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Performance Point Determination Criteria of Multi-Storeyed Building with Highest Importance Factor

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Abstract: Every construction needs various parameters to model it and the most important thing need to assign is how much safe it is under different loading conditions. Due to increase in population, construction in India plays a very important role under the guidance umbrella of Indian Standards with the major safety for human beings. The structure should be strong enough that each element should be economic and strong. To check the structure with more live load present in it, highest importance factor should be selected for the same. In this project a G+18 Storey structure has analysed using shear walls at corners and total seven structural models have been created abbreviated as OSWA1 to OSWA7. Case OSWA5 fails in structural components, hence after modifications Case OSWA5a created. The project concluded that the performance point obtained is 35% with OSWA6 and obtained as efficient Case and will be recommended to reduce the overall cost of the project with highest importance factor taken as 1.5 as per Indian Standards.
Keywords: Shear Wall, Opening Area, Axial forces, Durability, Highest Importance factor, Maximum Live load

I. INTRODUCTION

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.

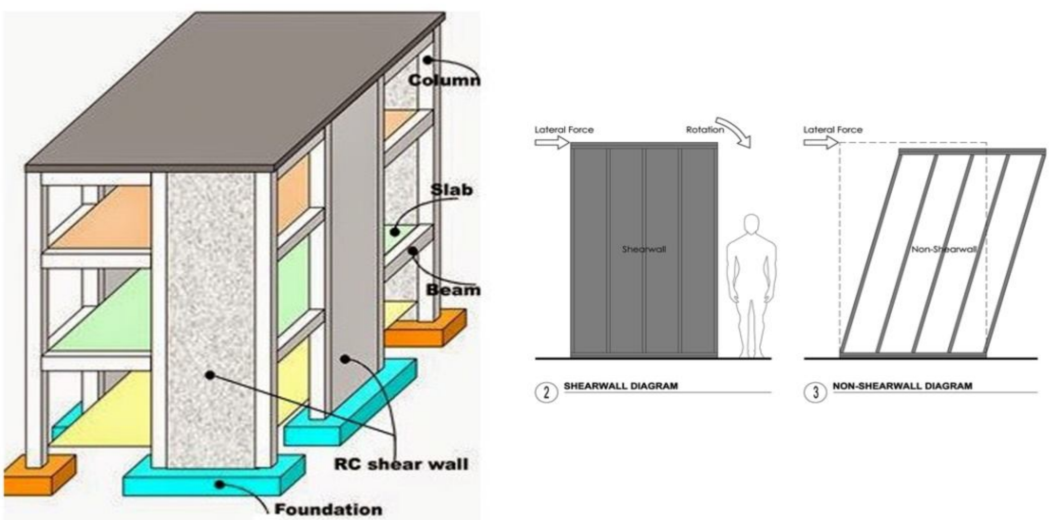

Fig. 1: Shear wall in Building

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 are 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

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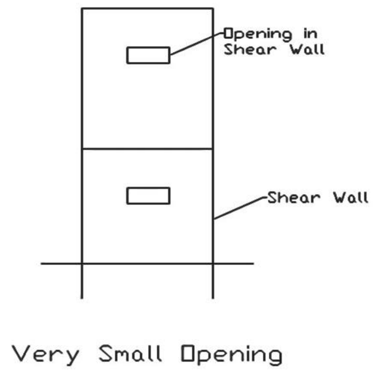

Fig. 2: Frame having very small opening of Shear wall

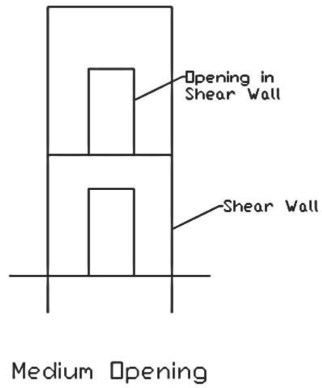

Fig. 3: Frame having medium opening of Shear wall

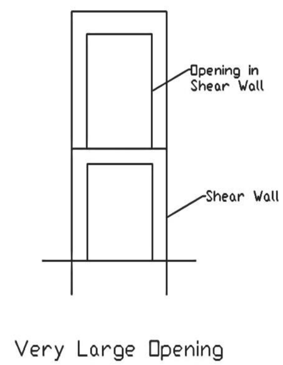

Fig. 4: Frame having very large opening of Shear wall

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. OBJECTIVES OF THE STUDY

To check the opening concept in terms of highest importance factor and to determine the minimum shear wall area usage, following objectives have been selected:-

1) 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.
2) To calculate Maximum displacement, Base Shear and Drift values and then comparing all the cases.
3) To explore the possibilities of overall structural resistance by minimal use of shear wall area.
4) To determine maximum Axial Forces in columns at ground level for various cases.
5) To study the variation of maximum Bending Moments & Shear Forces in columns of all cases for multi-storeyed buildings.
6) To study and compare maximum Bending Moments & Shear Forces in beams along X and Z direction.
7) To evaluate maximum Torsional Moments in beams along X and Z directions.

The main and foremost objective is to determination of the performance point of opening criteria of shear wall used in the periphery with highest importance factor as prescribed by the Indian Standards.

III.METHODOLOGY AND MODELLING

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 for highest importance factor

S. No.	Abbreviation	Shear Wall Deduction Area	% deduction	Overall concrete deduction area of structure
1.	OSWA 1	0m x 0m	0%	0 sq. m.
2.	OSWA 2	0.55m x 4m	11%	356.16 sq. m.
3.	OSWA 3	0.71m x 4m	14.2%	451.56 sq. m.
4.	OSWA 4	1m x 4m	20%	636 sq. m.
5.	OSWA 5	1.66m x 4m	33.20	1055.76 sq. m.

Table 2: Status of the structural components for highest importance factor

S. No.	Abbreviation	Shear Wall Deduction Area	% deduction	Overall concrete deduction area of structure	Status of the structural components
1.	OSWA 1	0m x 0m	0%	0 sq. m.	Pass
2.	OSWA 2	0.55m x 4m	11%	356.16 sq. m.	Pass
3.	OSWA 3	0.71m x 4m	14.2%	451.56 sq. m.	Pass
4.	OSWA 4	1m x 4m	20%	636 sq. m.	Pass
5.	OSWA 5	1.66m x 4m	33.20	1055.76 sq. m.	Fail

Table 3: List of buildings framed for extension of performance point criteria for highest importance factor

S. No.	Abbreviation	Shear Wall Deduction Area	% deduction	Overall concrete deduction area of structure
(0.5 H) Flared area used = 0.5 m height				
1.	OSWA 5a	1.66m x 3.5m	29.05%	1035.44 sq. m.
(0.5 H) Flared area used = 0.5 m height				
2.	OSWA 6	2m x 3.5m	35%	1170.12 sq. m.
(0.5 H) Flared area used = 0.5 m height				
3.	OSWA 7	2.10m x 3.5m	36.75%	1265.2 sq. m.

Table 4: Status of the structural components for extension of performance point criteria for highest importance factor

S. No.	Abbreviation	Shear Wall Deduction Area	% deduction	Overall concrete deduction area of structure	Status of the structural components
(0.5 H) Flared area used = 0.5 m height					Pass
1.	OSWA 5a	1.66m x 3.5m	29.05%	1035.44 sq. m.	
(0.5 H) Flared area used = 0.5 m height					Pass
2.	OSWA 6	2m x 3.5m	35%	1170.12 sq. m.	
(0.5 H) Flared area used = 0.5 m height					Fail
3.	OSWA 7	2.10m x 3.5m	36.75%	1265.2 sq. m.	

Table 5: Importance factor as per IS 1893:2016

S. No.	Structure Type	Importance Factor Value
1.	Important Buildings (all public buildings and gathering structures and places) (Occupancy more than 500)	1.5
2.	Residential and Commercial Buildings (Occupancy more than 200)	1.2
3.	All other structures (Occupancy less than 200)	1

Table 6: Input parameters taken for analysis of structure

IV.

V. Constraint	Assumed data for all buildings
VI. Soil type	Medium Soil
VII. Seismic zone	III
VIII. **IX.** Response reduction factor (ordinary shear wall with SMRF)	4
Importance factor (For all semi commercial building)	1.5 (highest as per Indian Standards
Damping ratio	5%
Fundamental natural period of vibration (T_a)	$0.09*h/(d)^{0.5}$ For X direction = 1.2094 sec For Z direction = 1.2094 sec
Plinth area of building (For Single Core)	925 sq. m
Floors configuration	G + 18
Height of building	79.5 m
Floor to floor height	4 m
Depth of foundation	3.5 m
Beam sizes	550 mm X 600 mm
Column sizes	650 mm X 700 mm
Slab thickness	180 mm (0.18 m)
Shear wall thickness	280 mm (0.28 m)
Material properties	M 30 Concrete Fe 500 grade steel
Method used for Seismic Analysis	Response Spectrum Method
Moment of Inertia Reduction Factor	For Columns 70% (0.70) For Beams 35% (0.35)

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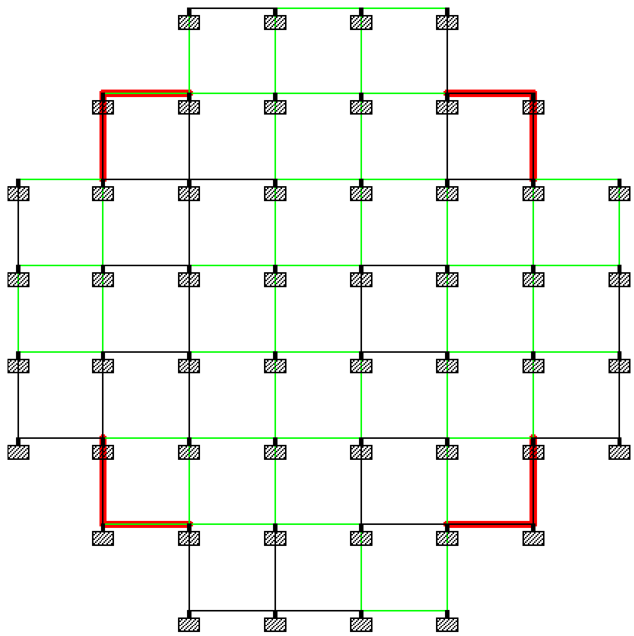

Fig. 5: Plan of all the building cases

Fig. 6: 3- D view of all buildings

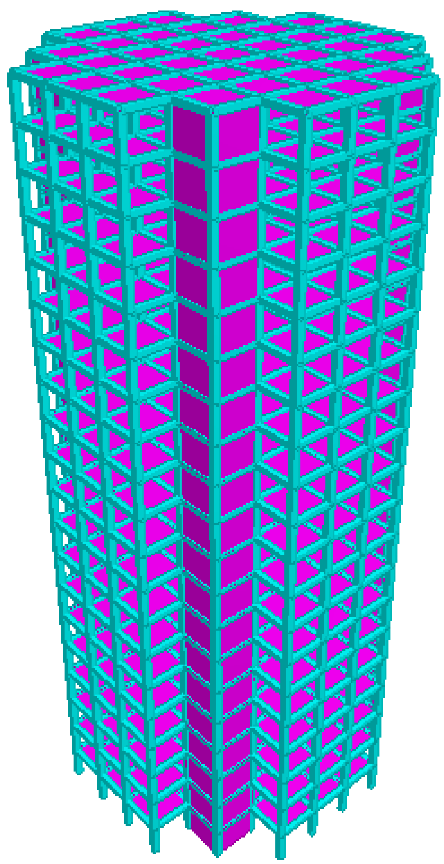

Fig. 7: Actual Rendered view of all buildings

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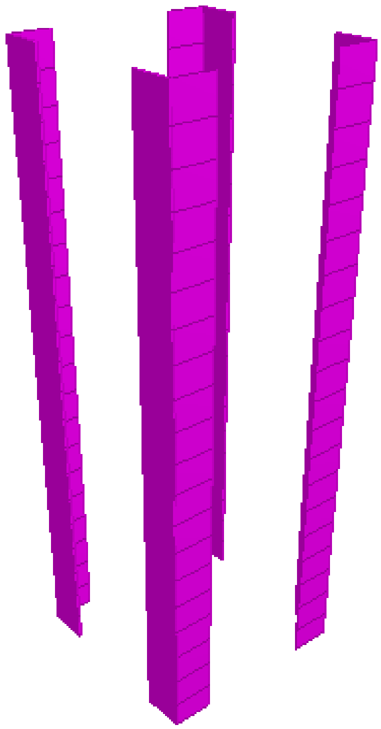

Fig. 8: Shear wall at periphery with 0 % opening (Case OSWA1)

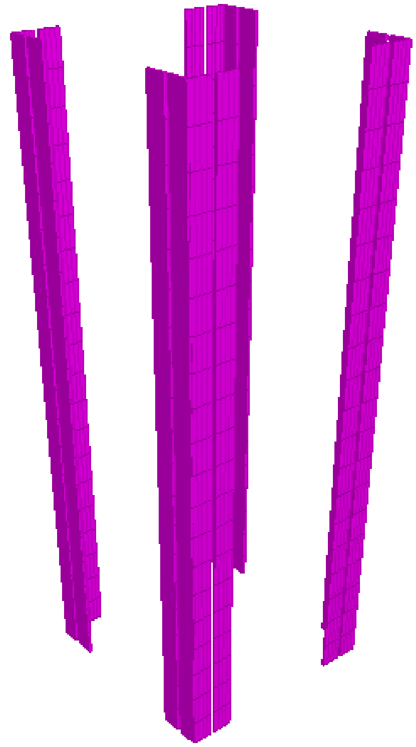

Fig. 9: Shear wall at periphery with 11 % opening (Case OSWA2)

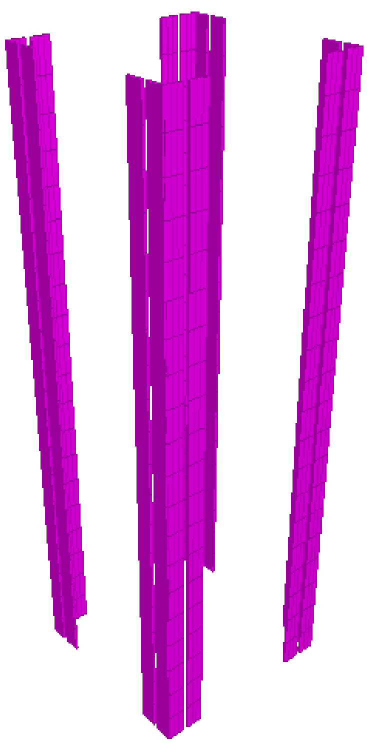

Fig. 10: Shear wall at periphery with 14.2 % opening (Case OSWA3)

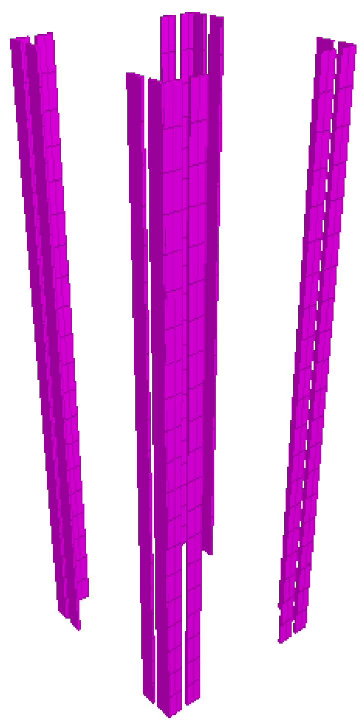

Fig. 11: Shear wall at periphery with 20 % opening (Case OSWA4)

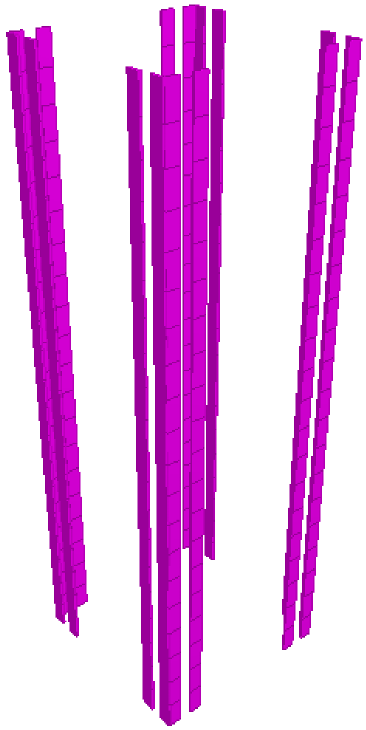

Fig. 12: Shear wall at periphery with 33.20 % opening (Case OSWA5)

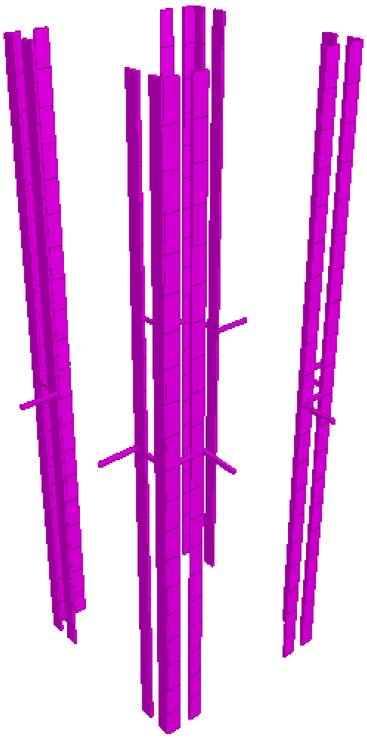

Fig. 13: Shear wall at periphery with 29.05 % opening (Case OSWA5a)

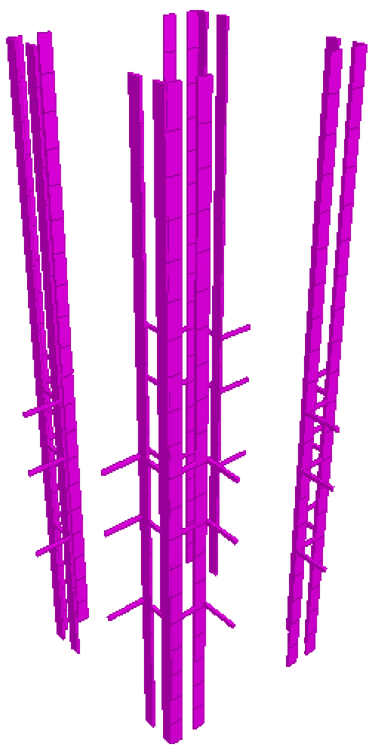

Fig. 14: Shear wall at periphery with 35 % opening (Case OSWA6)

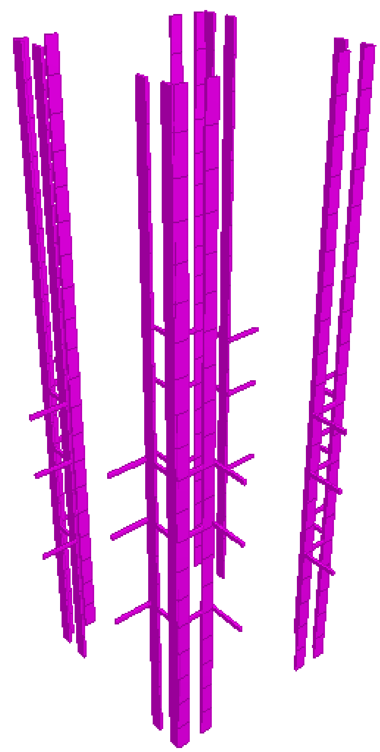

Fig. 15: Shear wall at periphery with 36.75 % opening (Case OSWA7)

IV. RESULTS 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:-

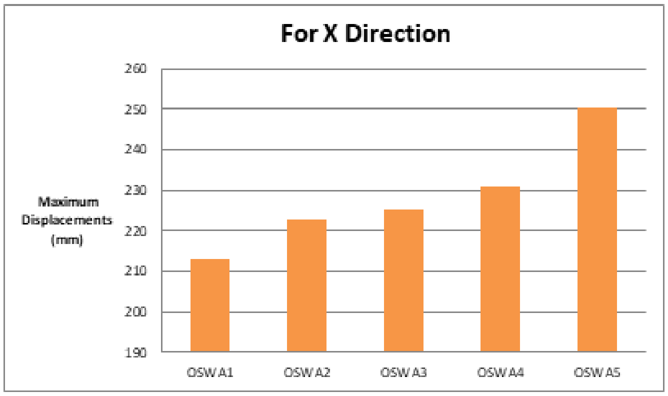

Fig. 16: Maximum Displacement in X direction for all shear wall deduction cases with highest importance factor cases

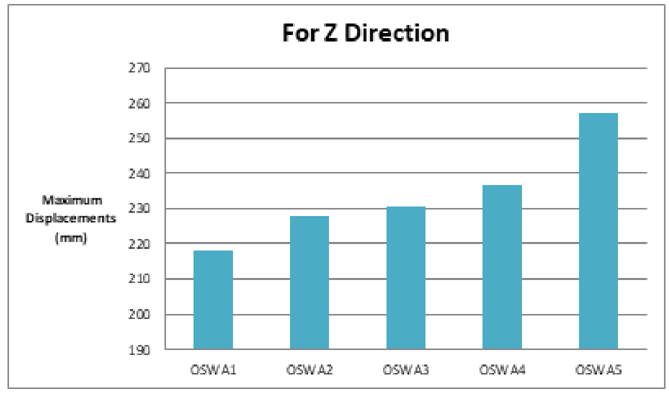

Fig. 17: Maximum Displacement in Z direction for all shear wall deduction cases with highest importance factor cases

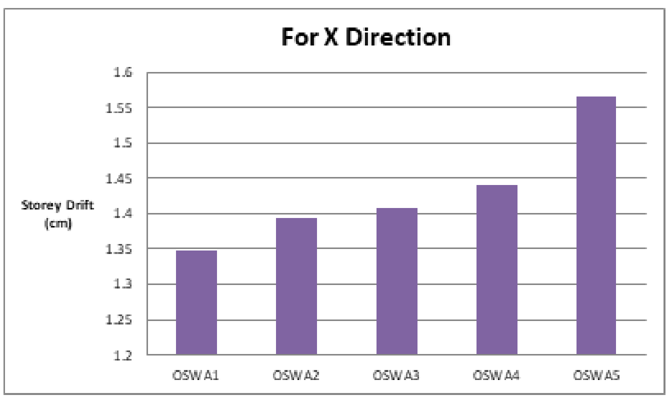

Fig. 18: Storey Drift in X direction for all shear wall deduction cases with highest importance factor cases

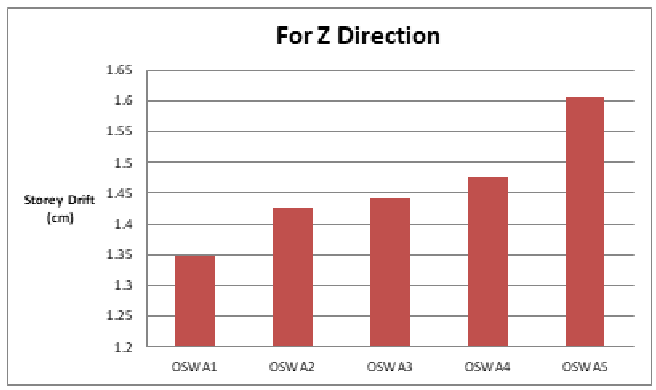

Fig. 19: Storey Drift in Z direction for all shear wall deduction cases with highest importance factor cases

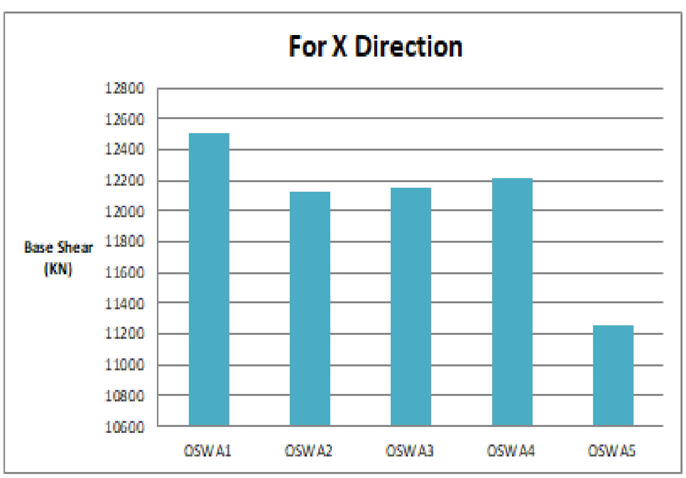

Fig. 20: Base Shear in X direction for all shear wall deduction cases with highest importance factor cases

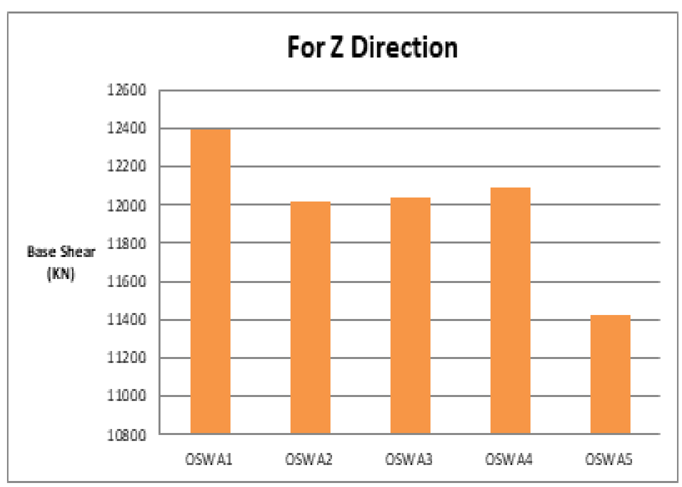

Fig. 21: Base Shear in Z direction for all shear wall deduction cases with highest importance factor cases

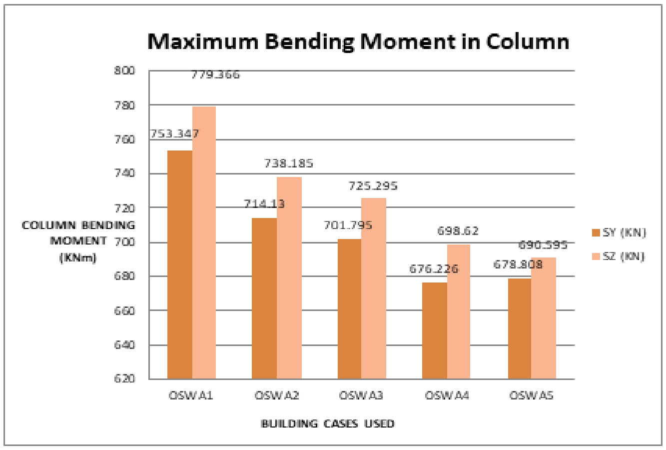

Fig. 22: Maximum Bending Moment in Columns for all shear wall deduction cases with highest importance factor cases

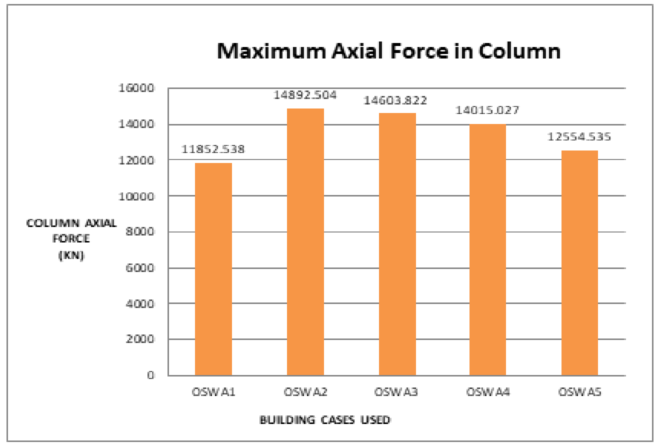

Fig. 23: Maximum Axial Forces in Column for all shear wall deduction cases with highest importance factor cases

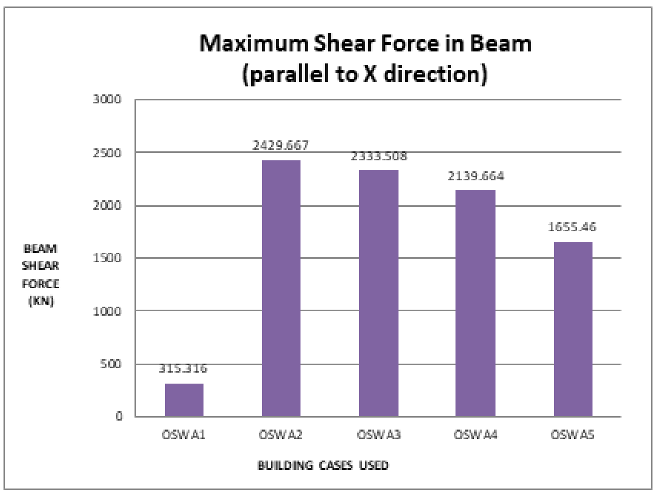

Fig. 24: Maximum Shear Forces in beams parallel to X direction for all shear wall deduction cases with highest importance factor cases

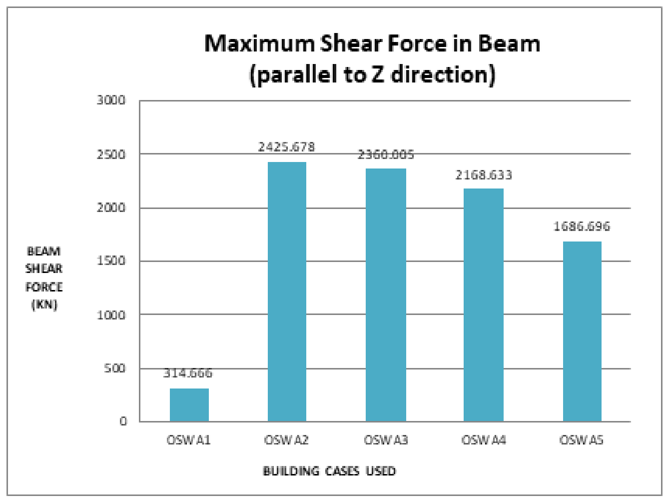

Fig. 25: Maximum Shear Forces in beams parallel to Z direction for all shear wall deduction cases with highest importance factor cases

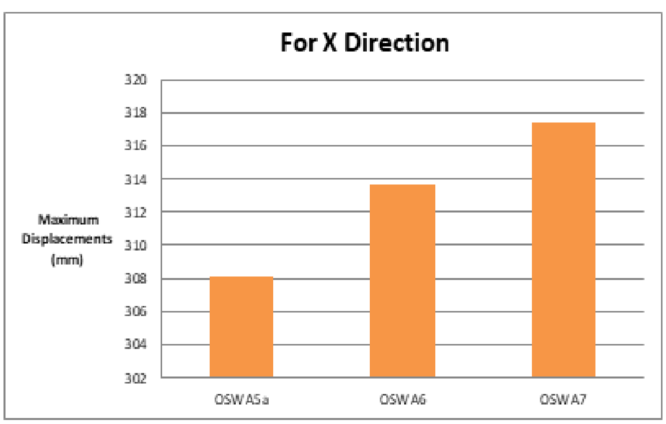

Fig. 26: Maximum Displacement in X direction for all shear wall deduction modified cases with highest importance factor

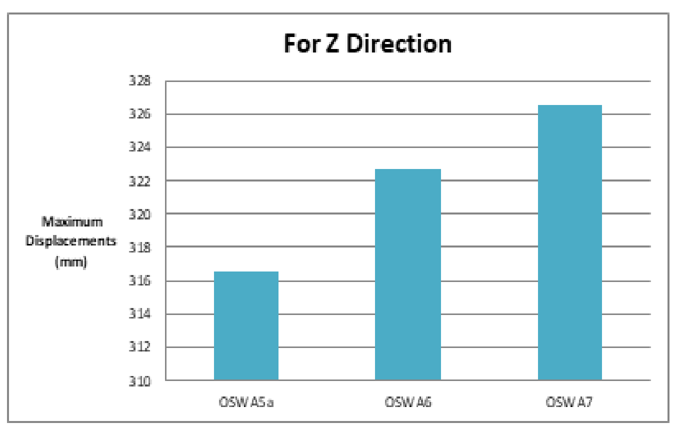

Fig. 27: Maximum Displacement in Z direction for all shear wall deduction modified cases with highest importance factor

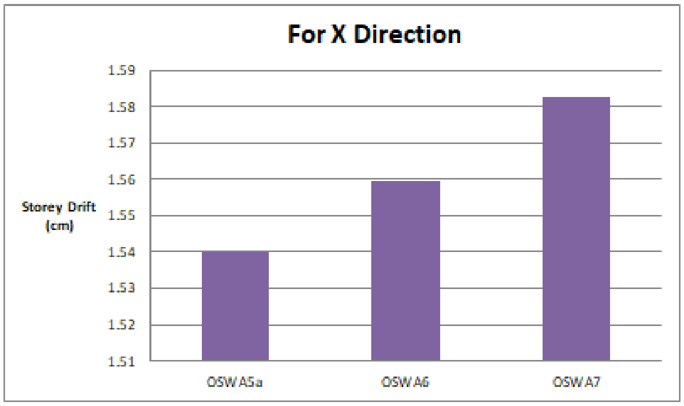

Fig. 28: Storey Drift in X direction for all shear wall deduction modified cases with highest importance factor

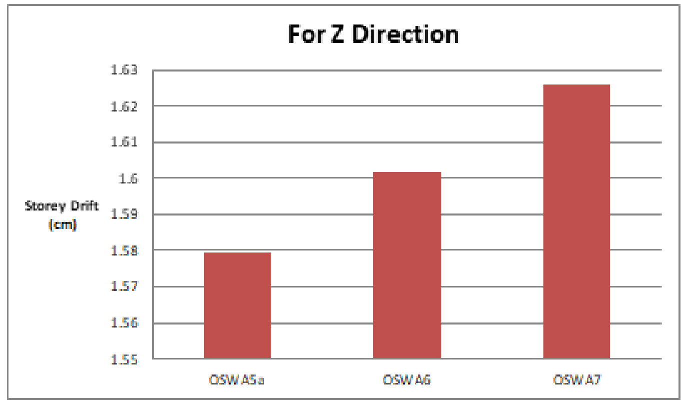

Fig. 29: Storey Drift in X direction for all shear wall deduction modified cases with highest importance factor

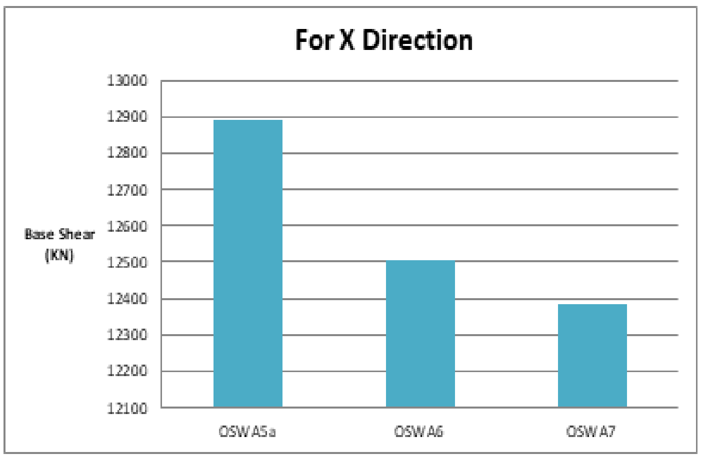

Fig. 30: Base Shear in X direction for all shear wall deduction modified cases with highest importance factor

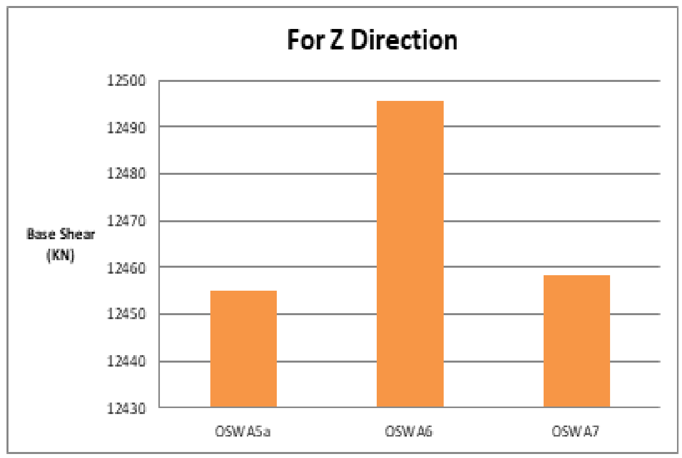

Fig. 31: Base Shear in Z direction for all shear wall deduction modified cases with highest importance factor

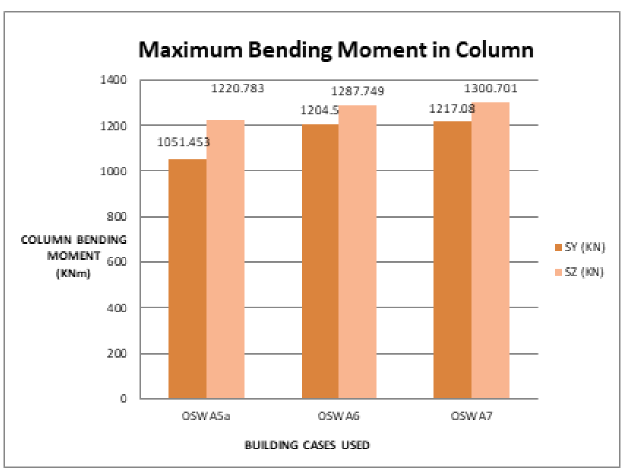

Fig. 32: Maximum Bending Moment in Columns for all shear wall deduction modified cases with highest importance factor

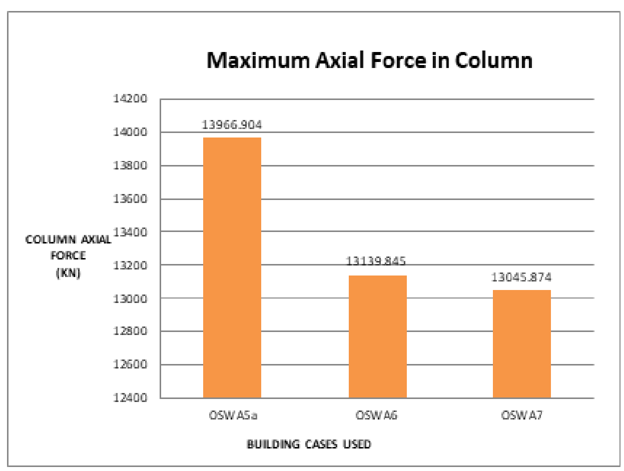

Fig. 33: Maximum Axial Forces in Column for all shear wall deduction modified cases with highest importance factor

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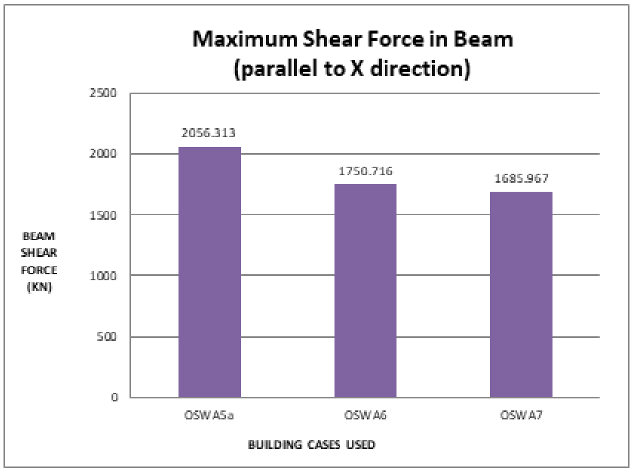

Fig. 34: Maximum Shear Forces in beams parallel to X direction for all shear wall deduction modified cases with highest importance factor

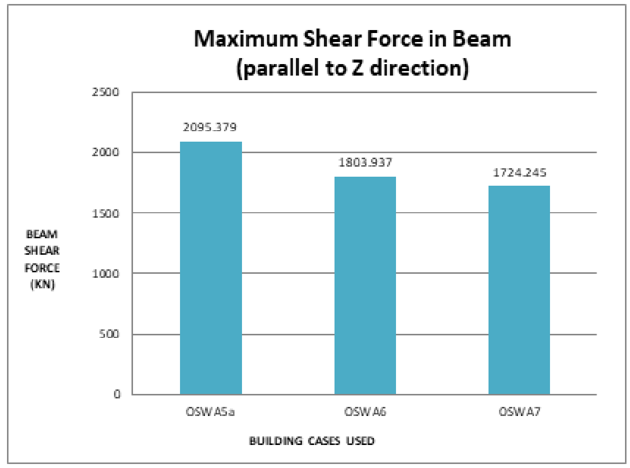

Fig. 35: Maximum Shear Forces in beams parallel to Z direction for all shear wall deduction modified cases with highest importance factor

In last case, members appear to be fail. By using flaring area concept of 0.5m height in case OSWA5 the same case pass with 29.05 % shear wall area deduction used abbreviated as OSWA5a respectively. With 35 % shear wall area deduction used abbreviated as OSWA6 and finally, the case appears to be fail with 36.75 % shear wall area deduction used abbreviated as OSWA7 respectively.

V. CONCLUSIONS

As we analysis about eight diverse cases regarding performance point determination in multistorey building by varying opening area percentage in shear wall used in periphery with earthquake zone III having highest importance factor. This approach gives the variety of outcome regarding every cases in the structure. In term of mentioned cases subsequent outcome are obtained from this comparative analysis.

1) On comparing Case OSWA1 to OSWA5 model it has been concluded that the Case OSWA4 has proved to be better among all cases for the performance point determination in multistory building by varying opening area percentage in shear wall used in periphery with earthquake zone with highest importance factor.
2) Case OSWA5 fails in structural components with the opening of 33.20%, hence for performance point extension, Case OSWA5 has re-modifies as Case OSWA5a with the opening of 29.05% and hence it has seen passed.
3) Case OSWA5a then extended to Case OSWA6 to 35% with structural components safe.
4) With the opening of 36.75%, Case OSWA7 has created but fails in structural components.
5) On comparing result parameters of all 3 cases, finally the performance point obtained as 35% and the case is Case OSWA6 respectively with least of:-

a) Base Shear in X direction.
b) Shear forces in Beam parallel to X directions.
c) Shear forces in Beam parallel to Z directions.
d) Shear forces in Columns.
e) Axial forces in Columns.

In this project a G+18 Storey structure has analyzed using shear walls at corners and total seven structural models have been created abbreviated as OSWA1 to OSWA7. Case OSWA5 fails in structural components, hence after modifications Case OSWA5a created. The project concluded that the performance point obtained is 35% with OSWA6 and obtained as efficient Case and will be recommended to reduce the overall cost of the project for the highest importance factor value of 1.5 as per Indian Standards.

VI. 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, with different soil conditions and using the flared area (shear belt) for providing more stiffness that ultimately used for reduction of the concrete area efficiently.

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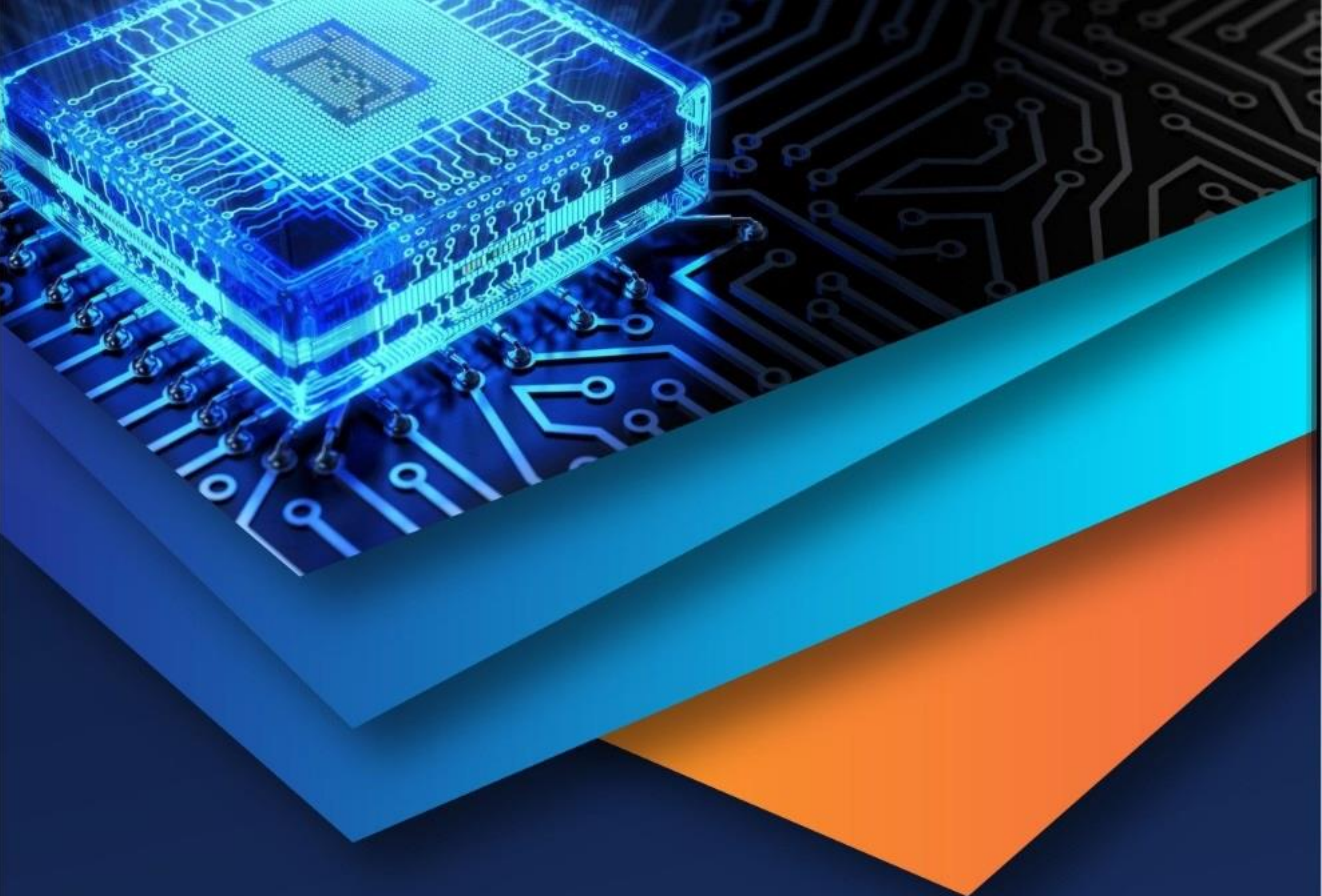

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