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Analysis and Design of Silo in STAAD-PRO

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Abstract: The concretes of flat bottom circular silos are often deployed to store materials in various industries, such as cement factories, power plants, oil and gas industries, etc. Silos are special designs, exposed to many different non-traditional conditions of loading, leading to unusual modes of failure. The failure of silo can be devastating because it can lead to loss of container, contamination of the material it contains, loss of material, cleansing, replacement of costs, environmental damage, as well as possible trauma or loss of life. The best design of the silo has helped in safe structure. Concrete can offer the protection of stored materials, requires little maintenance, aesthetically, and are relatively free of certain structural hazards, such as rubbing or because of the. In this work the silo is to be analyzed in the STAAD-PRO software, design of various of parts of the silo shall also be designed so that the economical approach shall be followed. The different parameters shall also be tested for the analysis and design of silo.

Keywords: Silo, rectangular, square, STAAD & forces.

I. INTRODUCTION

Storage structure like bunkers mainly called bunkers and bunkers for storing different types of materials. The classification of silos and Hopper depends on the plane gap. If Bin is in every way that the plane of the gap crosses at the top of the surface, then it is called a bunker and, if the Bin structures so that the plane gap crosses the opposite site of the structure called the silos. Silos are usually above structure, the height of the structure more diameter, diameter or breathing. According to Code 4995 (part I): 1974 ratio height/diameter greater than or equal to two to reduce lateral pressure at high altitude occurs.

The basic shape of the silo is round, but it can be square, rectangular or polygonal in shape and it is equipped with a roof and a bottom that can be tapered, pyramidal or flat.

Silos are usually supported with the number of columns, the general structure wall, the bottom of the hopper, and the columns connected using the beam ring to distribute the load. Silos are mainly constructions for vertical and horizontal pressure. In an earthquake analysis, an increase in lateral load causes an increase in bending moment results in a non-uniform pressure on the bottom of the hopper, which increases compared with pressure due to gravity cargo.

II. REVIEW OF LITERATURE:

Analysis of the silo is done using the response spectrum method and wind analysis. Considered bunkers are studied for various seismic zones, ie Zone-III and Zone-V: 1893 (Part-i): 2016 and wind analysis is carried out for it: 875 (part III): 2015. Circular silo is a model and an assay carried out by inSTAAD Pro. The result is obtained for different heights to the diameter coefficient in the form of lateral displacements and base shear. It can be seen that if the height to the diameter of the ratio increases, the wind load effect appears in critical load combinations for zone-III while in the earthquake load zone, be part of the critical load combination for lateral displacement (Sagar Ambat, et al 2018).

When using the silage in the structures of thermal power plants it should be able to store Ashes with high temperature. Compared to steel silo performances, RC silos are better off due to its lightweight design and maintenance. In this thesis and analysis for thermal power plants, a sequence of preparation of the plan was carried out, calculation of the load * combination of loads, analysis of use of STAFF PRO and design according to Indian standards. The height and diameter of the two silos are different, and they are connected by a ladder (Ddwani K. etc. 2017).

Analysis of silos, the use of equivalent method of lateral forces and study of structure performance, located in all seismic regions in terms of comparison of various models of concrete silos for earthquakes such as displacement, stress and vertical or horizontal pressure on the walls, etc. Presentation of results in tabular and graphical form. This method is made on a volume of 180 m3. All projects were based on recommendations I. S 4995-1974 (Part 1 -2) and I. S 456-2000 codes Based on these structures, that the dimension of silos shows the smallest amount of concrete and steel. These findings will be useful for the designers of silos (Akshta Masham and others 2019).

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III. MODELING

The modeling of silo is carried out for the rectangular and square silo, the modeling is carried out in the STAAD-PRO software as follows.

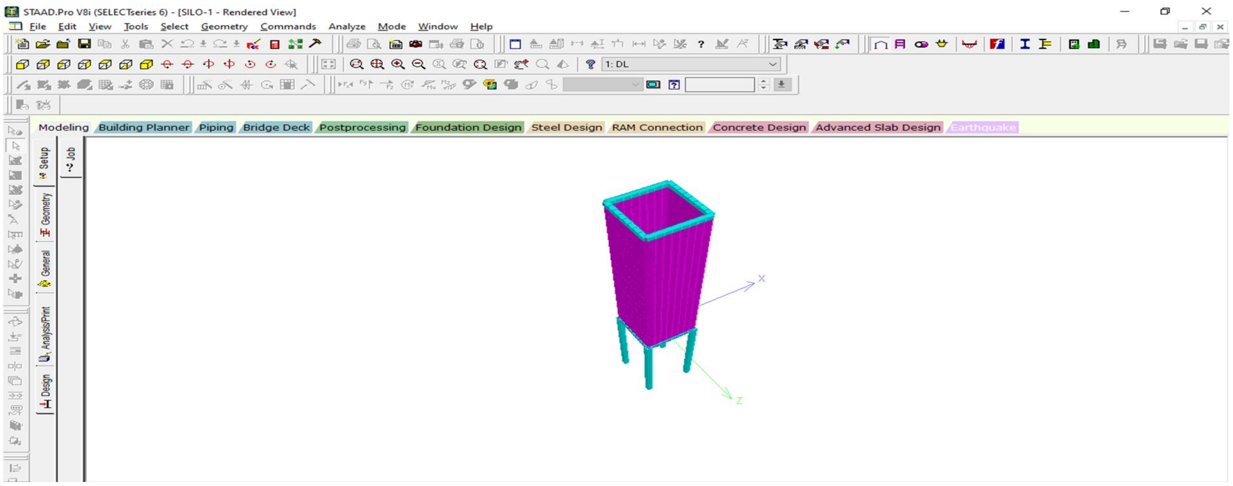

Fig.1: modeling of Silo

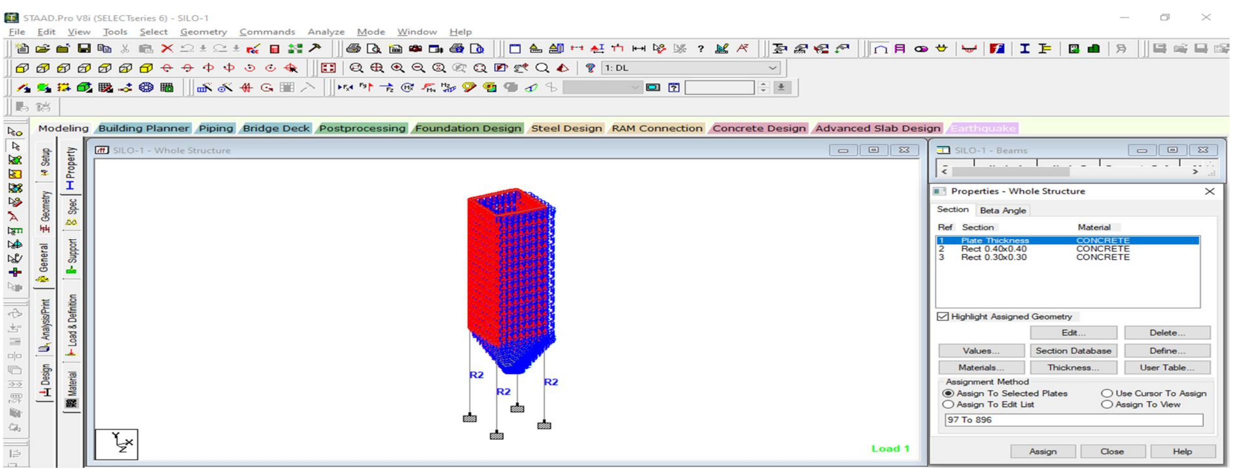

Fig.2: Assigning properties to Silo

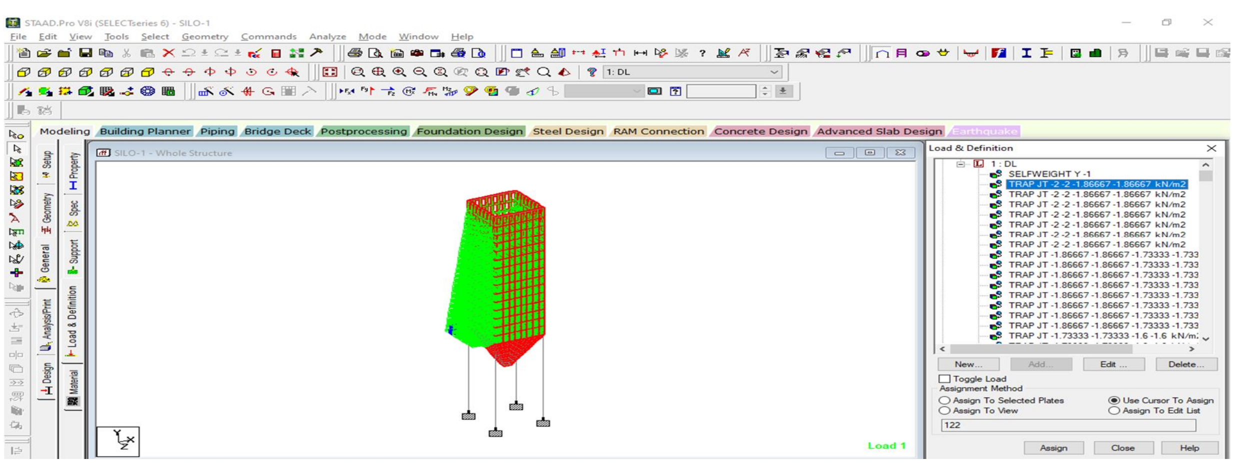

Fig.3: Assigning load to silo

Once the model is created using the STAAD-PRO software then the analysis is to be carried out and the results are to be considered.

IV. RESULTS

Table 1: Displacement for Square Silo

			Horizontal	Vertical	Horizontal	Resultant
	Node	L/C	X mm	Y mm	Z mm	mm
Max X	572	1 DL	78.501	-0.858	0	78.505
Min X	937	1 DL	0	0	0	0
Max Y	937	1 DL	0	0	0	0
Min Y	554	1 DL	78.451	-1.944	0	78.475
Max Z	148	1 DL	75.448	-1.194	0.185	75.457
Min Z	168	1 DL	75.448	-1.194	-0.185	75.457
Max rX	19	1 DL	74.341	-1.71	-0.018	74.36
Min rX	9	1 DL	74.341	-1.71	0.018	74.36
Max rY	63	1 DL	74.616	-0.763	0.015	74.62
Min rY	37	1 DL	74.616	-0.763	-0.015	74.62
Max rZ	937	1 DL	0	0	0	0
Min rZ	1	1 DL	74.322	-0.648	0.002	74.325
Max Rst	572	1 DL	78.501	-0.858	0	78.505

Table 2: Displacement for Rectangular Silo

			Horizontal	Vertical	Horizontal	Resultant
	Node	L/C	X mm	Y mm	Z mm	mm
Max X	509	1 DL	62.753	-0.822	0	62.758
Min X	833	1 DL	0	0	0	0
Max Y	833	1 DL	0	0	0	0
Min Y	493	1 DL	62.722	-1.692	0	62.745
Max Z	132	1 DL	60.325	-1.079	0.177	60.334
Min Z	150	1 DL	60.325	-1.079	-0.177	60.334
Max rX	17	1 DL	59.44	-1.478	-0.011	59.459
Min rX	9	1 DL	59.44	-1.478	0.011	59.459
Max rY	57	1 DL	59.659	-0.726	0.01	59.664
Min rY	33	1 DL	59.659	-0.726	-0.01	59.664
Max rZ	833	1 DL	0	0	0	0
Min rZ	1	1 DL	59.424	-0.628	0.003	59.427
Max Rst	509	1 DL	62.753	-0.822	0	62.758

From the above table it is clear that the horizontal and vertical displacement found to be more in square silo as compared to rectangular silo.

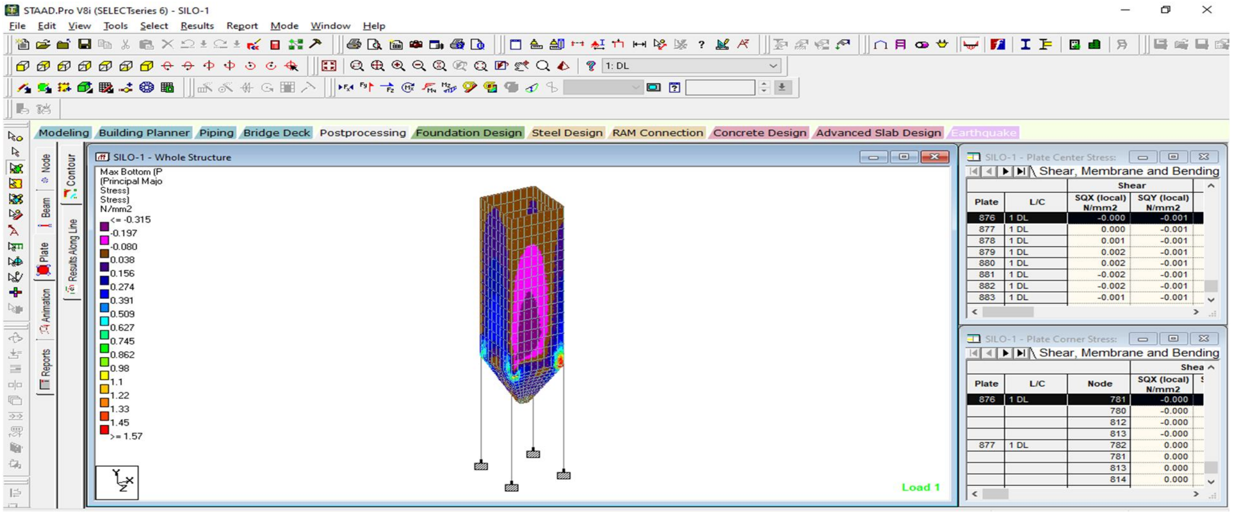

Fig.4: Principal stresses in Silo

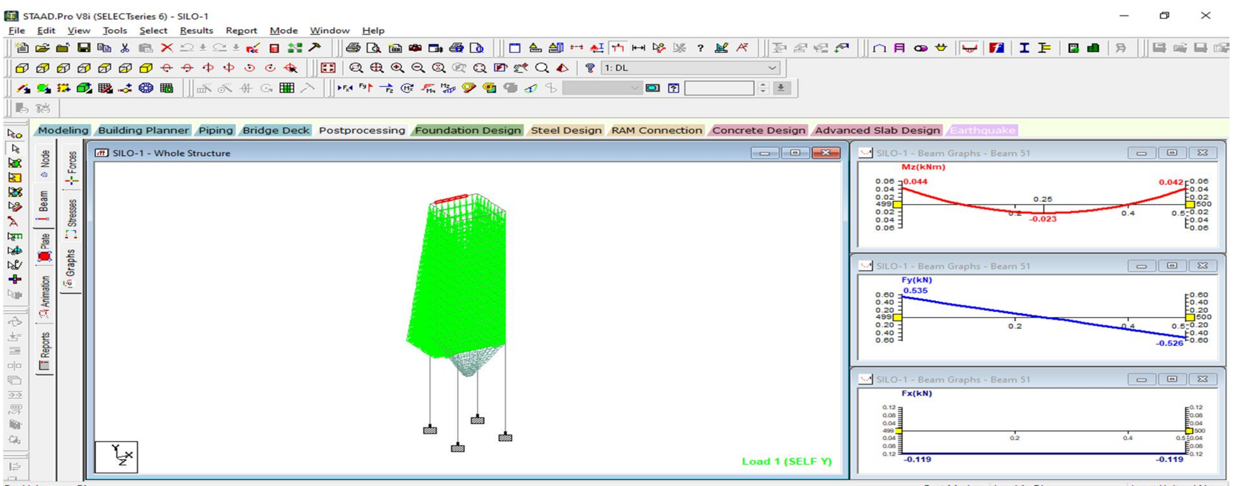

Fig.5: Shear Forces & Bending Moment Diagram for element of Silo

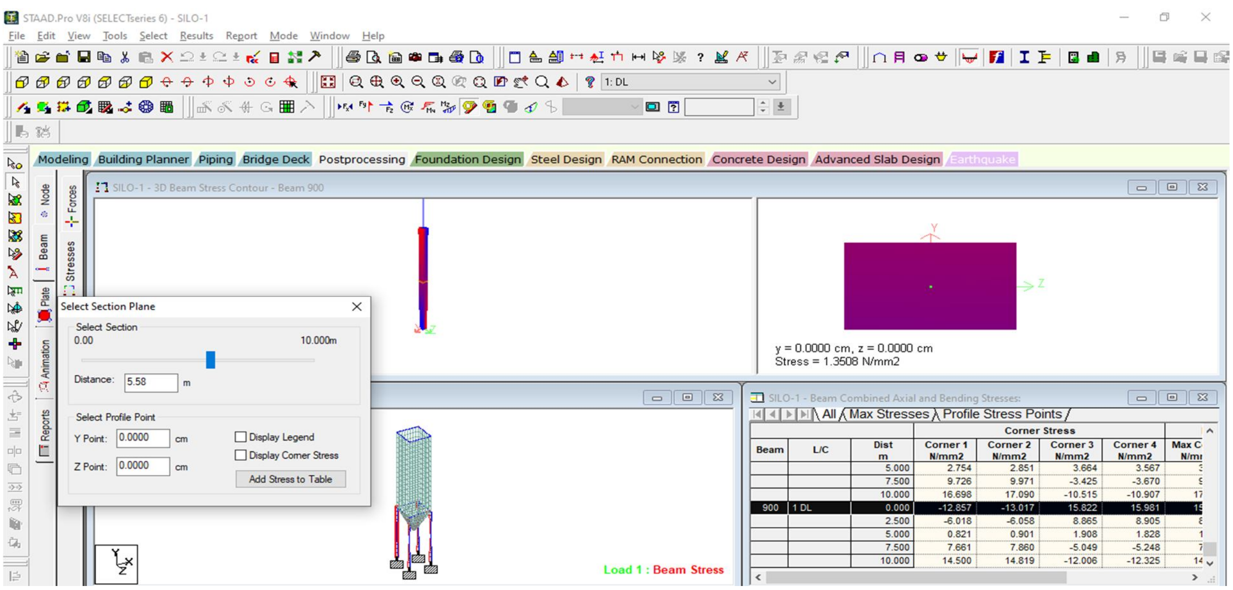

Fig.6: Stress Diagram of element of Silo

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Table 3: Reactions in Square silo

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	833	1 DL	-29.687	237.181	-0.255	-0.85	0.36	153.805
Min Fx	834	1 DL	-30.313	532.328	-0.315	-1.057	0.275	155.901
Max Fy	834	1 DL	-30.313	532.328	-0.315	-1.057	0.275	155.901
Min Fy	833	1 DL	-29.687	237.181	-0.255	-0.85	0.36	153.805
Max Fz	835	1 DL	-30.313	532.328	0.315	1.057	-0.275	155.901
Min Fz	834	1 DL	-30.313	532.328	-0.315	-1.057	0.275	155.901
Max Mx	835	1 DL	-30.313	532.328	0.315	1.057	-0.275	155.901
Min Mx	834	1 DL	-30.313	532.328	-0.315	-1.057	0.275	155.901
Max My	833	1 DL	-29.687	237.181	-0.255	-0.85	0.36	153.805
Min My	836	1 DL	-29.687	237.181	0.255	0.85	-0.36	153.805
Max Mz	834	1 DL	-30.313	532.328	-0.315	-1.057	0.275	155.901
Min Mz	833	1 DL	-29.687	237.181	-0.255	-0.85	0.36	153.805

Table 4: Reactions in Rectangle silo

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	937	1 DL	-37.144	244.097	-0.292	-0.974	0.45	192.412
Min Fx	938	1 DL	-37.856	612.993	-0.398	-1.341	0.402	194.796
Max Fy	938	1 DL	-37.856	612.993	-0.398	-1.341	0.402	194.796
Min Fy	937	1 DL	-37.144	244.097	-0.292	-0.974	0.45	192.412
Max Fz	939	1 DL	-37.856	612.993	0.398	1.341	-0.402	194.796
Min Fz	938	1 DL	-37.856	612.993	-0.398	-1.341	0.402	194.796
Max Mx	939	1 DL	-37.856	612.993	0.398	1.341	-0.402	194.796
Min Mx	938	1 DL	-37.856	612.993	-0.398	-1.341	0.402	194.796
Max My	937	1 DL	-37.144	244.097	-0.292	-0.974	0.45	192.412
Min My	940	1 DL	-37.144	244.097	0.292	0.974	-0.45	192.412
Max Mz	938	1 DL	-37.856	612.993	-0.398	-1.341	0.402	194.796
Min Mz	937	1 DL	-37.144	244.097	-0.292	-0.974	0.45	192.412

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Table 5: Maximum forces and Bending moment in square silo

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	898	1 DL	834	532.328	30.313	-0.315	0.275	1.057	155.901
Min Fx	1	1 DL	1	-62.473	-110.431	-6.347	-2.075	0.597	-52.18
Max Fy	17	1 DL	17	51.187	143.15	7.193	-1.619	1.917	57.431
Min Fy	8	1 DL	9	51.187	-143.15	-7.193	1.619	1.917	57.431
Max Fz	25	1 DL	25	-4.633	27.089	10.779	-15.82	-0.826	5.394
Min Fz	32	1 DL	32	-4.633	-26.029	-10.779	15.82	4.563	-7.886
Max Mx	32	1 DL	32	-4.633	-26.029	-10.779	15.82	4.563	-7.886
Min Mx	25	1 DL	25	-4.633	27.089	10.779	-15.82	-0.826	5.394
Max My	8	1 DL	8	51.187	-142.09	-7.193	1.619	5.513	-13.879
Min My	1	1 DL	2	-62.473	-111.491	-6.347	-2.075	-2.576	3.3
Max Mz	898	1 DL	834	532.328	30.313	-0.315	0.275	1.057	155.901
Min Mz	898	1 DL	9	494.63	30.313	-0.315	0.275	-2.092	-147.227

Table 6: Maximum forces and Bending moment in rectangular silo

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	1010	1 DL	938	612.993	37.856	-0.398	0.402	1.341	194.796
Min Fx	1	1 DL	1	-81.952	-138.438	-8.939	-2.185	0.31	-65.374
Max Fy	19	1 DL	19	68.454	175.83	10.775	-1.965	1.991	71.55
Min Fy	8	1 DL	9	68.454	-175.83	-10.775	1.965	1.991	71.55
Max Fz	27	1 DL	27	-4.781	32.783	14.996	-19.831	-1.757	6.681
Min Fz	36	1 DL	36	-4.781	-31.723	-14.996	19.831	5.741	-9.445
Max Mx	36	1 DL	36	-4.781	-31.723	-14.996	19.831	5.741	-9.445
Min Mx	27	1 DL	27	-4.781	32.783	14.996	-19.831	-1.757	6.681
Max My	8	1 DL	8	68.454	-174.769	-10.775	1.965	7.378	-16.1
Min My	1	1 DL	2	-81.952	-139.498	-8.939	-2.185	-4.16	4.11
Max Mz	1010	1 DL	938	612.993	37.856	-0.398	0.402	1.341	194.796
Min Mz	1010	1 DL	9	575.294	37.856	-0.398	0.402	-2.642	-183.761

Table 7: Maximum stresses in Square silo

			Principal		Von Mis		Tresca	
	Plate	L/C	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2
Max Principal (top)	601	1 DL	3.508	0.332	3.386	0.941	3.508	1.062
Min Principal (top)	121	1 DL	-3.157	-0.316	3.067	0.857	3.157	0.97
Max Principal (bottom)	585	1 DL	-0.353	1.569	1.451	1.516	1.595	1.569
Min Principal (bottom)	105	1 DL	-0.489	-2.47	0.701	2.702	0.804	2.886
Max Von Mis (Top)	601	1 DL	3.508	0.332	3.386	0.941	3.508	1.062
Min Von Mis (top)	867	1 DL	0.007	0.002	0.011	0.016	0.012	0.017
Max Von Mis (Bottom)	105	1 DL	0.315	0.416	0.701	2.702	0.804	2.886
Min Von Mis (bottom)	875	1 DL	0.008	0.003	0.011	0.013	0.012	0.015
Max Tresca (top)	601	1 DL	3.508	0.332	3.386	0.941	3.508	1.062
Min Tresca (top)	869	1 DL	0.01	0.001	0.011	0.016	0.012	0.017
Max Tresca (bottom)	105	1 DL	0.315	0.416	0.701	2.702	0.804	2.886
Min Tresca (bottom)	876	1 DL	0.01	0.002	0.011	0.013	0.012	0.014

Table 8: Maximum stresses in rectangular silo

			Principal		Von Mis		Tresca	
	Plate	L/C	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2	Top N/mm2	Bottom N/mm2
Max Principal (top)	675	1 DL	3.831	0.401	3.725	0.943	3.831	1.077
Min Principal (top)	135	1 DL	-3.826	-0.41	3.746	1.138	3.826	1.286
Max Principal (bottom)	116	1 DL	0.087	1.87	2.366	2.989	2.408	3.448
Min Principal (bottom)	117	1 DL	-0.534	-2.991	0.915	3.273	1.057	3.497
Max Von Mis (Top)	135	1 DL	-0.165	0.876	3.746	1.138	3.826	1.286
Min Von Mis (top)	977	1 DL	0.002	0.004	0.018	0.014	0.019	0.016
Max Von Mis (Bottom)	117	1 DL	0.522	0.505	0.915	3.273	1.057	3.497
Min Von Mis (bottom)	977	1 DL	0.002	0.004	0.018	0.014	0.019	0.016
Max Tresca (top)	675	1 DL	3.831	0.401	3.725	0.943	3.831	1.077
Min Tresca (top)	977	1 DL	0.002	0.004	0.018	0.014	0.019	0.016
Max Tresca (bottom)	117	1 DL	0.522	0.505	0.915	3.273	1.057	3.497
Min Tresca (bottom)	977	1 DL	0.002	0.004	0.018	0.014	0.019	0.016

The above tables shows the forces,bending moment and stresses for the rectangular and square silo.

V. CONCLUSION

The conclusions from the above study are as follows:

A. The displacement is found to be more in square silo as compared to rectangular silo
B. The vertical reaction is observed to be maximum in case of rectangular silo
C. F_x, F_y & F_z is maximum in case of rectangular silo
D. M_x, M_y & M_z is also maximum in case of rectangular silo
E. Principal and Von Mis stress is found to more in rectangular silo.

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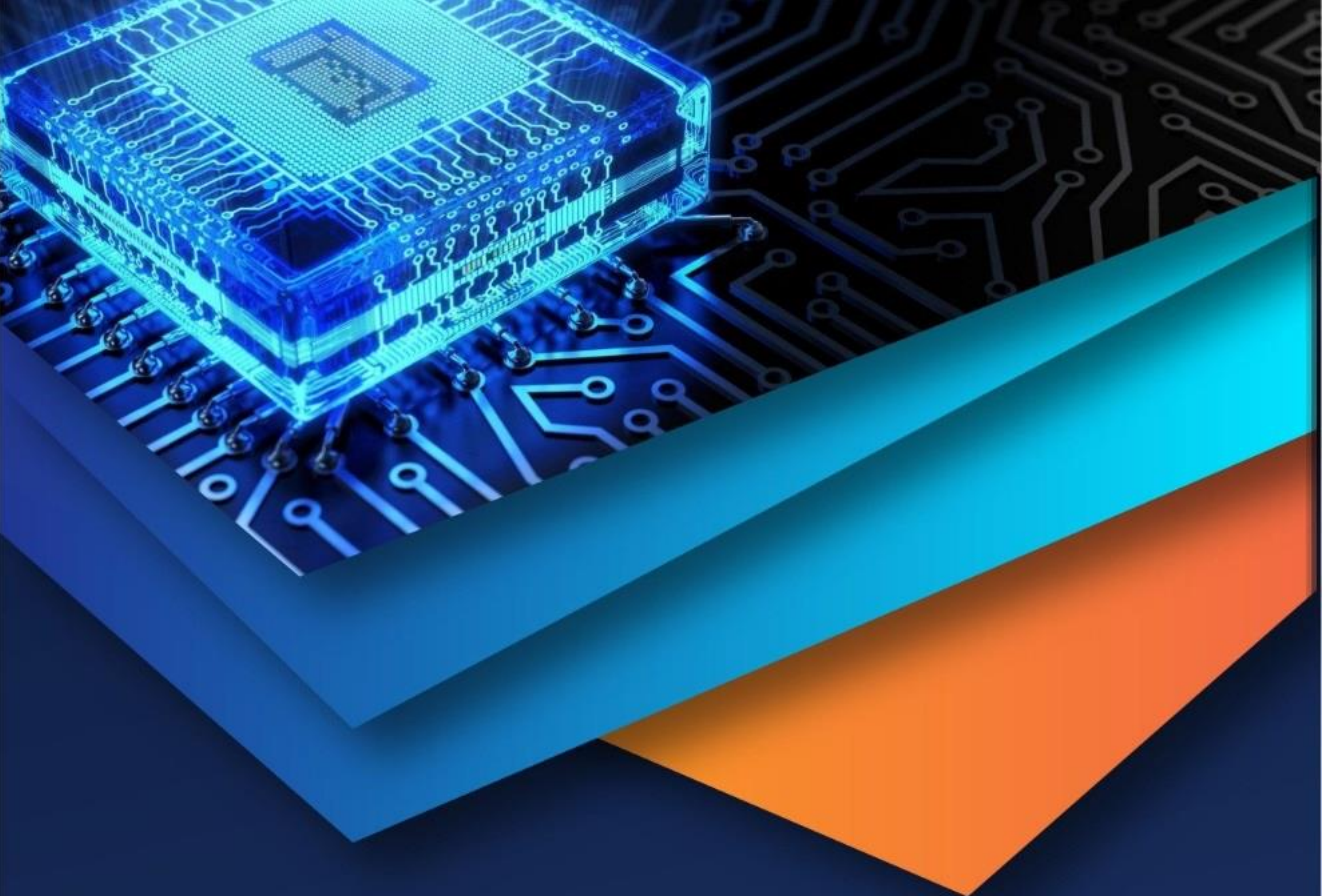

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