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Analysis & Design of Tall RC Chimney as per IS Code

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Abstract: Chimneys are generally intended for critical loads of earthquake or wind production. It is necessary to analyze dynamic chimney reaction due to earthquakes and wind loads. The chimney is a high and flexible structure, it is expected that the wind loads will be more critical than the earthquake loads. This article analyzes two RC chimneys for earthquakes and wind loads. Earthquakes analysis carried out for 1893 (Part 4): 2005 and wind analysis carried out by 4998 (Part 1): 1992. Such chimneys are now developed according to the Indian Standard Code of Practice (is 4998). The main loads that will be examined during the analysis are high structures such as wind flues loads, temperature loads and seismic loads in addition to dead loads. They are designed using a working stress method. Chimney-a wind structure, ie the structure in which the design of wind loads play dominant. The analysis is carried out for the tall RC chimney in the software STAAD-PRO. The results obtained in terms of forces and stresses.
Keywords: Chimney, STAAD, stress, tall & wind load

I. INTRODUCTION

As large-scale industrial developments around the world, a large number of high chimneys will need to be built every year. The main function of the chimney is the discharge of poisonous gases at a higher altitude, such that gases do not pollute the surrounding atmosphere. Due to the increased demand for air pollution, the chimney height rises from the last few decades, but the chimneys are high shapely structures, usually with circular cross sections, they have different related structural problems and should therefore be treated separately from other forms of tower structures. Analysis and design of the chimney depends on various factors, such as wind power, environmental conditions, the types of materials used and the cross-sectional area of the chimney. Chimneys above the height of 150 m are considered as high chimneys. High RC chimneys form an important part of major industries and power plants.

Function of the chimney: chimney is a means by which the gas waste is discharged at a high altitude, so that after dilution through atmospheric turbulence, their concentration and that of their trained solids within the permissible limits to achieve the Earth. The chimney achieves simultaneous reduction of the concentration of a number of pollutants such as sulfur dioxide, Fly Ash, etc. and be very reliable it does not require waiting. Although it is a different merit, it is good to remember that the chimney is not a complete solution to the pollution problem

II. REVIEW OF LITERATURE

A detailed review of the literature is conducted in the framework of this study on wind engineering, design and analysis of reinforced concrete chimneys. The estimation of wind effects such as along the wind and through wind methods is studied. There is no literature published on the effect of stress due to the presence of flue ducts. For this study is taken a typical reinforced concrete chimney height of 275m. The chimney is simulated as a two-dimensional element of the beam and three-dimensional elements of the plate. Both models are analyzed for the wind load. After the analysis of the chimney, the stress around the corners of the flue duct are studied for two different holes such as a rectangular hole and a semicircular hole. It is seen that the compression emphasizes around the angles significantly reduced by around 30% and also seen that as wind speed increases, along wind load also increases (B. Jose Ravindraraj et al, 2016).

All the criteria involved in the analysis and design of reinforced concrete chimneys are examined and analyzed. All the cargoes which should be considered during the analysis of the chimney phase are taken into account. Of all the loads considered the most important were wind loads. Earthquake loads and seismic loads have not proven to be critical for design. The design of the chimney is mainly engaged in the analysis of the concrete shell in various areas and the search for stresses in steel as well as concrete and ensuring that they are within admissible limits in accordance with the provisions of Codal. The methods proposed by the code are studied. However, the calculation was performed using the response spectrum method. This profile was calculated and built. Loads due to seismic action were discovered much less than the wind speed, and hence it would not be a major consideration in the design (S.Sowjanya Lakshmi, 2017).

Seismic reaction of high chimneys largely influenced the soil support of its base and the nature of excitation affects the foundation. Ignoring any of them, can significantly affect the performance of the chimney during the earthquake and lead to devastating consequences. Most researchers have made an analysis on the chimney under seismic loading. Most of them have used STADD and SAP2000 software for modeling and chimney analysis, but still there is a lack of study of the structural behavior and the performance of the flue chimney, so now it is necessary to find out the seismic behavior of the flue chimney by means of modal analysis using the time journal method in ANSYS and to check and compare the range of H/D ratio and find the optimal (best) chimney for various loads, stresses and material properties (Ratnadeep R. Fulari, 2017).

III. MODELING:

The modeling of chimney considered for the top diameter of 45m, bottom diameter of 90m, variation in height of 100 m and 120 m while the plate thickness varies from 0.25, 0.3, 0.4 and 0.5. The following analysis is carried out in STAAD-PRO software.

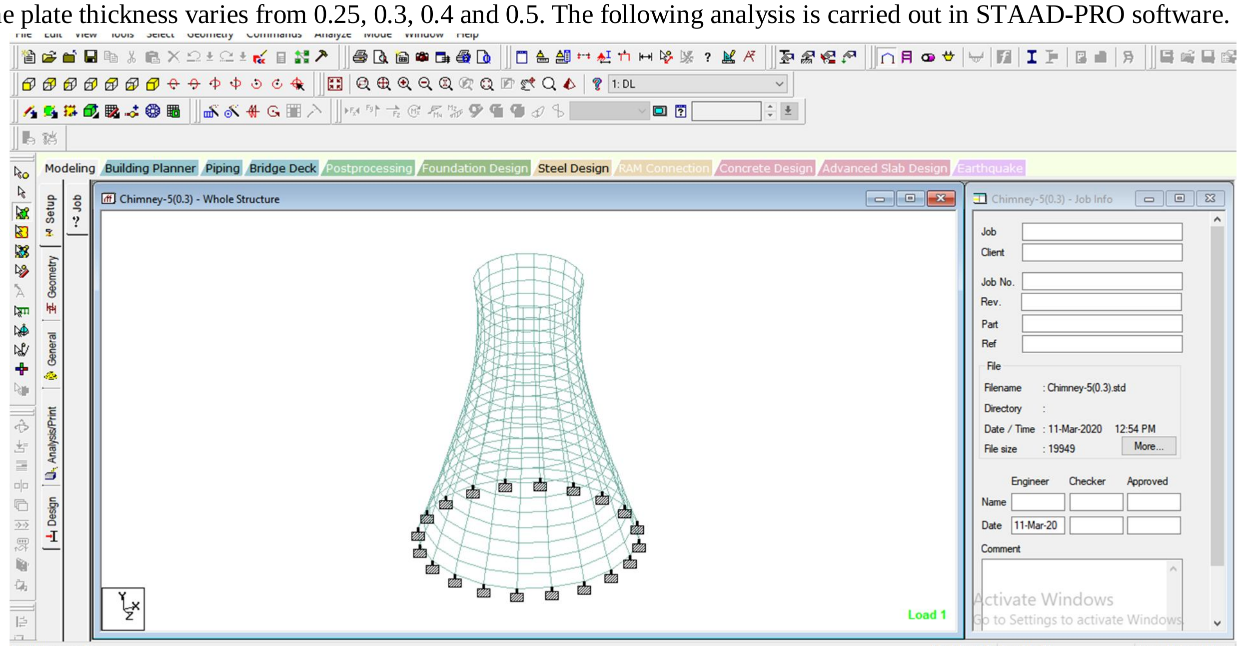

Fig.1: Modeling in STAAD-PRO

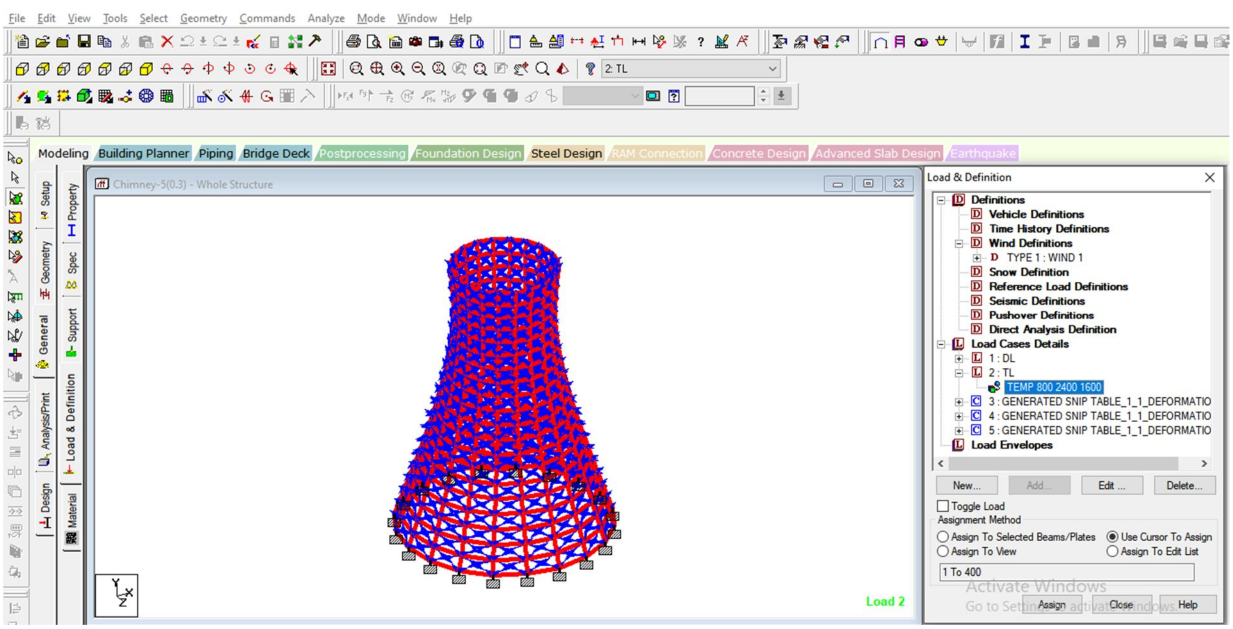

Fig.2: Load combination for Chimney

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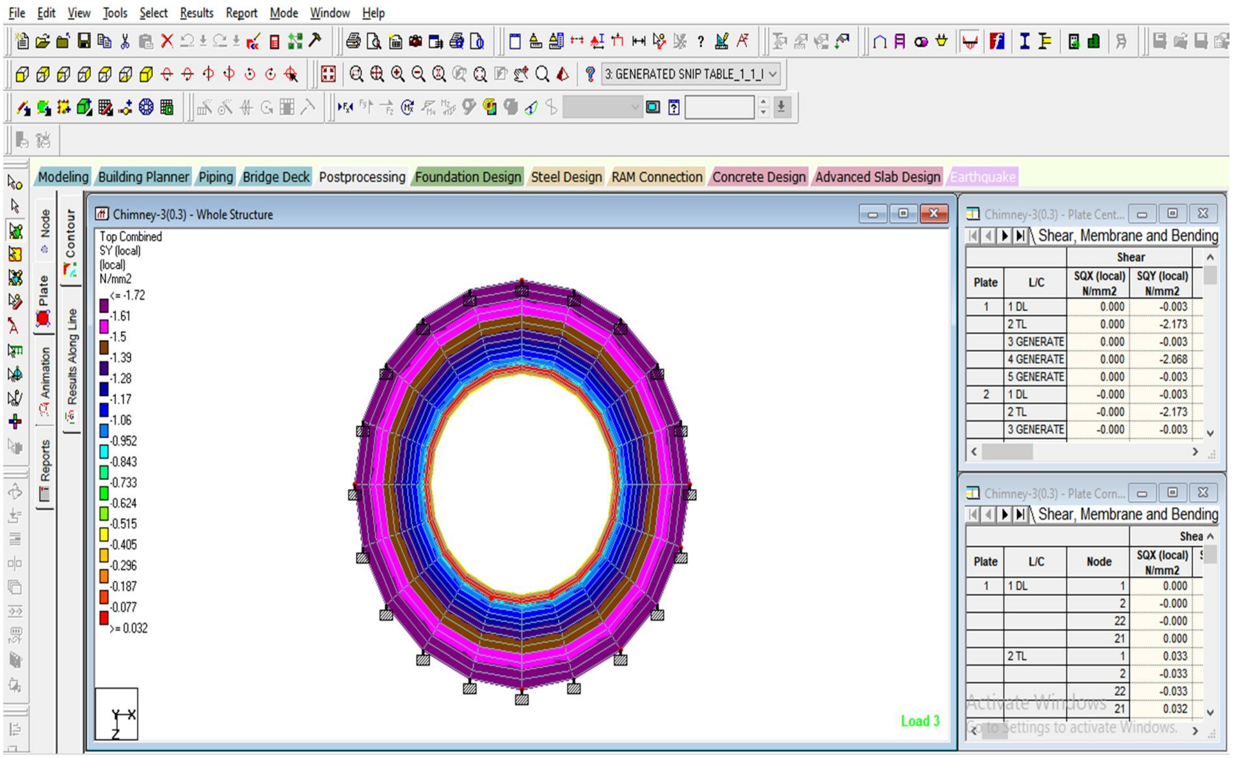

Fig.3: Top Combined stress for chimney

IV. RESULTS

The results are obtained for the chimney with different height of 100 m and 120 m, the different analysis obtained as follows.

Table 1: Reaction for Chimney model (120 height)

		Horizontal	Vertical	Horizontal	Moment		
	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	416	56439.984	4.299	0.412	30.814	-10.481	-22603.262
Min Fx	406	-56439.984	4.299	-0.412	-30.814	-10.481	22603.262
Max Fy	401	0.539	7955.371	-56354.328	-18616.396	-9.886	-29.152
Min Fy	404	-45656.953	-8.376	-33172.371	-13293.425	0.186	18295.084
Max Fz	411	-0.412	4.299	56439.984	22603.262	-10.481	30.814
Min Fz	401	0.412	4.299	-56439.984	-22603.262	-10.481	-30.814
Max Mx	411	-0.412	4.299	56439.984	22603.262	-10.481	30.814
Min Mx	401	0.412	4.299	-56439.984	-22603.262	-10.481	-30.814
Max My	405	-53675.047	0.46	-17439.41	-6940.307	11.706	21513.744
Min My	403	-33173.527	1.355	-45660.457	-18316.234	-11.84	13249.705
Max Mz	406	-56439.984	4.299	-0.412	-30.814	-10.481	22603.262
Min Mz	416	56439.984	4.299	0.412	30.814	-10.481	-22603.262

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Table 2: Reaction for Chimney model (100 height)

		Horizontal	Vertical	Horizontal	Moment		
	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	416	49516.199	1.568	-0.018	-1.093	-0.026	-12856.809
Min Fx	406	-49516.199	1.568	0.018	1.093	-0.026	12856.809
Max Fy	401	0.021	5986.612	-48986.105	-10386.352	0	1.033
Min Fy	405	-47091.066	-1.082	-15300.603	-3967.566	1.138	12230.124
Max Fz	411	0.018	1.568	49516.199	12856.809	-0.026	-1.093
Min Fz	401	-0.018	1.568	-49516.199	-12856.809	-0.026	1.093
Max Mx	411	0.018	1.568	49516.199	12856.809	-0.026	-1.093
Min Mx	401	-0.018	1.568	-49516.199	-12856.809	-0.026	1.093
Max My	405	-47091.066	-1.082	-15300.603	-3967.566	1.138	12230.124
Min My	403	-29104.568	0.106	-40058.945	-10406.44	-1.54	7551.623
Max Mz	406	-49516.199	1.568	0.018	1.093	-0.026	12856.809
Min Mz	416	49516.199	1.568	-0.018	-1.093	-0.026	-12856.809

Table 3: Bending analysis of Chimney (100 m height)

		Shear		Membrane			Bending Moment	
	Plate	SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	Mxy kNm/m
Max Qx	4	0	-2.173	-2.109	-0.432	0	-4379.505	0
Min Qx	3	0	-2.173	-2.109	-0.432	0	-4379.508	0.001
Max Qy	384	0	2.633	-107.788	-0.882	0	-4651.015	0
Min Qy	1	0	-2.173	-2.109	-0.432	0	-4379.509	0.01
Max Sx	365	0	-0.52	6.965	0.206	0	-4799.012	0.001
Min Sx	382	0	2.633	-107.788	-0.883	0	-4651.013	0.001
Max Sy	364	0	-0.52	6.964	0.207	0	-4799.017	0
Min Sy	381	0	2.498	-102.721	-2.554	0	-4418.475	0
Max Sxy	381	0	2.633	-107.788	-0.884	0	-4651.015	0
Min Sxy	385	0	2.633	-107.788	-0.883	0	-4651.013	0
Max Mx	4	0	-0.003	0.076	-0.061	0	0.263	0
Min Mx	364	0	-0.52	6.964	0.207	0	-4799.017	0
Max My	1	0	-0.003	0.076	-0.061	0	0.263	0
Min My	361	0	-0.52	6.965	0.206	0	-4799.016	0
Max Mxy	1	0	-2.173	-2.109	-0.432	0	-4379.509	0.01
Min Mxy	5	0	-2.173	-2.109	-0.432	0	-4379.518	-0.011

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Table 4: Bending Analysis of Chimney (120 m Height)

		Shear		Membrane			Bending Moment	
	Plate	SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m
Max Qx	4	0	-1.811	-6.573	-0.423	0	-4463.133	-3366.343
Min Qx	2	0	-1.811	-6.573	-0.424	0	-4463.171	-3366.348
Max Qy	384	0	1.997	-103.499	-0.715	0	-4665.501	-4430.232
Min Qy	1	0	-1.811	-6.573	-0.424	0	-4463.161	-3366.322
Max Sx	362	0	-0.405	9.485	0.177	0	-4780.183	-5086.72
Min Sx	382	0	1.996	-103.501	-0.725	0	-4665.498	-4430.231
Max Sy	364	0	-0.405	9.483	0.181	0	-4780.192	-5086.707
Min Sy	385	0	1.893	-98.699	-2.627	0	-4432.22	-4208.673
Max Sxy	363	0	-0.405	9.483	0.181	0	-4780.183	-5086.702
Min Sxy	225	0	-0.002	-0.29	-1.369	0	-4474.534	-4474.504
Max Mx	3	0	-0.003	0.063	-0.073	0	0.258	1.347
Min Mx	361	0	-0.405	9.484	0.179	0	-4780.193	-5086.729
Max My	3	0	-0.003	0.063	-0.073	0	0.258	1.347
Min My	361	0	-0.405	9.484	0.179	0	-4780.193	-5086.729
Max Mxy	1	0	-1.811	-6.573	-0.424	0	-4463.161	-3366.322
Min Mxy	125	0	0	-0.003	0	0	-4710.031	-4710.007

Table 5: Stresses in Chimney (100 m height)

		Principal		Von Mis		Tresca	
	Plate	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2
Max Principal (top)	4	0.093	0.058	0.082	0.19	0.093	0.212
Min Principal (top)	381	-417.856	202.279	370.822	256.229	417.856	288.13
Max Principal (bottom)	365	-312.969	346.127	330.56	336.925	345.714	346.127
Min Principal (bottom)	383	-1.717	-1.712	1.581	1.576	1.717	1.712
Max Von Mis (Top)	381	-289.897	288.13	370.822	256.229	417.856	288.13
Min Von Mis (top)	5	0.029	-0.138	0.074	0.171	0.084	0.191
Max Von Mis (Bottom)	361	-312.969	346.127	330.561	336.925	345.715	346.127
Min Von Mis (bottom)	24	-0.178	-0.15	0.186	0.16	0.192	0.169
Max Tresca (top)	381	-289.897	288.13	370.822	256.229	417.856	288.13
Min Tresca (top)	5	0.029	-0.138	0.074	0.171	0.084	0.191
Max Tresca (bottom)	365	-312.969	346.127	330.56	336.925	345.714	346.127
Min Tresca (bottom)	24	-0.178	-0.15	0.186	0.16	0.192	0.169

Table 6: Stresses in Chimney (120 m height)

		Principal		Von Mis		Tresca	
	Plate	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2
Max Principal (top)	3	0.08	0.046	0.074	0.19	0.08	0.209
Min Principal (top)	382	-414.534	207.532	369.818	262.162	414.534	294.624
Max Principal (bottom)	364	-309.197	339.295	325.086	333.868	338.933	339.295
Min Principal (bottom)	383	-1.935	-1.942	1.778	1.785	1.935	1.942
Max Von Mis (Top)	382	-296.073	294.624	369.818	262.162	414.534	294.624
Min Von Mis (top)	1	0.015	-0.147	0.066	0.171	0.072	0.188
Max Von Mis (Bottom)	361	-309.196	339.295	325.088	333.868	338.936	339.295
Min Von Mis (bottom)	4	0.015	-0.147	0.066	0.171	0.072	0.188
Max Tresca (top)	382	-296.073	294.624	369.818	262.162	414.534	294.624
Min Tresca (top)	1	0.015	-0.147	0.066	0.171	0.072	0.188
Max Tresca (bottom)	364	-309.197	339.295	325.086	333.868	338.933	339.295
Min Tresca (bottom)	9	0.015	-0.147	0.066	0.171	0.072	0.188

V. CONCLUSION

From the above study following conclusions can be drawn:

A. Displacement and reaction at base is found to be maximum for chimney with 120 m height.
B. The maximum bending moment of 4800 Knm/m is found to be for the chimney with height of 120 m height.
C. Plate membrane stress is found to be 104 N/mm^2.
D. Maximum principal stress is found to be of 418 N/mm^2.
E. Von Mis stress of maximum 371 N/mm^2 is observed.

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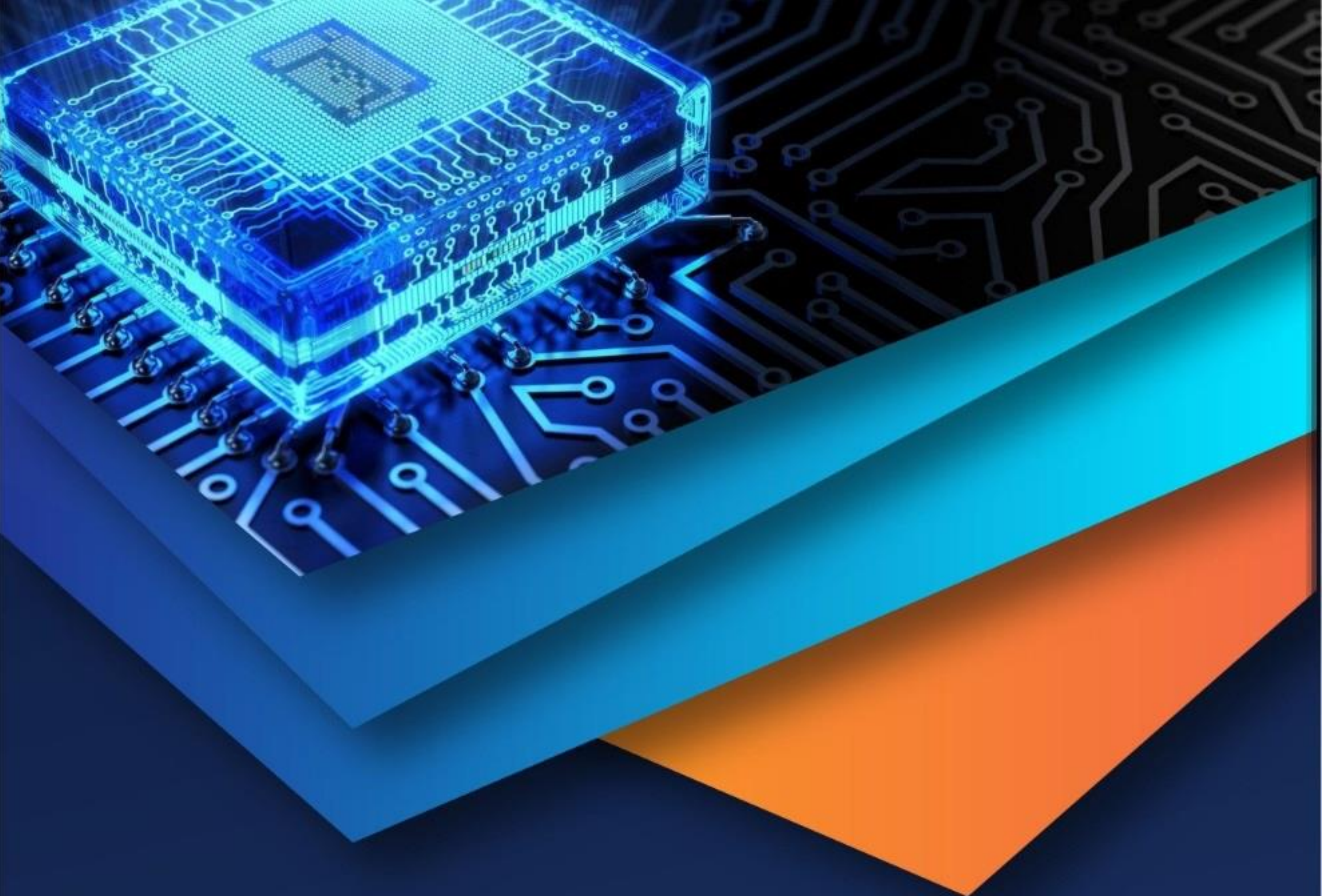

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