure, parameters such as the nodal displacement in both seismic directions, storey drift in both seismic directions, etc. obtained by application of loads and their combinations on various cases of the multistorey building have discussed. The results of each parameter with its maximum values are discussed with its graphical form for comparative analysis below:-



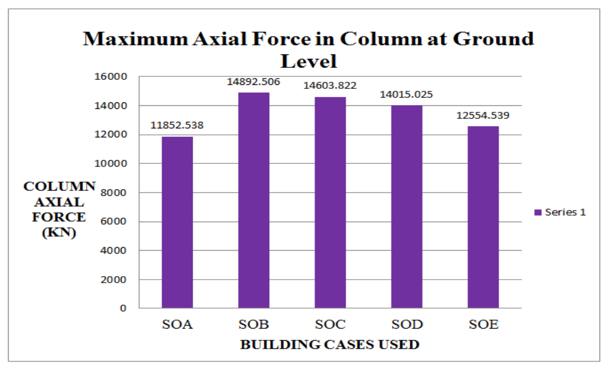
Graph 1: Maximum Displacement in X and Z direction for all 5 Buildings in Zone III



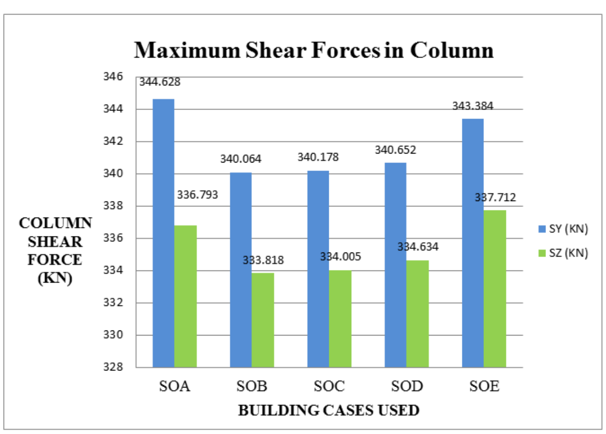
Graph 2: Storey Drift in X and Z direction for all 5 Buildings in Zone III



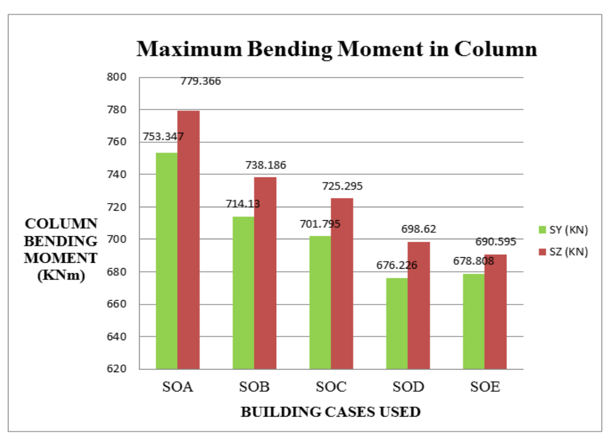
Graph 3: Base Shear in X and Z direction for all 5 Buildings in Zone III



Graph 4: Maximum Axial Forces in Column at ground level for all 5 Buildings in Zone III



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



Graph 6: Maximum Bending Moment in Columns for all 5 Buildings in Zone III

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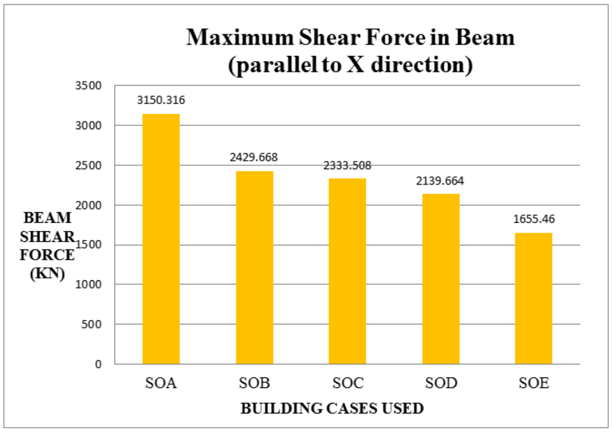
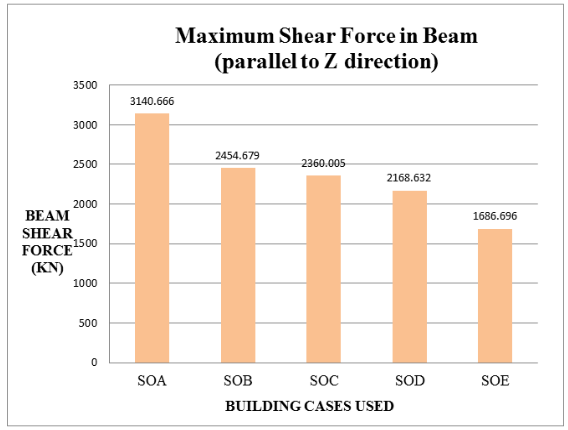
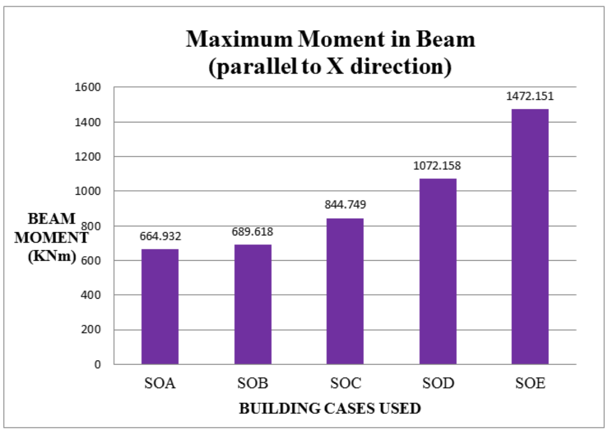


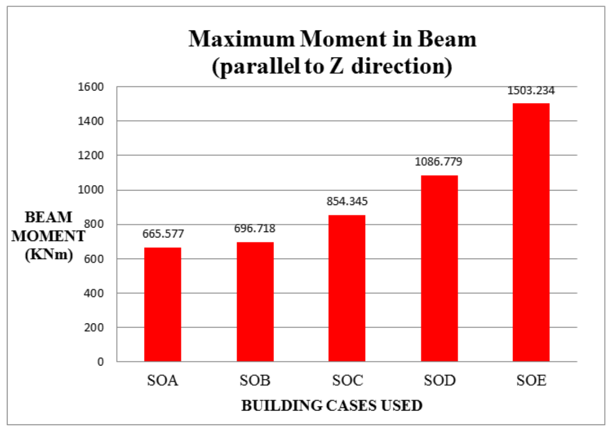
Graph 7: Maximum Shear Forces in beams parallel to X direction for all 5 Buildings in Zone III



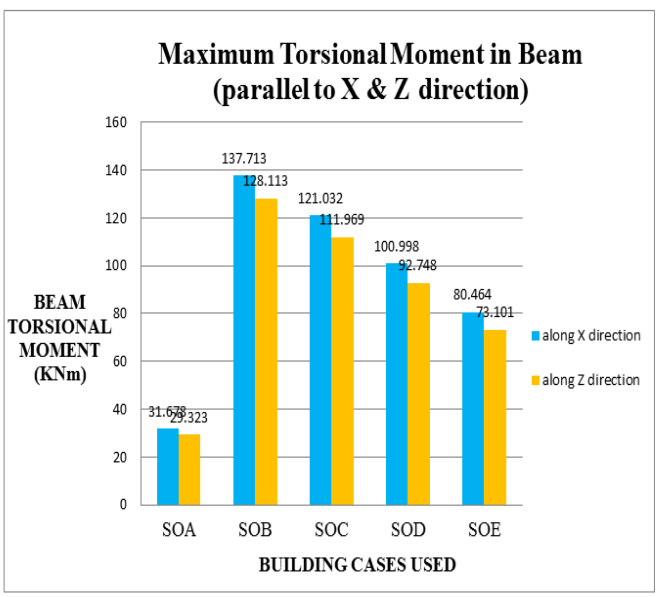
Graph 8: Maximum Shear Forces in beams parallel to Z direction for all 5 Buildings in Zone III



Graph 9: Maximum Bending Moment in beams parallel to X direction for all 5 Buildings in Zone III



Graph 10: Maximum Bending Moment in beams parallel to Z direction for all 5 Buildings in Zone III



Graph 11: Maximum Torsional Moment in beams parallel to X & Z direction for all 5 Buildings in Zone III

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VII. CONCLUSIONS

The conclusion can be pointed out are as follows:-

A. Maximum displacement in X direction and Z direction increases and when it crosses the limit of 20 %, the structural components fails and it needed to have increase in dimension. Building SOD will be economical.
B. 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 SOD will be safe and efficient.
C. 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 SOD shows the best parametric values at 20 % shear wall opening.
D. 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 SOD shows the safest value for axial forces.
E. Shear forces in column in both Y and Z direction increase with reduction in Shear wall area, the members fail beyond building SOD values. Hence building SOD shows the safest values for shear forces in column.
F. The moment values in column decreases from building SA to SE and beyond building SOD, the member fails. Hence building SOD shows the safest values for bending moment in columns.
G. Beam in both X and Z direction shows least values of shear forces in building SOD and beyond this, the beam fails.
H. For moments in beam in both X and Z direction, the values increases gradually and beyond the limit, it seems that up to building SOD the structural components are safe and beyond this, the beam fails.
I. Torsion in beam shows limiting parametric values up to building SOD 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 SOD with 80% coverage performs best of all.

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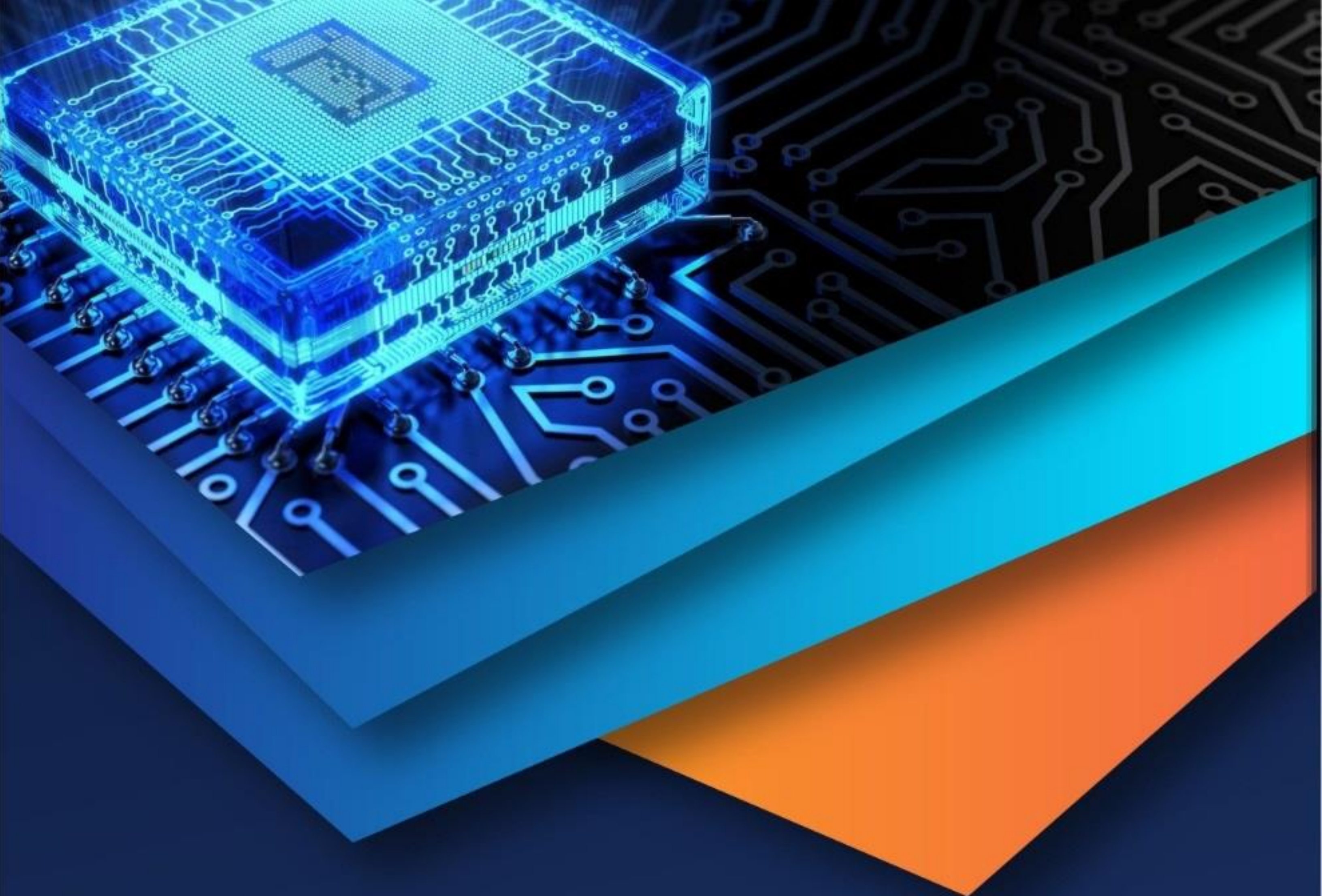

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