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Comparative Study on Seismic Analysis of Multi Storied RC Framed Structure with and without Diaphragm Discontinuity

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Abstract: Any Structure that is designed in today's world has to be designed not only for aesthetics but also for stability. These days high rise multi storied structures are quiet prominent. These types of structures, should not only be designed for aesthetic point of view but also must be designed to resist earthquake forces which are subjected on these structures. These earthquake forces acting on the structures are also known as seismic forces. Due to architectural purposes, some buildings, have openings, provided in them, this creates structural discontinuities in the building. These openings or discontinuities can change the load transfer path of the structures which may cause significant change in the building behavior, under the application of the seismic forces. In this paper pushover analysis is carried out to study the behavior of the building in case of architectural opening for staircase or cut outs etc which results in discontinuity in the structure.
Keywords: Diaphragm, Discontinuity, ETABS, Pushover Analysis, Seismic

I. INTRODUCTION

In the history of the Asian sub continents, structures have been subjected to several severe earthquakes. Due to the application of such severe earthquake forces, the damage caused to the multi storey building is mainly at the places of structural weakness that is present in the lateral load resisting system of the building's frame. Many researches have investigated that these weaknesses arise due to the application of the seismic forces at place of discontinuities in stiffness, strength or mass along the diaphragm. The response of the multistoried building, upon the application of such severe seismic forces depends on the distribution of mass, stiffness and strength in horizontal & vertical planes of the building. In order to design a stable and reliable structure it is necessary for the structural engineer to analyze and investigate such responses.

The Diaphragm is defined as a structural system which is used to transfer the lateral loads to frames or shear walls or to the vertical resisting elements of the structure. Lateral loads are mainly earthquake and wind loads. The Indian Standard Design Code 1893-2002 defines Diaphragm Discontinuity as the Diaphragms with a sudden change in stiffness, which is inclusive of the open areas greater than 50% of the gross diaphragm area or cut outs or change in effective diaphragm stiffness of more than 50% from one storey to the next.

II. SCOPE & OBJECTIVES

During the elastic analysis of the building, we know that the structure deforms within elastic limit. But this concept cannot be applied on a multi-storeyed building as we cannot analyse them using this technique. So, we need an advanced technique by which we are capable of in-depth analysis of the structure, as to how it will behave beyond elastic limit. Pushover Analysis helps us in understanding the non-linearity of the of the structure and its response during the excitation caused due to seismic forces. In this study, G+10 building is considered and there are some structural openings that are provided in the building as per concerning percentages to the building that are given and discussed in the further section of this paper. These structural opening are also known as diaphragm discontinuities.

The main objectives of this paper is to investigate the seismic behaviour of the building under the application of the earthquake forces. In this research it is also investigated that what are the effects on various parameters due to the application of the seismic forces on the structures. As the discontinuities on the structure have been considered. Due to these diaphragm discontinuities, there are some sort of variations in the engineering parameters. These changes have been investigated in this research under the application of the seismic forces. Finally, the structure has been compared with the standard one to came to a conclusion that what are the changes in the structure came due to these discontinuities and these architectural openings.

III. METHODOLOGY

A. *Pushover Analysis*

There are various technical approaches to analyse a structure under the application of various loads and their combinations. The pushover analysis helps in analysing the static non –linear behaviour of the structure under permanent vertical loads and gradually increasing lateral loads. This non-linear behaviour cannot be predicted by using the elastic analysis of the structure. As in this elastic analysis, the results only show the elastic behaviour of the structure but it doesn't clarify the failure mechanism of the building. A monotonically increasing combination of lateral loads is subjected on the structure in pushover analysis which shows the inertial forces which would be experienced by the structure when subjected to ground motion.

IV. MODELLING AND ANALYSIS

For the structural analysis, a building plan of size 25m x 25m has been considered and for the sake of the load applications, the building is considered as a residential building. Considering a generic storey height of 3m, the structure has been analysed. In order to investigate the effects of seismic forces on the structure which is having a diaphragm discontinuity, various percentages of the openings have been provided in the structure. The openings have been provided as the percentage of gross area. We have taken four models with increasing opening percentages i.e., 0%, 5%, 10% and 17%. Further details have been described in the following table:

Particulars	Details
Plan size	25m X 25m
Usage	Residential building
Storey height	3m
No. of storeys	G + 10
Length of grid in X direction	5m
Length of grid in Y direction	5m
Slab thickness	200mm
Column size	500m X 500m
Beam size	350m X 500m
Grade of concrete	M30
Grade of steel	Fe500
Density of concrete	25KN/m^3
Earthquake zone	III
Zone factor	Z = 0.16 (clause 6.4.2)
Importance factor	I =1 (clause 7.2.3)
Type of soil	Medium soil (clause 6.4.2.1)
Response Reduction factor	R = 5 (clause 7.2.6)

Table 1 Structural details of model

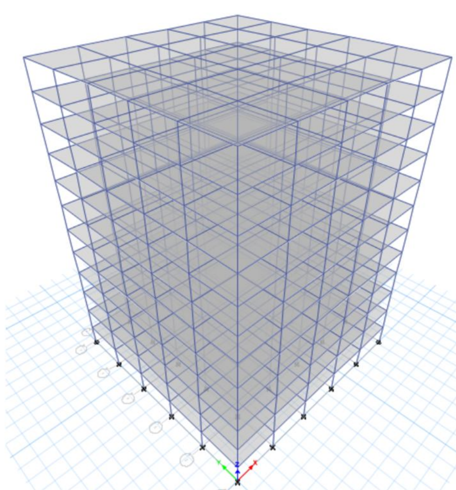

Fig. 1 TYPICAL 3D VIEW

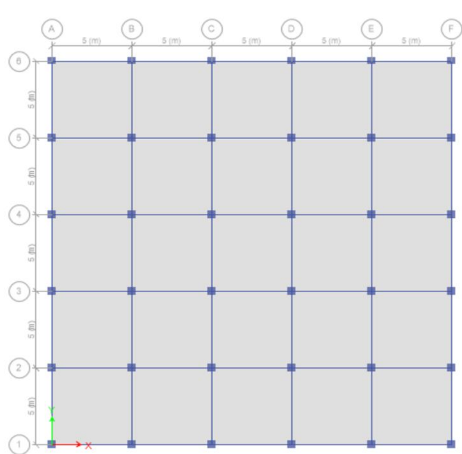

Fig. 2 PLAN (MODEL 1)

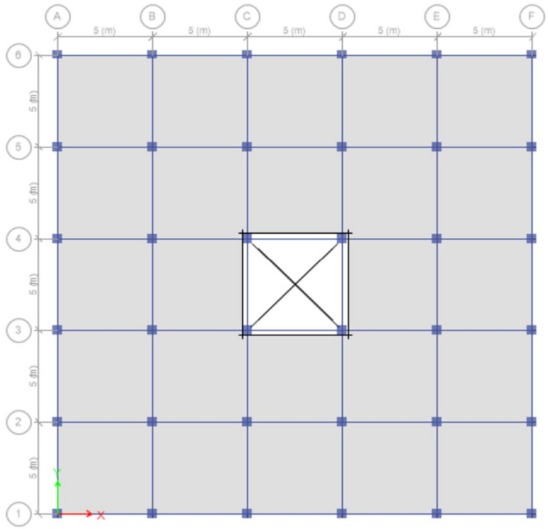

Fig. 3 PLAN (MODEL 2)

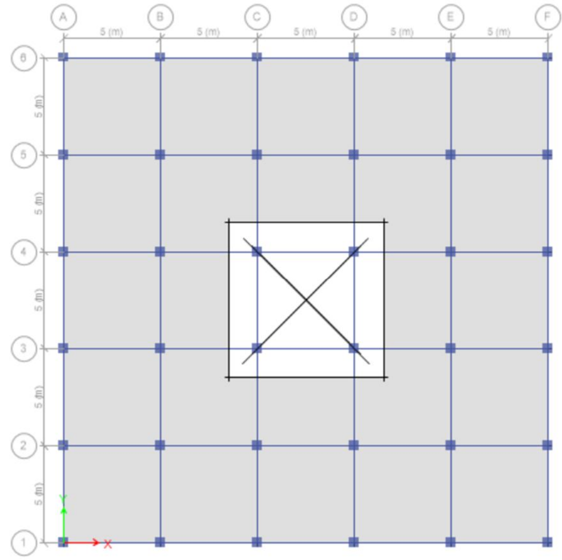

Fig. 4 PLAN (MODEL 3)

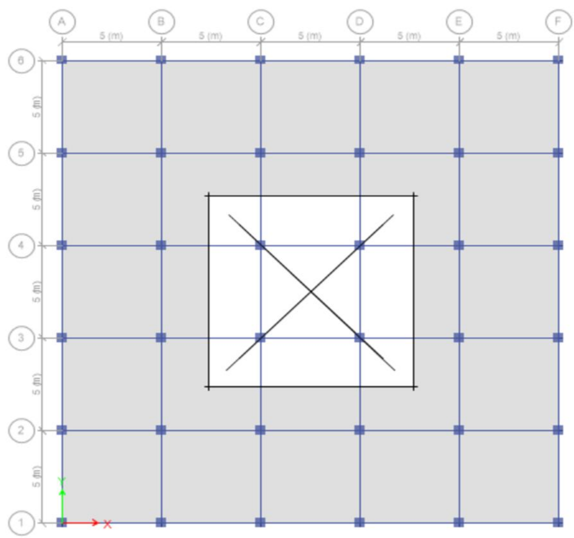

Fig. 5 PLAN (MODEL 4)

V. RESULT AND DISCUSSION

For a building to be well designed and to be reliable each and every engineering parameter must be analysed. For a dynamic analysis, pushover method approach has been used in this research. Result discussed in the study are in terms of:

A. Pushover Plot

A plot of total base shear versus top displacement in a structure is obtained by this analysis that would indicate a premature failure or weakness. If we talk about the performance of the building, the building must be so designed that it is having a minimum base shear as minimum as possible, because as the base shear is less it indicates that the building is experiencing a less amount of lateral forces at its base. Here, in this research it has been observed that as the percentage of the opening is increased the base shear is reduced which can be identified from the following plots. In the plots below, on the X-axis the displacement has been plotted and, on the Y-axis, the base shear has been plotted. Now, as we increase our percentage of the opening of the gross area of the plan it can be clearly seen that the base shear is reducing.

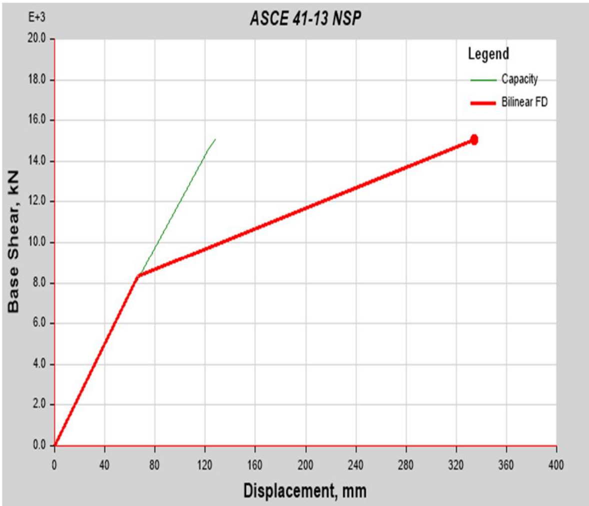

Fig. 6 Pushover Curve For Model 1

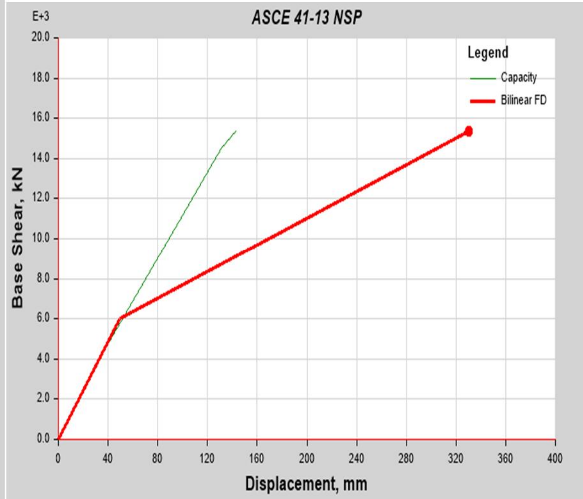

Fig. 7 Pushover Curve For Model 2

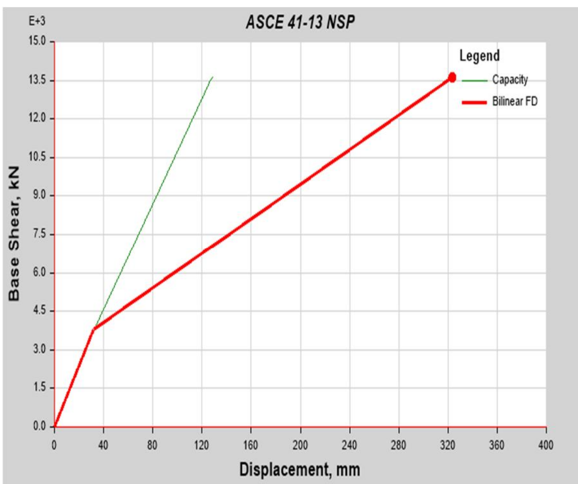

Fig. 8 Pushover Curve For Model 3

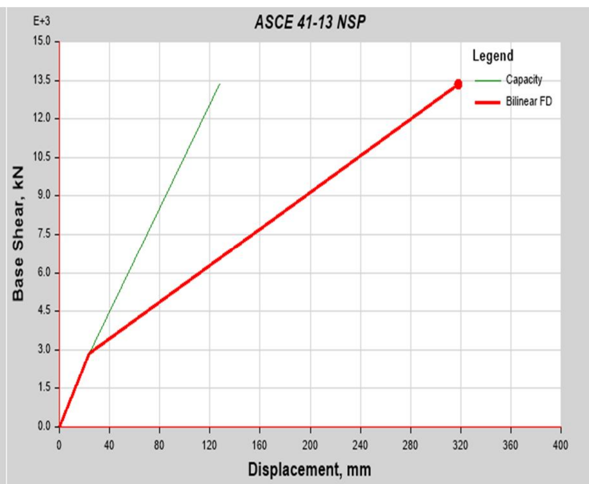

Fig. 9 Pushover Curve For Model 4

B. Base Shear

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.

Openings	Base shear(KN)
0%	15847.97
5%	15367.64
10%	13615
17%	13334

Table 2 Openings v/s Base Shear

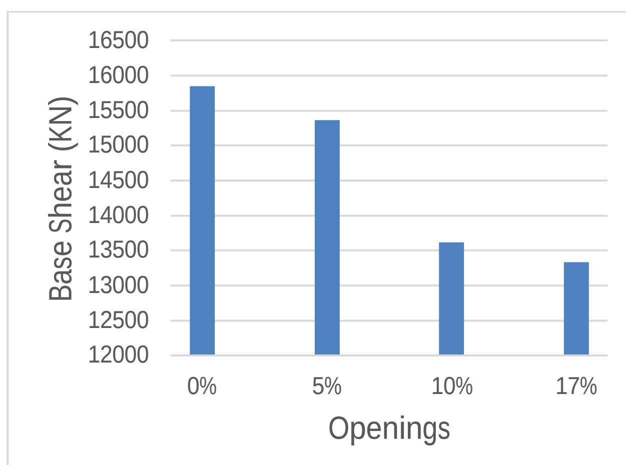

Fig. 10 BASE SHEAR V/S OPENING GRAPH

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C. *Maximum Storey Drift*

Storey drift is another type of engineering which has to be considered for a reliable designing. The Storey Drift is the lateral displacement of a floor relative to the floor below. From the plot shown below it is clear that when the percentage of the openings is increasing the storey drift is decreasing which indicates that as the percentage of the opening is increased the lateral displacement is reduced resulting in lesser storey drift. As per IS 1893, Storey Drift shall not exceed 0.004 times storey height.

storey	model 1	model 2	model 3	model 4
storey	storey drift X1	storey drift X2	storey drift X3	storey drift X4
Story12	0.000407	0.000207	0.000196	0.000169
Story11	0.000643	0.00032	0.000302	0.000258
Story10	0.000901	0.000447	0.000421	0.00036
Story9	0.001161	0.000575	0.000542	0.000463
Story8	0.00142	0.000703	0.000662	0.000566
Story7	0.001676	0.000829	0.000782	0.000667
Story6	0.00193	0.000954	0.0009	0.000768
Story5	0.002181	0.001078	0.001016	0.000867
Story4	0.002425	0.001198	0.001129	0.000964
Story3	0.002644	0.001305	0.001229	0.001049
Story2	0.002679	0.001319	0.001241	0.001059
Story1	0.001577	0.000773	0.000725	0.000618
Base	0	0	0	0

Table 3 Maximum Storey Drift

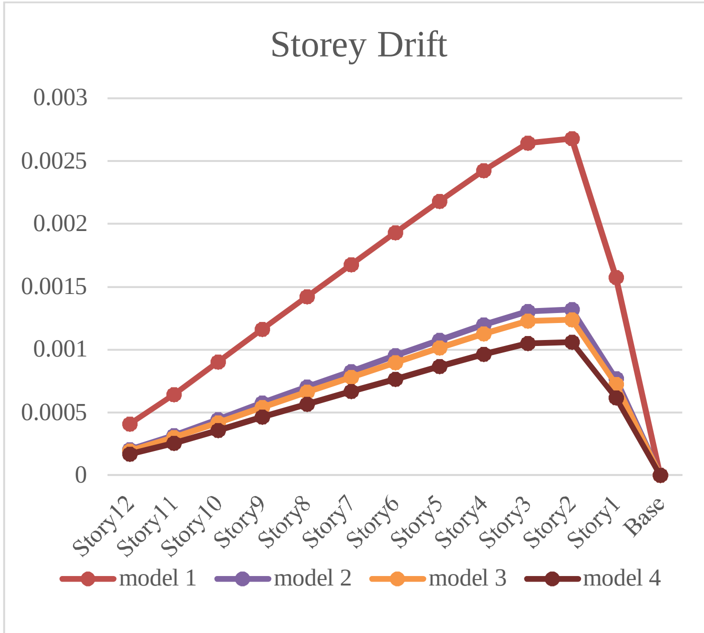

Fig. 11 MAXIMUM STOREY DRIFT GRAPH

D. *Maximum Storey Displacement*

It is another term related to the strcutural design. Storey displacement is some what similar to the storey drift but in storey displacement is the lateral displacement relative to the base of the structure. From the graph its is clear that as the percentage of the opening is increased in the building stoery displacement is reduced.

storey	model 1	model 2	model 3	model 4
storey	storey displacement X1	storey displacement X2	storey displacement X3	storey displacement X4
Story12	58.106	28.716	27.049	23.092
Story11	56.899	28.105	26.471	22.597
Story10	54.971	27.145	25.565	21.823
Story9	52.268	25.806	24.303	20.744
Story8	48.785	24.081	22.677	19.356
Story7	44.526	21.974	20.69	17.659
Story6	39.498	19.486	18.346	15.657
Story5	33.707	16.624	15.647	13.353
Story4	27.166	13.391	12.6	10.752
Story3	19.893	9.797	9.215	7.861
Story2	11.967	5.884	5.529	4.716
Story1	3.943	1.933	1.813	1.545
Base	0	0	0	0

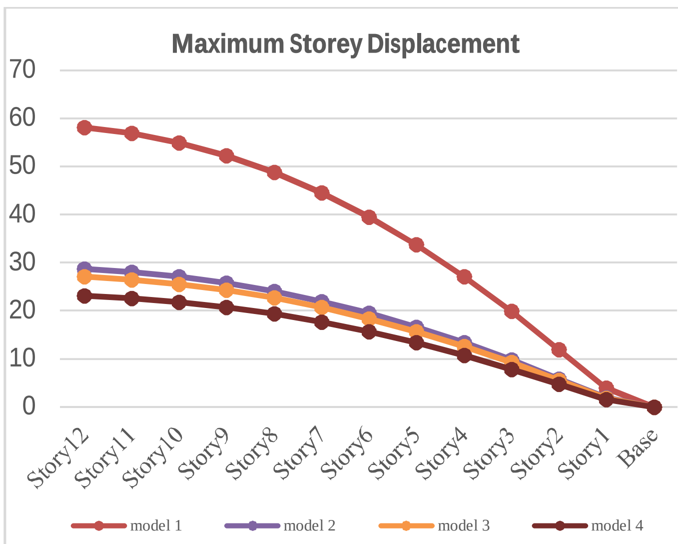

Table 4 Maximum Storey Displacement

Fig. 12 MAXIMUM STOREY DISPLACEMENT GRAPH

VI. CONCLUSION

From the analysis and investigation of the building for various engineering parameters it is observed that on providing diaphragm opening in the building the behaviour of the building is altered. After proper analysis it is observed that base shear is reduced which ultimately result in lesser seismic forces. In this investigation the diaphragm opening is symmetrical in both the direction which results in similar response of the concerning parameters. In Model 2 it is clear in that on providing 5% opening in the structure the base shear is decreased and similarly on further increasing the opening it is decreased significantly. Furthermore, it is also observed that on increasing the opening size storey drift, storey displacement & storey shear is decreased.

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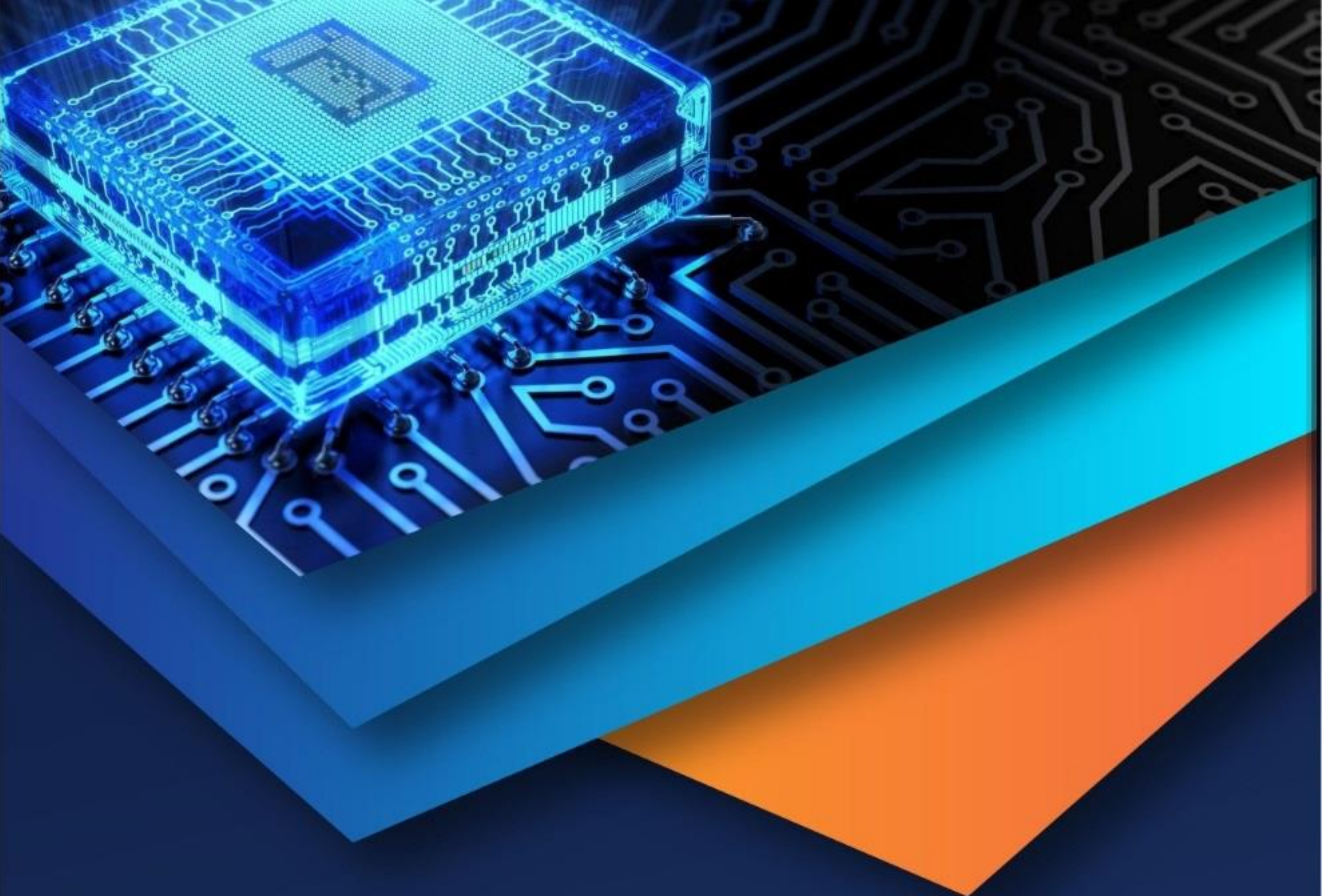

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