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Dynamic Analysis and Design of Steel Silo

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ABSTRACT:The silos are the storage structures used to store various materials such as cement, agricultural products, mining products etc. This research deals with the study on response of the structure to the wind load in accordance with Indian standard codes. The entire analysis and design of the structure is carried out using STAAD Pro V8i software. In this study, two different models of the structure with same height and different plan geometry have been prepared i.e. square and circular. The results obtained for both the structures such as base shear, vertical displacement, and stress, have been compared to study the behaviour of structures when subjected to wind loads.

KEYWORDS:Steel silo, Plate element, surface, Wind load analysis, STAAD. proV8i

I. INTRODUCTION

A silo is defined as a "pit for holding grain" in Greek. It is a tall structure or pit on a farm to use for bulk material storage and is used in food production to store grain or fermented feed recognized as silage to store bulk quantities of grain, carbon black, coal, cement, wood chips, sawdust, and food products. Large containers, known as bins, are used to store raw materials on a large scale in any industry. Silo refers to tall structures with a large height in comparison to their lateral dimension. A silo is a structure in which the opposite sides are cut in the angle of rupture. The silo design is given special consideration and is treated as a special structure for design due to its importance. Silos are usually made of steel or concrete. Silos can be supported by steel columns with concrete pedestals or concrete self-cleaning or emptying columns. Its bottom height is set so that a vehicle can pass beneath it. It has a shallow spherical or conical dome on top, or a beam and slab type flat roof with a suitable man-hole.

The silo design is affected by the type of stored materials and their properties. The properties of stored material, such as density and friction, influence the design of the silo. The silo is designed to withstand both horizontal and vertical pressures caused by stored material.

II. RELATED WORK

"Dynamic analysis of steel silo"^[1], Published by -International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-9 Issue-1, May 2020

In this paper, Any structure's structural response is the result of multiple dynamic forces. phenomena that cause going to depend on the period, noise and vibration or wobbling of the structure frequency, and time period of the ground motion. The current work uses linear Time History and the Response Spectrum technique to perform a dynamic simulation of a typical steel silo for seismic Zones V as according Indian code. STAAD.ProV8i software is used to perform two analyses: THA (Time History Analysis) and RSA (Frequency Response Analysis) (RSA). The load combinations are calculated in accordance with IS-1893-2002. The results of the two silo models studied in this study are compared of Basic natural period, Design Base shear, and Oblique Displacements.

"Dynamic analysis of steel silo as per Indian standard"^[2], Published by - International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2278-0181, Volume-8 Issue-11, Nov- 2019

The dynamic phenomenon of structural response to earthquakes is going to depend on the dynamic properties of structures, as well as the exciting ground motion's severity, time frame, and frequency. There are two types of dynamic analysis procedures: Non - linear dynamic analysis and linear dynamic analysis are two types of dynamic analysis. The influence of wind load on the silo is investigated in this work, as well as variation from across height Load combinations exists. Evaluated using Indian code. For the two distinct silo models under evaluation in this study The results are compared Fundamentally speaking fundamental period, Design Base shear, Lateral Displacements, and column reactions.

“Analysis of steel silos subjected to wind load with Various slenderness Ratio”^[3], *Published by international Research Journal of Engineering and Technology (IRJET). Volume: 06 Issue: 03 | Mar 2019.*

This study. Steel silos are used. built with very thin shells and thus are widely used in a variety of industries to store cement and other granular and chalky materials coal, wheat, and so on. The current study investigated the structural behaviour of Wind load on circular thin metal silos with varying slenderness ratios study included determining shell stresses and deformational behaviour Load Instances WE (wind and empty silo) as well as WF (wind and full silo) of steel silos (wind and full silo). Three silos with exactly equal capacities and slenderness ratios, such as slender, slender, slender, slender, slender, Substituent and squat are ready for examination. Its goal is to learn what steel silos behave when subjected to wind pressure, and to gather helpful info for steel silo design The numerical models are finished.

III. METHODOLOGY

A. Software modelling and Analysis

The analysis of the structure is carried out using STAAD Pro. software. fixing the dimension steel silos and performing study and Dynamic Analysis design of steel silo using wind load on the square and circular steel silos with same height using IS 875 part-3 cod.

For present work two steel silos analysis and design square and circular at same height 23m with different geometry, circular 6m dia, Rectangular 4x4m for using cement storing different capacities situated in zone 3.

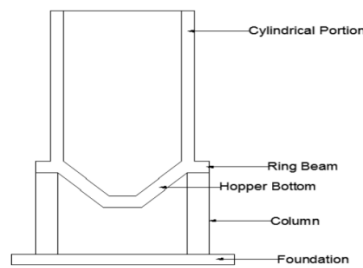


Fig 1. Component of silo

This structure is basically analysed as a fixed supported structure, Wind loads are calculated in silo analysis. understanding the proposed design for a steel silo in accordance with Indian Standard IS.

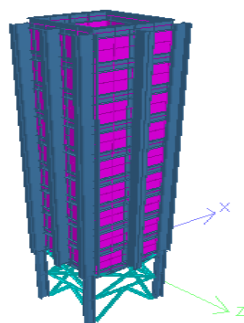


Fig 2. Square silo.

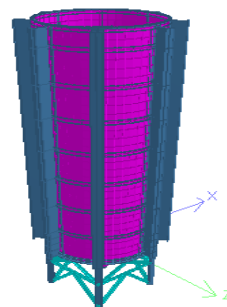


Fig 3. Circular silo.

In this study we have used different types and sizes of the sections for various structural members of the square silo. The sections used are: 10mm thick steel column size, ISHB400T with 20 mm top and bottom cover plates of width 400mm for bottom, Ring beam size ISMB600, and provide stiffeners of size ISWB600, and support bracing star angle size 120x120x15mmS provide, the grade of steel Fe250

In this study we have used different types and sizes of the sections for various structural members of the Circular silo. The sections used are: 10mm thick steel column size, ISHB350T with 20 mm top and bottom cover plates of width 400mm for bottom, Ring beam size ISHB300, and provide stiffeners of size ISMB300, and support bracing star angle size 120x120x15mmS provide, the grade of steel Fe250.

Beam displacement minimum at support, and maximum at end in check the the displacement check at top of the silos. And also compare the result bending and displacement and plate stress Square silo to circular silo.

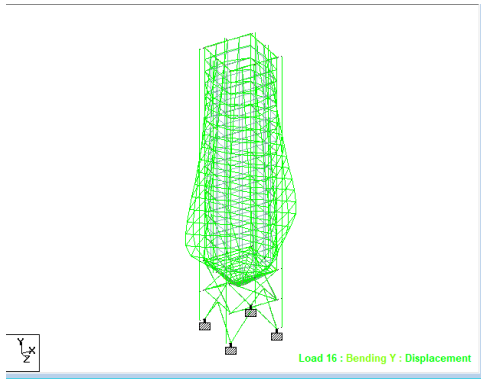


Fig 4. Bending and displacement.

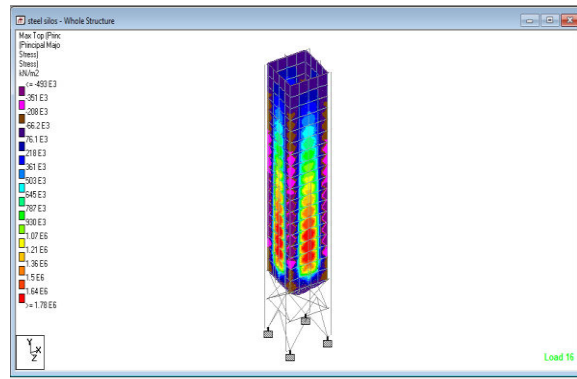


Fig 5. Plate stress.

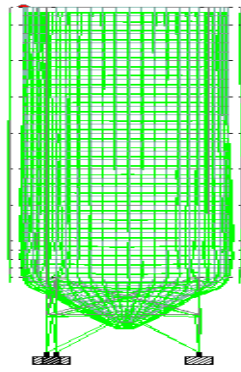


Fig 6. Bending and displacement.

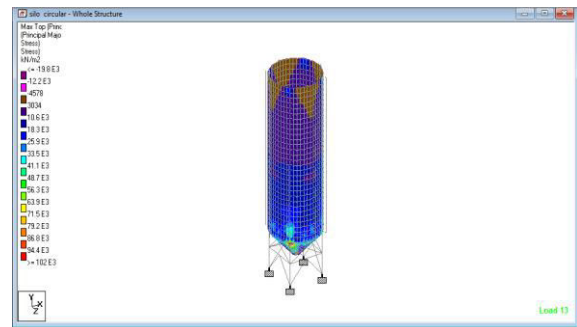


Fig 7. Plate stress.

The horizontal and vertical pressure on steel silo calculated by manually. Initially we select storage material as cement powdery material density of cement is 15.50KN/m^3 . Calculate pressure acting on steel silos, by using formula we got 49.84KN/M^2 horizontal pressure and 99.69 for vertical pressure.

Table 1 Beam displacement Square silo

	Beam	L/C	d (m)	X (m)	Y (m)	Z (m)	Resultant (m)
Max X	22	4:PLATE H3	1.000	0.027	-0.002	0.000	0.027
Min X	30	2:PLATE H1	1.000	-0.027	-0.002	-0.000	0.027
Max Y	520	5:PLATE H4	18.000	0.000	0.004	0.008	0.009
Min Y	520	3:PLATE H2	18.000	-0.000	-0.004	-0.009	0.009
Max Z	18	5:PLATE H4	1.000	-0.000	-0.003	0.038	0.038
Min Z	26	3:PLATE H2	1.000	0.000	-0.003	-0.038	0.038
Max Rst	505	5:PLATE H4	18.000	-0.000	-0.004	0.038	0.038



Table 2 Beam end force summary Square silo

	Beam	Node	L/C	Axial	Shear		Bending	
				F _x (kN)	F _y (kN)	F _z (kN)	M _y (kNm)	M _z (kNm)
Max F _x	542	469	5:PLATE H4	1.9E 3	-36.352	15.681	-2.763	-60.743
Min F _x	542	469	3:PLATE H2	-1.9E 3	37.748	15.81	2.857	63.603
Max F _y	542	469	4:PLATE H3	-1.6E 3	109.333	1.160	0.182	52.827
Min F _y	545	472	2:PLATE H1	-1.6E 3	-109.389	0.903	0.156	-52.915

Table 3 Beam displacement circular silo

	Beam	L/C	d (m)	X (m)	Y (m)	Z (m)	Resultant t (m)
Max X	6357	10-COMBINATION LOAD	9.000	0.004	-0.003	0.000	0.027
Min X	6356	11-COMBINATION LOAD	9.000	-0.003	-0.003	-0.002	0.005
Max Y	6374	3-PLATE H	2.039	-0.000	0.000	0.000	0.000
Min Y	6415	9-COMBINATION LOAD	0.032	0.000	-0.004	0.000	0.004
Max Z	5877	10-COMBINATION LOAD	0.154	-0.000	-0.003	0.001	0.003
Min Z	6223	11-COMBINATION LOAD	0.384	0.000	-0.004	-0.003	0.005
Max R _{st}	6357	10-COMBINATION LOAD	9.000	0.004	-0.003	0.000	0.012

B. Manual calculation

1.Horizontal and vertical pressure on silo

Horizontal and vertical pressure calculated by using formula given below

$$(P_h) = \frac{wR}{\mu e} (1 - e^{-\frac{h\mu e K_c}{R}})$$

W=density of cement 15.50 KN/m³

μe =co efficient wall friction =tan(ϕ)

tan(25)=0.4663

h=18m

R=radius

(Ph)=49.84KN/M2

(Pv)=Ph/Kf=99.69

2.Wind Loading:

The following relationship should be used to calculate the Design Wind Load at any same height. As according IS:875 (PART-3)-2015

$$P_z = 0.6V_z^2$$



Wind load is calculated using a basic wind velocity of 47 m/s and a risk coefficient of 1.07. The Design Standard specifies this as category 3. The terrain factor is calculated using table-2 of IS:875-III. So because upwind slope is much less than 3, the topographical factor is set to 1. The wind pressure obtained below is applied to Silo's circumference. the structure is consider as non-cyclonic.

$$\text{wind speed design}(V_z) = V_b * K_1 * K_2 * K_3 * K_4 \text{ (m/s)}$$

Table 4 wind load parameter

Height (m)	10 m	20m	23m
V _b (m/s)	47	47	47
K ₁	1.07		
K ₂	0.91	1.01	1.021
K ₃	1	1	1
V _z = (m/s)	45.76	50.79	51.34
P _z = (Kn/m ²)	1.26	1.55	1.582

Combination of load case

1. 1.5(DL)
2. 1.5(DL+LL)
3. 1.5(DL+LL+W_{LX})
4. 1.5(DL+LL+W_{LX}-)
5. 1.5(DL+LL+W_{LZ})
6. 1.5(DL+LL+W_{LZ}-)

IV. RESULTS

1. Displacement Result:

Table 5 Displacements in mm

Support	Square Silos	Circular silos
At support	0	0
Hopper bottom	9	7
Top	38	27

Above table displays the displacement disparity. For 23m height of silos, of two different shape, square and circular. The maximum displacement at top for square and circular silos are 38mm and 27mm respectively. From these results it is clear that the displacement in circular silos is 28.94% less as compared to square silo.

2. Base reaction result:

Table 6 Base reaction in KN

Reaction	Square Silos	Circular silos
Minimum	118.64 KN	240 KN
Maximum	434 KN	1960 KN

The above table shows the maximum base reaction at support with a combination of 1.5(DL+LL+W_Z+) for a square silo and circular silo for a same height. Reaction in circular silo is more compared to rectangular silo. The base reaction is increased 77% in circular silos, due to the base moment increase and increase in their capacity.

3. Total weight of structure :



Table 7 Total Weight of structure

Shape of structure	Weight in KN
Square	742.78
Circular	599.92

In this above table show that total weight of structure show in KN , the total weight of square and circular silos at the same height , show 742.78 for square and 599.92 for a circular , the total weight of circular silo is less compare to square silo.

4. Plate stress:

Table 8 Principal stresses

Shape of structure	Major principal stress KN/m ²
Square	490289
Circular	101903

In this above table show that total weight of structure show the maximum principal stress on the silo in KN/m². Maximum principal stress at square silo 490289 KN/m² and circular silo 101903 KN/m² .major principal stress of square silos is increases by 79.22% compared to circular silo.

V. CONCLUSIONS

- In this study Dynamic static analysis and design carried out , Two different silo are consider Square and circular with a same height.
- Base shear and base moment are increased with the increase in the capacity at same height. It show base reaction in circular silo more compare to square silo.
- In radial configuration base reaction are compare between the square and circular silos.
- Displacement value is increased with increase in capacity and from the comparison between displacement form two different type silo, its show that the square silo deflection is more than the circular silo.
- As of the explanations made above, it can be resolved that Circular silo is most effective in reducing displacement.
- Steel production ensures quality control. Compare to RCC silos.

REFERENCES

[1] Uzma Bashir Wani, Nirendra Dev, “Dynamic analysis of steel silo International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-9 Issue-1, May 2020

[2] Uzma Bashir Wani “Dynamic analysis of steel silo as per indian stander”.International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2278-0181, Volume-8 Issue-11, Nov- 2019

[3] Harshawardhan G. Patil1, P.S. Patil2, India,“Analysis of steel silos subjected to wind load with Various slenderness Ratio” international Research Journal of Engineering and Technology (IRJET). Volume: 06 Issue: 03 | Mar 2019

[4] Raj Kumar Janghel 1 , R. C. Singh2, “Dynamic Analysis of Cylindrical Steel Silo Structure with the Effect of Shear Wall” IJARIE-ISSN(O)-2395-4396, Vol-4 Issue-5 2018

[5] Raichel Prince1, Nincy Jose2, REVIEW ON THIN SHELL CYLINDRICAL STEEL SILO”. International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 05 | May -2017.



- [6] Raj Kumar Janghel1 , R. C. Singh2, “A Survey Approach of Analysis of Cylindrical Steel Silo Structure Under Seismic Condition”. International Research Journal of Engineering and Technology (IRJET), IJARIE-ISSN(O)-2395-4396, Vol-4 Issue-2 2018.
- [7] JOHN W. CARSON1 AND TRACY HOLMES2, “SILO FAILURES: WHY DO THEY HAPPEN?”, 2Jenike & Johanson, Ltd., 400 Carlingview Drive, Etobicoke, Ontario, Canada M9W 5X9 (Received 3 July 2003).
- [8] Indian Code of practice for design of earthquake loads for buildings and structures IS:1893-2002.
- [9] Indian Code of practice for design loads (other than earthquake loads) IS: 875-PART-I & PART-II-1987. PART-3
- [10] Indian code of practice criteria for design of steel bins for storage of bulk materials IS:9178-PART-I; General requirements and assessment of loads, IS:9178-PART-II; Design criteria and IS:9178- PART-III; Bins designed for mass flow and funnel flow.
- [11] Indian Code of practice for silos for grain storage IS:5503(PART-I)- 1969.
- [12] Indian Code of practice for general construction in steel IS : 800-2007



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