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Optimization of Setback Position in RC Building under Dynamic Earthquake Response

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Abstract: Now day, tall buildings have been widely used in semi-urban and urban areas of developed and developing countries, as they provide large space for commercial or residential use. As per civil and structural Engineering concept a building consist of different discontinuity related to mass, structural geometry, stiffness and et. al. This discontinuity imparts the irregularities in the structure. Earthquake analysis performance of structure becomes really important under the effect of vertical irregularities. For this study, analysis has been carried out on five different models having same base plan area of 30.00m x 30.00m and structure height of 78.75m (i.e. G+20 Storied Structure), in which one is regular model without setbacks (Designated as Model "0") while four other models having setbacks at different positions. The setbacks are of same plan area (20.00m x 20.00m and 10.00m x 10.00m) and of same heights as 31.50 m 26.25m and 21.00 m from the base. Storey Displacement, Maximum Storey Displacement, and Base Shear Result are evaluated. The analysis is carried out in ETABSvr.16 Software. On the basis the results is taken out are Story Displacement, Maximum Story Displacement and Base Shear, Overturning Moments of each models and at the place of setback provided.
***Keywords*: setbacks, tall buildings, G+20 Storied Structure, vertical irregularities, ETABSvr.16**

I. INTRODUCTION

In urban areas, high-rise construction has become a necessity for people. To satisfy the same need, they became popular in culture. Buildings can be broadly classified as ordinary and irregular plan buildings. A building that is symmetrical or with uniform geometry and with a constantly distributed mass is known as an ordinary building. A building can have various shapes, designs, and types of frame structures. In the same structure, when changes occur at any point in the region compared to the upper and lower floors, and the other side of the building is called an irregular building. A building that is classified as irregular, structural failure can occur due to this uncertainty, such as geometry discontinuity, mass discontinuity, load resistance rupture, and rupture in the absence of building symmetry. Structural irregularities can be classified as vertical and horizontal (plan) irregularities. Roughness in the structures can be associated with uneven distribution of mass, strength and rigidity along the height of the building. There are various types of horizontal irregularities in the building, followed by Torsional irregularities, repeating angular irregularities, overlapping ceilings with an excessive opening and notches, deviation from the plane in the vertical element, and the latter is a non-parallel system of lateral forces. Different categories of vertical unevenness are stiffness unevenness (soft number of storey's), mass unevenness, vertical geometric unevenness, a gap in the plane in a vertical element withstanding lateral load, unevenness of strength (weak floor), floating or indirect columns, irregular modes of oscillations in two . Analysis and design of such a high-rise structure for lateral wind loads can become more difficult for a civil engineer. In this project, vertical geometric irregularity was carefully studied.

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II. MODELLING AND ANALYSIS

The models can be sub-divided into three different sections i.e. Section 1: Base to G+6 stories, Section "B": G+6 to G+13 stories and Section "C" from G+13 to G+20 stories. The setbacks have been kept at the top of Section "A" and Section "B" i.e. at stories G+6 and G+13. The geometrical properties of the structures have been shown in table 1.

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Table 1: Structure Geometric Details

S.No.	Description	Model 0	Model 1	Model 2	Model 3	Model 4
1	Plan Area : Section "A"	30m x 30m	30m x 30m	30m x 30m	30m x 30m	30m x 30m
	Section "B"	30m x 30m	20m x 20m	20m x 20m	20m x 20m	20m x 20m
	Section "C"	30m x 30m	10m x 10m	10m x 10m	10m x 10m	10m x 10m
2	Levels Height :Section "A"	31.50 m	31.50 m	31.50 m	31.50 m	31.50 m
	Section "B"	26.25 m	26.25 m	26.25 m	26.25 m	26.25 m
	Section "C"	21.00 m	21.00 m	21.00 m	21.00 m	21.00 m
3	Structure Height	78.75m	78.75m	78.75m	78.75m	78.75m
4	Offsets: X-Direction First	Nil	5	10	5	10
	Second	Nil	5	10	10	5
5	Offsets: Y-Direction First	Nil	5	5	5	5
	Second	Nil	5	5	5	5

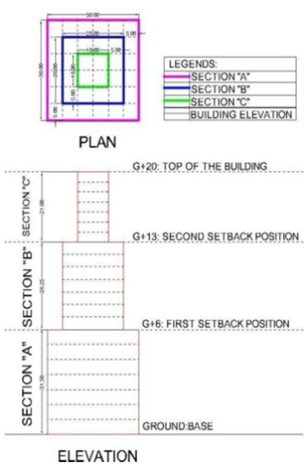

Fig 1: Model 1:

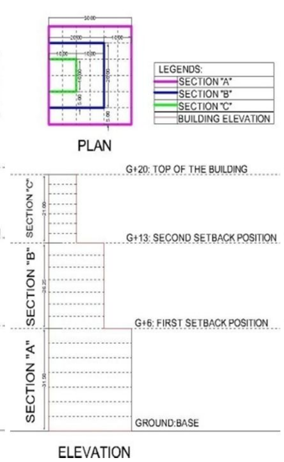

Fig 2: Model 2

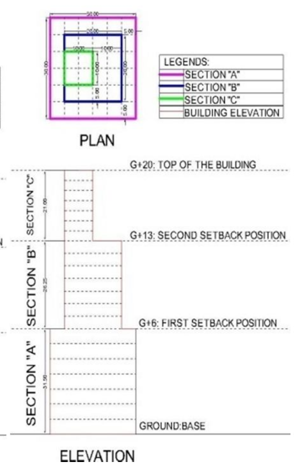

Fig 3: Model 3:

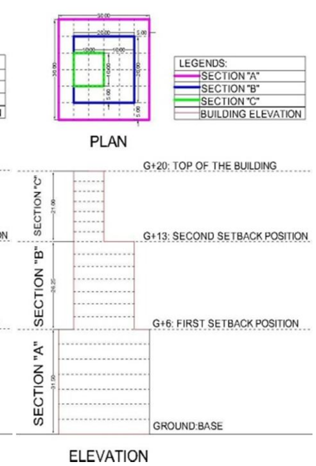

Fig 4: Model 4:

Structural Models

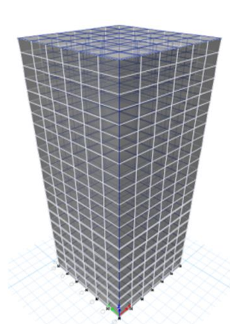

Fig 5: 3D view of Model 0

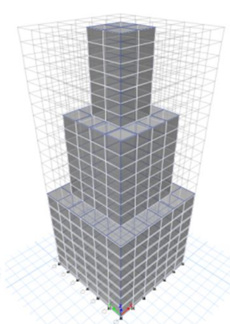

Fig 6: Model 1

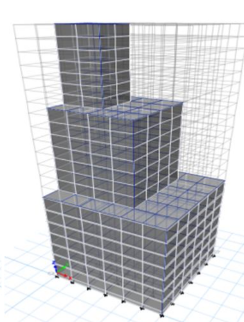

Fig 7 : Model 2

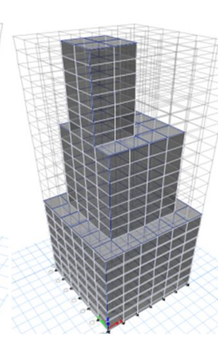

Fig 8: Model 3

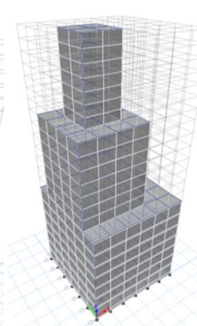

Fig 9: Model 4

A. Seismic Data and Material Properties

1) *Seismic Data:* Zone-4, Zone Factor: 0.24, Soil Type: Medium, Importance Factor:1.15, Response Reduction Factor:5, Direction: Both X and Y, Eccentricity: Nil

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Table 2: Structure Parameters for All Models

S. No	Particular	Details
1	Column Size	
1.a	Ground - G+6	400x600mm
1.b	G+7 - G+13	300x500 mm
1.c	G+14 - G+20	200x400 mm
2	Column Spacing	
2.a	X-direction	5.00 m c/c
2.b	Y-direction	5.00 m c/c
3	Beam Size (Main)	
3.a	Plinth Beam	250x600mm
3.b	Ground - G+6	300x600mm
3.c	G+7 - G+13	250x500 mm
3.d	G+14 - G+20	200x400 mm
4	Slab thickness	150 mm thick
5		20.00 KN/m^3

III. RESULTS AND DISCUSSIONS

A. *Storey Displacements*

Table 3 : Storey Displacement In X-Direction

Story	Model 0	Model 1	Model 2	Model 3	Model 4
G+20	376	334.73	356.144	349.516	344.432
G+19	371.698	323.994	343.62	337.439	333.386
G+18	365.199	306.367	324.097	318.385	315.394
G+17	356.355	281.947	297.738	292.51	290.611
G+16	345.102	251.749	265.205	260.466	259.68
G+15	331.412	217.692	228.03	224.489	224.993
G+14	315.408	181.802	189.682	187.073	188.646
G+13	298.864	154.936	160.034	158.566	161.12
G+12	283.568	145.28	146.927	145.9	148.62
G+11	266.415	133.554	133.832	133.339	135.763
G+10	247.63	119.745	119.684	119.325	121.496
G+9	227.397	104.088	103.986	103.765	105.581
G+8	205.532	86.943	86.907	86.816	88.209
G+7	182.228	68.927	68.976	68.825	69.935
G+6	159.834	53.72	53.481	53.595	54.207
G+5	139.552	46.64	46.294	46.515	46.95
G+4	117.919	39.242	38.782	39.032	39.422
G+3	95.214	31.874	31.215	31.553	31.75
G+2	71.666	24.206	23.436	23.907	23.881
G+1	47.558	16.173	15.55	15.946	15.886
GF	23.386	7.992	7.655	7.872	7.826
Ground	1.859	0.637	0.609	0.627	0.622
Base	0	0	0	0	0

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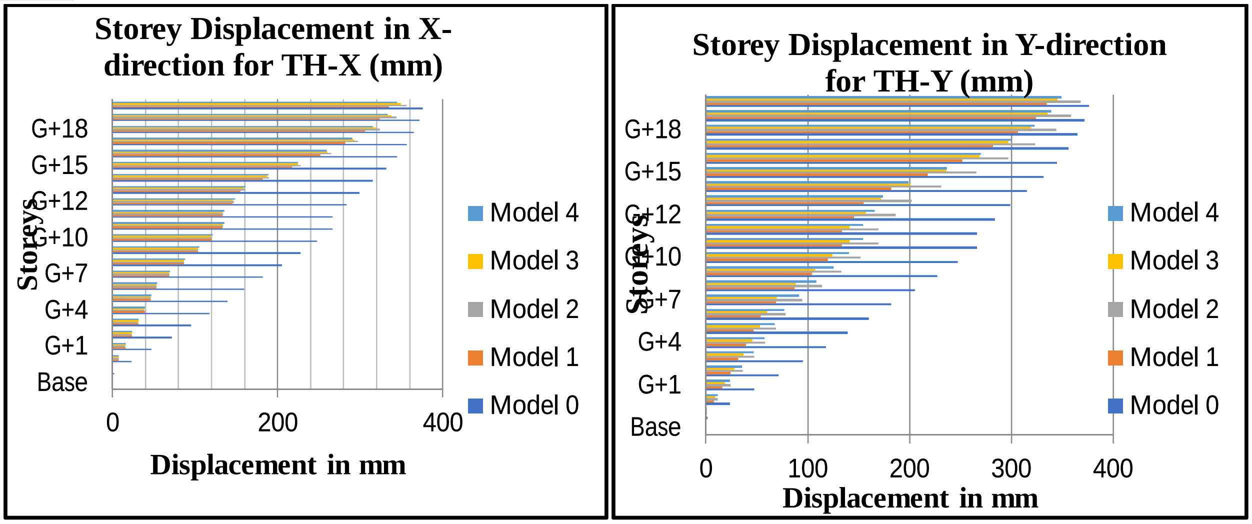

Fig 10: Storey Displacement in X-Direction for Th-X And Th Y

Table 4: Storey Displacement In Y-Direction (mm)

Story	Model 0	Model 1	Model 2	Model 3	Model 4
G+20	376	334.73	367.933	345.175	349.443
G+19	371.698	323.994	358.893	335.373	339.3
G+18	365.199	306.367	344.018	319.318	322.599
G+17	356.355	281.947	323.231	296.97	299.258
G+16	345.102	251.749	296.83	268.722	270.244
G+15	331.412	217.692	265.495	236.006	236.387
G+14	315.408	181.802	230.837	200.604	199.133
G+13	298.864	154.936	201.989	171.702	173.625
G+12	283.568	145.28	186.687	156.897	165.709
G+11	266.415	133.554	169.72	141.189	154.146
G+10	247.63	119.745	151.802	124.46	140.492
G+9	227.397	104.088	133.107	106.905	125.239
G+8	205.532	86.943	114.003	88.304	108.744
G+7	182.228	68.927	94.513	69.481	91.527
G+6	159.834	53.72	78.046	60.234	76.798
G+5	139.552	46.64	68.721	53.186	67.69
G+4	117.919	39.242	58.465	45.414	57.626
G+3	95.214	31.874	47.522	36.979	46.86
G+2	71.666	24.206	35.988	28.018	35.497
G+1	47.558	16.173	24.017	18.694	23.692
GF	23.386	7.992	11.87	9.234	11.71
Ground	1.859	0.637	0.948	0.737	0.935
Base	0	0	0	0	0

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B. Maximum Storey Displacement AND Storey Drift At Setbacks

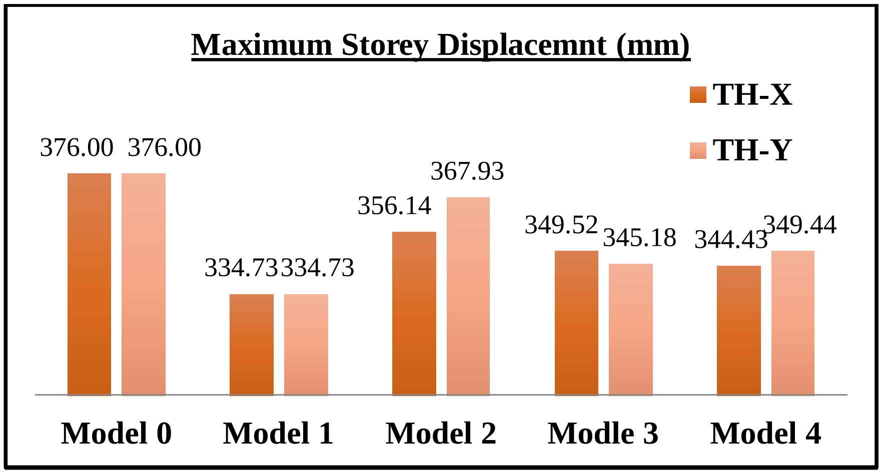

Fig 11: Maximum storey Displacement

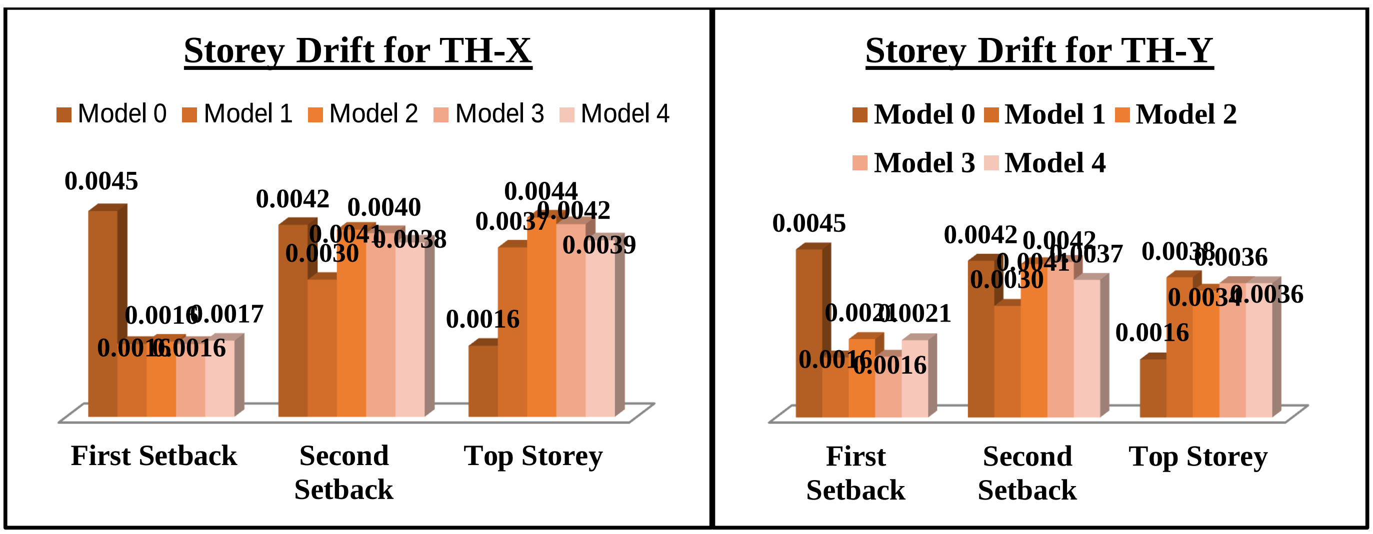

Fig 12: Storey Drift for TH-X and TH-Y

C. Overturning Moments/Base Moment

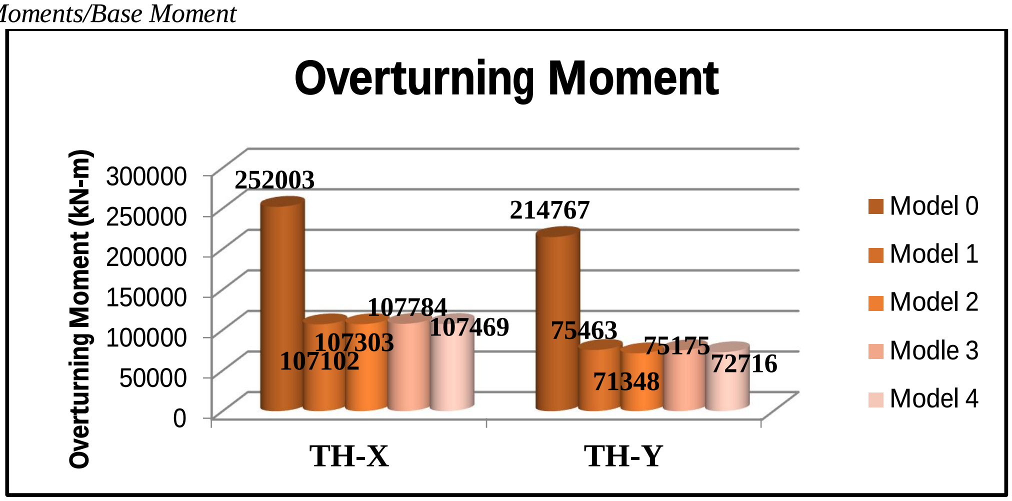

Fig 13: Overturning Moment

D. Storey Shear at Setbacks

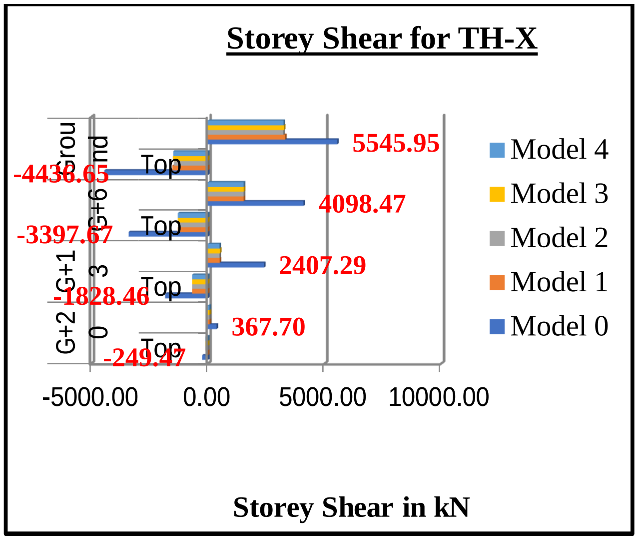

Fig 14: Storey shear for TH-X

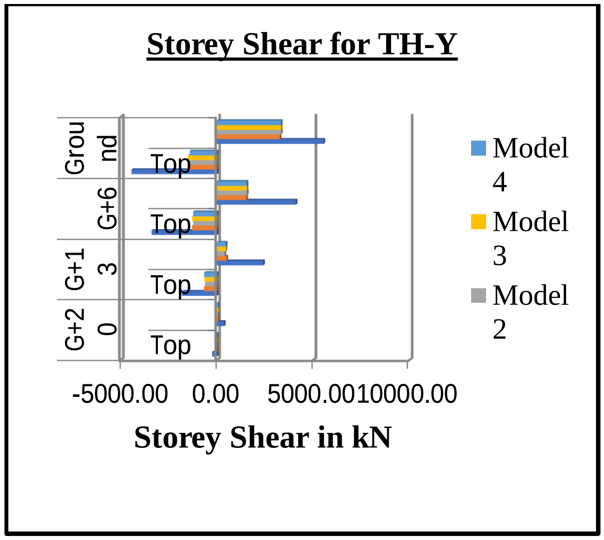

Fig 15: Storey shear for TH-X

IV. CONCLUSIONS

In this Thesis on different setback position on same plan area and same set back heights when compared with regular symmetric building analyzed in ETABSv.16 following conclusions were made:

A. Symmetric building with setback i.e. Model 1 shows minimum value of storey displacement for earthquake forces in both the directions while on comparing asymmetric setback building Model 3 and Model 4 shows lowest value for Y-direction and X-direction respectively.

B. In Irregular setback building, all the structures shows almost equal value at first setback, while at second setback and top storey Model 1 shows lowest value. Although the difference is small, highest value observed in Model 2 and Model 3 for second setback and top storey respectively.

C. In terms of Storey Drift Model 2 and Model 4 shows minimum values as compared to other Models. Although the difference is very small.

D. Model 2 and Model 1 shows minimum overturning moments with respect to all other models.

E. From here it can concluded that Model 1 i.e. symmetric building with setbacks outperformed all other asymmetric setback building.

F. When it is not possible to provide Model 1 like structure than Model 2 is the most preferable than other type asymmetric models.

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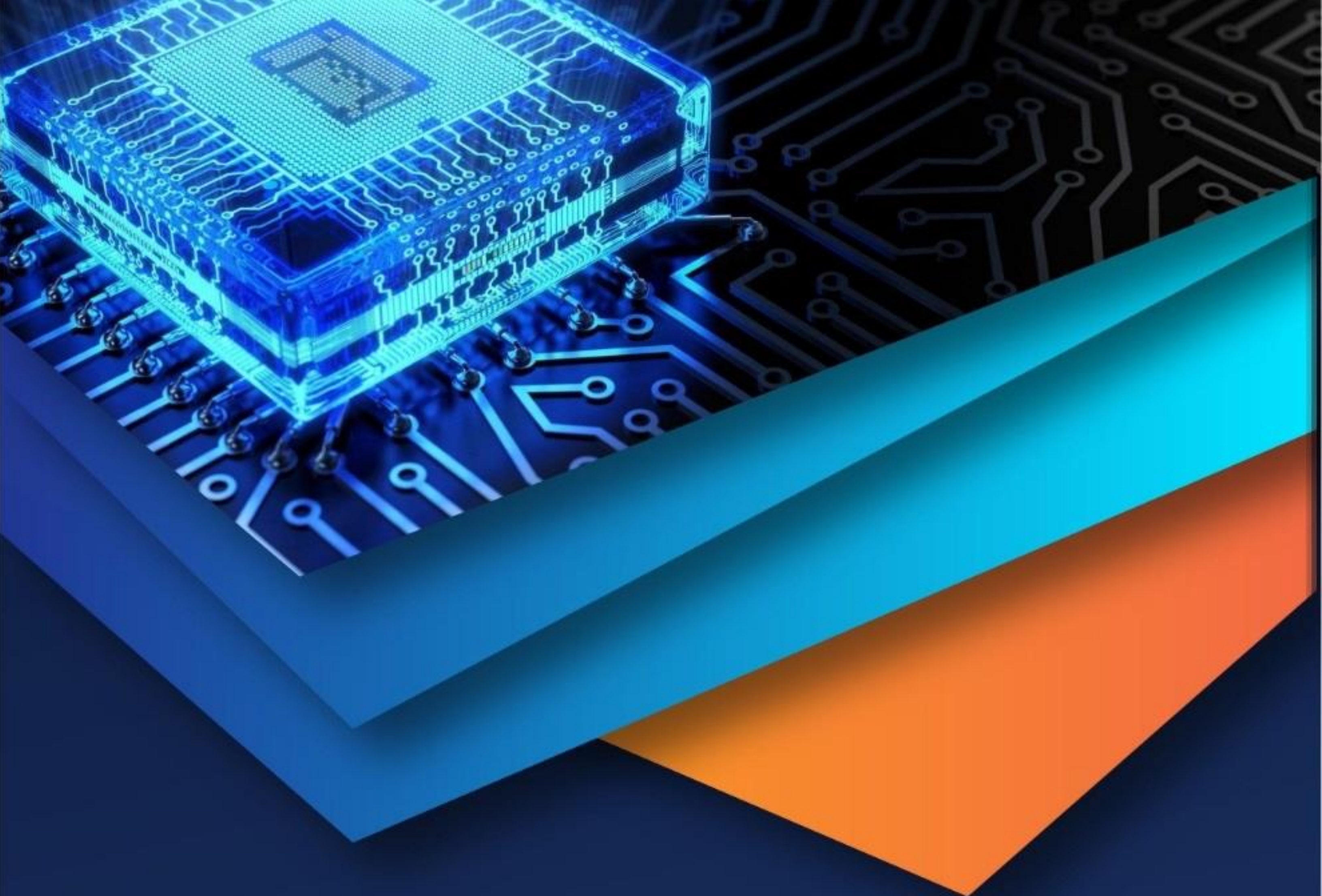

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