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Comparative Study on the Behaviour of RC Flat Slab Structures V/S Conventional RC

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Abstract: A three- dimensional RC structure with and without flat slab is modeled using ETABS 2016. Flat slab model with shear wall and perimeter beams are analyzed for earthquake loads using Response spectrum analysis. The results like displacement, storey drift , storey shears, Base reactions are extracted. Comparisons are made. Providing shear walls and perimeter beams significantly reduces displacement and storey drift. From the results it can be concluded that R C structure with flat slabs shows a better performance and preferred to the conventional RC slab.
.Keywords: Displacement, Storey drift, Storey shear, Base reaction, ETABS-2016.

I. INTRODUCTION

The scarcity of space in urban areas has led to the development of vertical growth consisting of low-rise, medium-rise and tall buildings. Generally framed structures are used for these buildings. They are subjected to. both vertical and lateral loads. Lateral loads due to wind and earthquake governs the design rather than the vertical loads. The buildings designed for vertical load may not have the capacity to resist the lateral loads. The lateral loads are the premier ones because in contrast to vertical load that may be assumed to increase linearly with height; lateral loads are quite variable and increase rapidly with height. Under a uniform wind and earthquake loads the overturning moment at the base is very large and varies in proportion to the square of the height of the building. The lateral loads are considerably higher in the top storey rather than the bottom storey due to which building tends to act as cantilever. These lateral forces tend to sway the frame. In many of the seismic prone areas there are several instances of failure of buildings which have not been designed for earthquake loads. All these reaction makes the study of the effect of lateral loads very important.

Pure rigid frame system or frame action obtained by the interaction of slabs, beam and column is not adequate. The frame alone fails to provide the required lateral stiffness for buildings taller than 15 to 20 (50m to 60m) stories. It is because of the shear taking component of deflection produced by the bending of columns and slab causes the building to deflect excessively. There are .two ways to satisfy these requirements. First is to increase the size of members beyond and above the strength requirements and .second is to change the form of .structure into more .rigid and stable to confine deformation. First approach has its own limits, whereas second one is more elegant which increases rigidity and stability of the structure and also confine the deformation requirement. In earthquake engineering, the structure is designed .for critical force condition among the load combination.

II. OBJECTIVES

A. To study The main objective of the analysis is to. study the different forces acting on a building. The analysis is carried out in. ETABS - 2016.
B. Conventional R.C.C structure and flat slab R.C.C for different. heights are modeled and analyzed for the different. combinations of Dynamic loading. The comparison is made between the conventional R.C.C structure and flat slab R.C.C. Buildings are situated in seismic. zone. IV.
C. To study the vulnerability of purely. frame and purely flat-slab models under different factors such as Storey. drift, lateral displacement, time. period and base shear have been obtained for SPECX (EX) and SPECY (EY) in zone IV. The axial load and moments in. columns have been obtained for various load combination in zone. IV.

III. METHODOLOGY

A 3D RC residential building is modeled. Flat is introduced at different levels for different models.
A. Model one with no flat slab.
B. Model two with flat slab at 1st floor
C. Model three with flat slab at 3rd floor
D. Model four with flat slab at 7th floor

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Flat slab model with perimeter beams are analyzed for earthquake loads.
Results like displacements, storey drifts, base reactions, response spectrum analysis, time history method are extracted.
The results are compared with the conventional building.
Conclusions are made accordingly.

IV. MODELING

It includes the modeling of G+9 storey building. It is modeled with RCC elements.

Following are the types of models prepared for the analysis,

1) *MODEL 1:* Conventional structure with no flat slab
2) *MODEL 2:* A structure with flat slab at first floor
3) *MODEL 3:* A structure with flat slab at third floor
4) *MODEL 4:* A structure with flat slab at seventh floor.

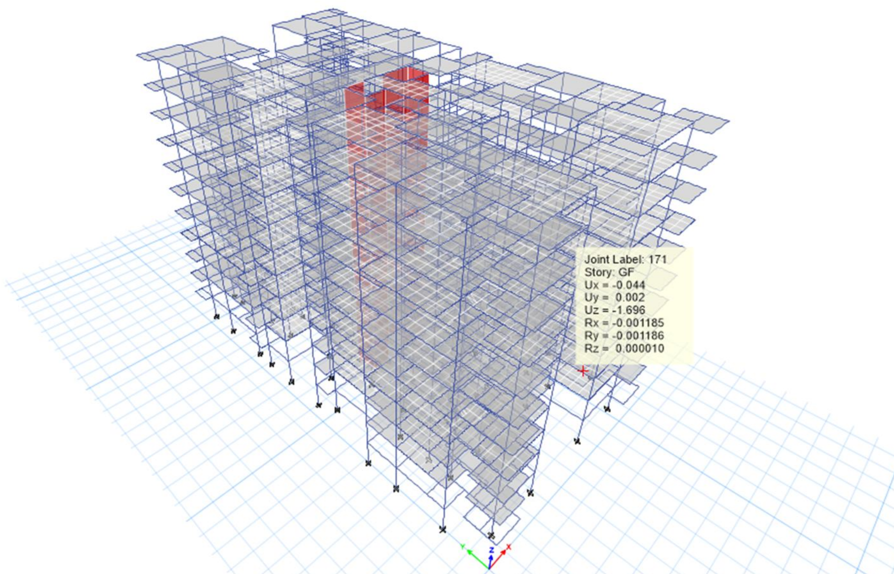

Fig 1 3D model of the RCC residential building

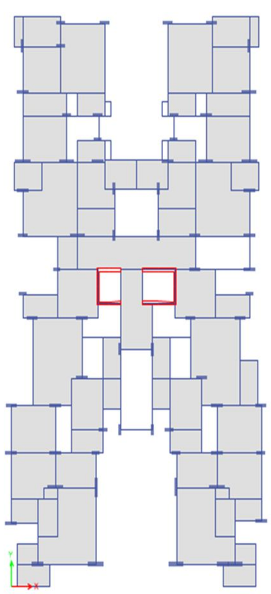

Fig 2 Floor plan

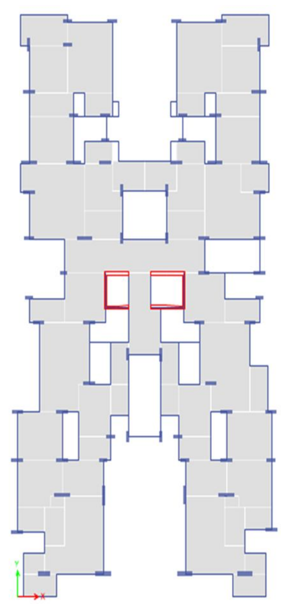

Fig 3 Floor Plan with Flat Slab

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V. RESULT AND DISCUSSION

A. Maximum storey displacement

Table 1 Maximum Storey displacement(Model 1)

TABLE: Storey Response		eqx		Eqy		Specx		Specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	M	mm	mm	Mm	mm	mm	Mm	mm	Mm
TERRACE	33	9.11	1.266	0.902	13.81	39.253	21.05	10.547	64.02
9	30	8.502	1.192	0.761	11.01	37.06	13.603	10.07	49.159
8	27	7.797	1.096	0.626	8.592	34.375	9.354	9.465	37.062
7	24	7.001	0.975	0.532	7.593	31.459	8.621	8.73	31.975
6	21	6.095	0.848	0.458	6.623	28.068	7.785	7.814	28.528
5	18	5.084	0.708	0.373	5.474	23.795	6.639	6.704	23.686
4	15	4.025	0.561	0.293	4.299	19.158	5.362	5.48	18.93
3	12	3.004	0.398	0.231	3.233	14.871	4.219	4.24	14.498
2	9	2.036	0.264	0.168	2.509	10.604	3.113	2.975	11.574
1	6	1.121	0.154	0.091	1.456	5.957	1.807	1.677	6.907
GF	3	0.614	0.148	0.049	0.529	2.168	1.047	0.882	2.561
Base	0	0	0	0	0	0	0	0	0

Table 2 Maximum Storey displacement(Model 2)

TABLE: Storey Response		eqx		eqy		specx		Specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	m	mm	mm	mm	mm	mm	mm	mm	Mm
TERRACE	33	42.02	1.266	1.283	328.047	19.343	2.225	4.8E-06	0.00007038
9	30	36.12	1.183	1.088	278.48	16.422	2.133	4.5E-06	0.0000596
8	27	30.257	1.067	0.905	229.29	13.555	2	4.2E-06	0.00004899
7	24	24.508	0.931	0.74	181.251	10.797	1.827	3.8E-06	0.00003872
6	21	18.99	0.779	0.609	135.532	8.215	1.619	3.3E-06	0.00002902
5	18	13.853	0.616	0.482	93.621	5.882	1.382	2.8E-06	0.00002017
4	15	9.27	0.453	0.363	57.248	4.048	1.119	2.3E-06	0.00001252
3	12	5.431	0.303	0.255	28.32	2.997	0.835	1.7E-06	0.000006426
2	9	2.541	0.182	0.163	8.867	1.964	0.546	1.1E-06	0.000002478
1	6	1.081	0.075	0.088	1.092	1.069	0.306	6.3E-07	0.00000138
GF	3	0.558	0.18	0.037	0.471	0.44	0.238	3E-07	0.000000589
Base	0	0	0	0	0	0	0	0	0

Table 3 Maximum Storey displacement(Model 3)

TABLE: Storey Response		eqx		eqy		Specx		Specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	m	mm	mm	mm	mm	mm	mm	mm	Mm
TERRACE	33	23.91	1.155	1.172	139.659	131.543	9.606	66.955	151.021
9	30	20.159	1.073	0.99	113.386	106.101	9.202	54.832	121.376
8	27	16.445	0.959	0.82	87.491	81.113	8.606	42.865	92.571
7	24	12.843	0.825	0.67	62.745	57.389	7.823	31.368	65.648
6	21	9.47	0.681	0.547	40.32	36.213	6.876	20.816	42.063
5	18	6.475	0.54	0.431	21.702	22.388	5.789	11.831	23.933
4	15	4.029	0.412	0.332	8.621	17.937	4.627	7.457	18.554
3	12	2.798	0.277	0.254	3.12	13.749	3.619	5.646	14.077
2	9	1.833	0.214	0.18	2.157	10.24	2.688	3.839	11.103
1	6	1.031	0.152	0.111	1.205	6.367	1.57	2.117	6.776
GF	3	0.556	0.147	0.045	0.496	2.091	0.977	1.052	2.298
Base	0	0	0	0	0	0	0	0	0

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Table 4 Maximum Storey displacement(Model 4)

TABLE: Storey Response		eqx		eqy		Specx		Specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	M	mm	mm	mm	mm	mm	mm	mm	Mm
TERRACE	33	8.827	1.113	1.077	12.972	38.828	18.82	14.644	54.067
9	30	8.245	1.053	0.928	10.514	36.176	12.446	13.91	43.633
8	27	7.561	0.974	0.783	8.559	33.604	8.698	13.023	37.378
7	24	6.776	0.868	0.677	7.705	30.787	8.04	11.945	33.983
6	21	5.908	0.763	0.592	7.14	27.581	7.33	10.654	32.422
5	18	4.956	0.647	0.495	6.617	23.666	6.358	9.151	33.522
4	15	3.931	0.541	0.424	5.685	19.271	5.245	7.464	32.275
3	12	2.889	0.421	0.323	4.397	14.591	4.759	5.661	27.658
2	9	1.904	0.279	0.211	2.922	9.884	3.711	3.829	20.082
1	6	1.065	0.142	0.107	1.504	5.418	2.168	2.092	11.147
GF	3	0.551	0.142	0.053	0.499	2.104	1.001	1.04	3.381

From the results obtained it can be seen that displacement values are high for the conventional RC structure.

B. Maximum storey drift

Table 5 Maximum Storey drift (Model 1)

TABLE:Storey Response		eqx		eqy		specx		specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	m								
TERRACE	33	0.0003	0.000051	0.000047	0.000933	0.001542	0.002552	0.000257	0.00529
9	30	0.000288	0.000051	0.000045	0.000806	0.001471	0.002187	0.000276	0.004511
8	27	0.000267	0.000051	0.000034	0.000419	0.001256	0.00118	0.000263	0.002273
7	24	0.000302	0.000046	0.000029	0.000326	0.001179	0.00032	0.000318	0.001297
6	21	0.000338	0.000049	0.000031	0.000434	0.001455	0.000394	0.00038	0.001774
5	18	0.000354	0.000052	0.000032	0.000464	0.001567	0.000433	0.000414	0.001947
4	15	0.00034	0.000054	0.000025	0.000355	0.001466	0.000385	0.000417	0.001494
3	12	0.000323	0.000049	0.000024	0.00034	0.001494	0.000388	0.000424	0.001501
2	9	0.000306	0.00004	0.000026	0.000351	0.001573	0.000436	0.000434	0.001571
1	6	0.000296	0.000095	0.000022	0.000335	0.001323	0.000404	0.000444	0.001571
GF	3	0.000205	0.000027	0.000015	0.000176	0.000723	0.000231	0.000293	0.000854
Base	0	0	0	0	0	0	0	0	0

Table 6 Maximum Storey drift (Model 2)

TABLE: Storey Response		eqx		eqy		specx		specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	m								
TERRACE	33	0.001966	0.000043	0.000065	0.016522	0.001001	0.000221	0	0
9	30	0.001954	0.000039	0.000061	0.016397	0.00099	0.000204	0	0
8	27	0.001916	0.000046	0.000055	0.016013	0.00096	0.000162	0	0
7	24	0.001839	0.000051	0.00005	0.01524	0.000905	0.000098	0	0
6	21	0.001712	0.000054	0.000047	0.01397	0.000824	0.000083	0	0
5	18	0.001528	0.000055	0.000043	0.012124	0.00072	0.00009	0	0
4	15	0.001279	0.00005	0.000037	0.009643	0.000591	0.000099	0	0
3	12	0.000963	0.000041	0.000032	0.006484	0.000432	0.000101	0	0
2	9	0.000577	0.000037	0.000025	0.002621	0.000299	0.00008	0	0
1	6	0.000261	0.000083	0.000019	0.000279	0.000233	0.000067	0	0
GF	3	0.000186	0.000016	0.000012	0.000157	0.000147	0.000044	0	0
Base	0	0	0	0	0	0	0	0	0

Table 7 Maximum Storey drift (Model 3)

TABLE: Storey Response		eqx		eqy		specx		specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	m								
TERRACE	33	0.00125	0.00005	0.000061	0.008758	0.008545	0.000566	0.00404	0.010096
9	30	0.001238	0.00005	0.000057	0.008633	0.00843	0.000516	0.003992	0.009888
8	27	0.001201	0.00005	0.00005	0.008249	0.008075	0.000399	0.003843	0.009327
7	24	0.001124	0.00005	0.000045	0.007476	0.007367	0.000333	0.003541	0.008329
6	21	0.000998	0.00005	0.00004	0.006207	0.006232	0.000375	0.003052	0.006844
5	18	0.000816	0.00005	0.000039	0.004361	0.004632	0.000395	0.002351	0.00479
4	15	0.000569	0.00005	0.00003	0.00188	0.002576	0.000341	0.001427	0.002068
3	12	0.000358	0.000039	0.000027	0.000385	0.001437	0.000335	0.000602	0.001434
2	9	0.00028	0.000028	0.000028	0.000327	0.001451	0.000374	0.000574	0.001451
1	6	0.000266	0.00008	0.000024	0.000272	0.001429	0.00035	0.000559	0.001533
GF	3	0.000185	0.00002	0.000014	0.000165	0.000697	0.000188	0.00035	0.000769
Base	0	0	0	0	0	0	0	0	0

Table 8 Maximum Storey drift (Model 4)

TABLE: Storey Response		eqx		eqy		specx		specy	
Storey	Elevation	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir	X-Dir	Y-Dir
	m								
TERRACE	33	0.000307	0.000058	0.00005	0.000819	0.001462	0.002191	0.000344	0.003705
9	30	0.000296	0.000058	0.000048	0.000702	0.00141	0.001892	0.00037	0.003146
8	27	0.000262	0.000058	0.000037	0.000347	0.00125	0.001062	0.000377	0.001508
7	24	0.000304	0.00004	0.000034	0.000323	0.001182	0.000368	0.000475	0.001346
6	21	0.000318	0.000039	0.00004	0.000375	0.001369	0.000386	0.000517	0.001584
5	18	0.000342	0.000047	0.000037	0.00039	0.001505	0.000383	0.000571	0.001689
4	15	0.000347	0.000049	0.000036	0.000429	0.001583	0.000407	0.000606	0.001717
3	12	0.000333	0.000047	0.000037	0.000492	0.001593	0.000413	0.000614	0.002573
2	9	0.000298	0.000045	0.000035	0.000473	0.00149	0.000517	0.000581	0.002995
1	6	0.000272	0.000086	0.000026	0.000359	0.001212	0.000496	0.000554	0.002591
GF	3	0.000184	0.000023	0.000016	0.000166	0.000701	0.000227	0.000346	0.001127
Base	0	0	0	0	0	0	0	0	0

From the results we can say that drift is more in model without flat slab.

C. Base reaction

Table 9 Base Reaction Model 1

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
	kN	kN	kN	kN-m	kN-m	kN-m
eqx	-2344.1106	-6.561E-07	0	-14.3527	-59080.2249	55011.1136
eqy	-0.0004	-1791.4401	0	45102.1941	-0.0112	-22434.2886
specx Max	11351.3394	1162.1319	7.348E-07	25951.8192	255092.6548	281114.1249
specy Max	1162.1281	8633.4318	0.00000057	190317.9541	26282.9192	124532.9419

Table 10 Base Reaction Model 2

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
	kN	kN	kN	kN-m	kN-m	kN-m
eqx	-2204.119	0	0	-14.6179	-56120.417	51539.0658
eqy	-0.00001981	-1637.4925	0	41649.2886	-0.0024	-20562.4985
specx Max	2204.2268	230.9801	0	5136.0246	50021.8658	53614.1066
specy Max	0.0003	0.0021	0	0.0451	0.0066	0.0315

Table 11 Base Reaction Model 3

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
	kN	kN	kN	kN-m	kN-m	kN-m
Eqx	-2207.1639	-7.027E-07	5.874E-07	-14.0698	-55933.1095	51621.1997
Eqy	-0.0003	-1654.6612	0	41886.7632	-0.0077	-20776.2675
specx Max	10360.9405	1079.7931	0.00000229	23815.1768	232984.3473	250041.2948
specy Max	1079.7905	7816.101	0.000001371	171273.4451	24209.7516	117322.1894

Table 12 Base Reaction Model 4

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
	kN	kN	kN	kN-m	kN-m	kN-m
Eqx	-2139.1896	- 0.000003064	7.354E-07	-14.6234	- 54443.4561	50071.7303
Eqy	0.0003	-1600.891	0	40700.0447	0.0054	-20085.6723
specx Max	10342.7597	1140.4046	0.000002976	25838.6947	236928.362	249489.7144
specy Max	1140.4072	7685.3966	8.338E-07	172461.8818	26147.0693	117421.2553

Moments and the forces of all models are tabulated.

D. Comparison Of Different Parameters

Table 13 Comparison

Model	Base Reaction (kN)		Displacement (mm)		Drift	
	X	Y	X	Y	X	Y
1	11352	8633.4	21	64	0.0015	0.0053
2	2204	0.002	19.34	0.00007	0.001	0
3	10360	7816	131.5	151	0.0085	0.01
4	10342	7685	38.8	54.06	0.0014	0.003

The above table shows the comparison of various parameters, where

1) Model 1 is the conventional RC building.
2) Models 2,3,4 are provided with flat slabs.
3) Shear wall and perimeter beams are provided for flat slab structure for reduction of displacement and storey drifts.

Model two has least storey drift and displacements. Flat slab has been provided at the first floor of the structure.

VI. CONCLUSIONS

Following conclusions can be made from the above results,

A. Shear walls in flat slab structures helps in reduction of storey drift and storey displacement.
B. Perimeter beams also significantly help in reduction of storey drift and storey displacement.
C. The structures with shear wall and perimeter beam in flat slabs are more preferable than the conventional RC structure.

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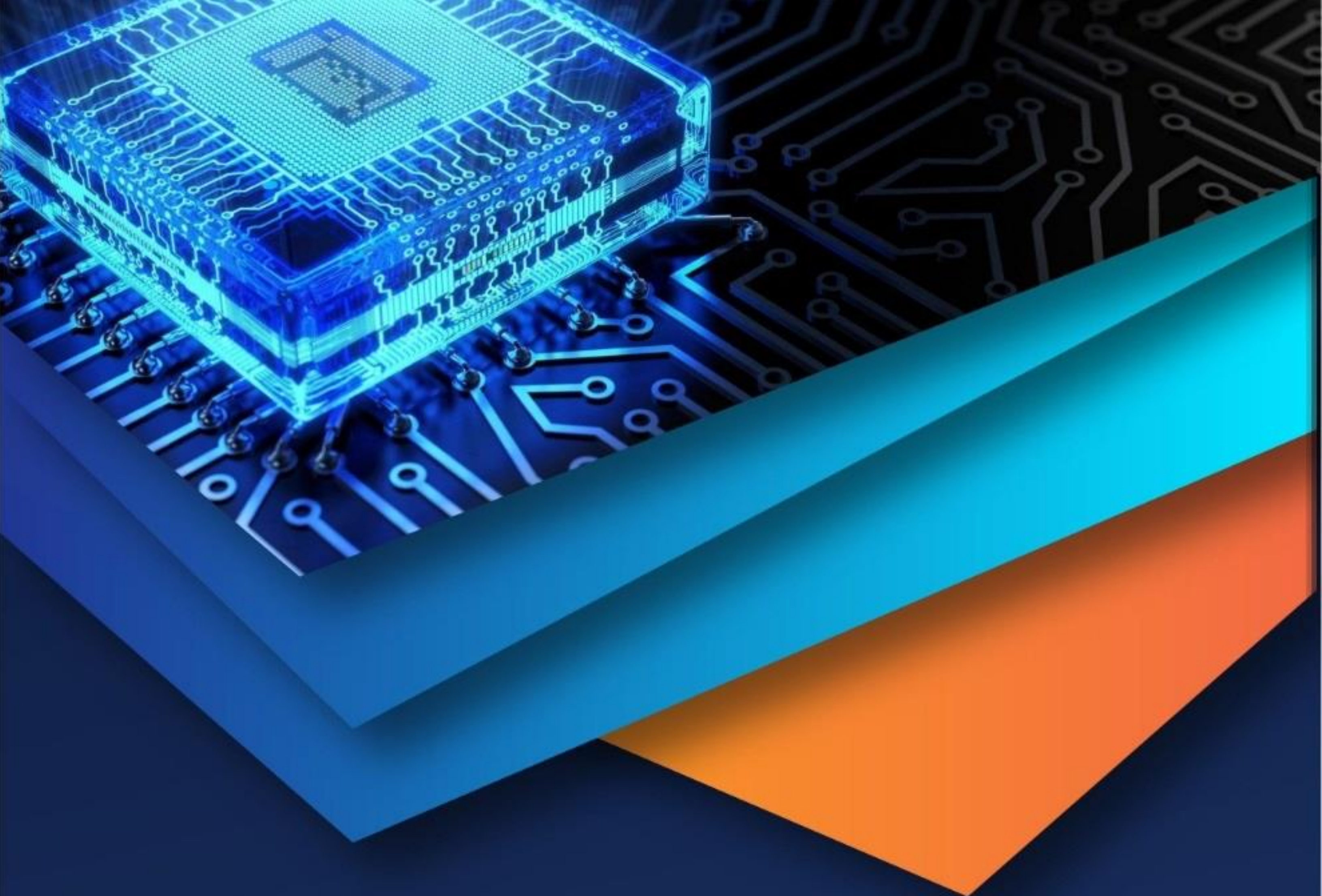

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