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DESIGN & ANALYSIS OF RCC SILOS OF SAME HEIGHT WITH VARYING DIAMETER USING STAAD PRO

[1]MR. CH RAJENDRA PRASAD, [2]D JASWANTH JOSHI, [3]A VENU GOPAL, [4]D SOHAN LAL & [5]G RESHMA

[1]ASSISTANT PROFESSOR, DEPARTMENT OF CIVIL ENGINEERING, CMR COLLEGE OF ENGINEERING & TECHNOLOGY

[2,3,4,5] B-Tech, DEPARTMENT OF CIVIL ENGINEERING CMR COLLEGE OF ENGINEERING & TECHNOLOGY

ABSTRACT:

Structures used for storing bulk solids are called bins, bunkers, silos, or tanks. There is no generally accepted definition for these terms, shallow structures containing coal, crushed stone, gravel, and similar materials are called bins or bunkers and tall structures containing materials such as grain, cement and wheat are usually called silos. Elevated silos generally consist of a conical roof, a cylindrical shell and a conical hopper and they could be elevated and supported by frames or reinforced concrete columns. Circular silos (both steel and reinforced concrete) are used to store material in various industries like cement plants (clinkers), power plants(raw coal), oil and gas industry (sulfur pellets) etc. Elevated steel and reinforced concrete circular silo for storage show performance in earthquake reinforced concrete silo stability increases by using shear wall but loss of steel silo in earthquake stability increases using steel panel on opposite side Displacement of structure decreases in case of shear wall panel and stiffness increases. In the present study, The load calculations, load combinations, load assignment, earthquake parameters, and analysis have been represented, and the results from this analysis are represented and compared the result outputs of all the models are displayed, max absolute stresses and max shear stresses developed in each model are represented via contour diagrams, tables, and graphs, the values of minimum required Ast for beams and columns are mentioned. The max lateral displacements obtained for the critical load case/combination are noted down for each model at heights of H25, the following is the maximum of nodal displacements to height H25 of constant diameter of D5 as 9.133 mm at nodal point 73. Keywords: RCC, Silo, Displacements, Maximum Absolute Stresses, Maximum Shear stresses, IS: 456-2000, is: IS 1893-2016, STAA

INTRODUCTION:

Background Concrete comes in mind as the first option when we think about the construction of material storage facilities. Concrete has the ability to conform to any desired shape and also, it's economical. Concrete proves to be a very useful material as it offers all the flexibilities in designing and construction of silos and bunkers which are required by any industry and foremost being in the economical limits. Silo is an upright granular material storage tank. Such structures are constructed on higher elevations with an opening created at the bottom to collect the material. The term "silo" mainly incorporates two types of structures i.e., bin and bunker. Out of these two, the first one is the deep upright container while the second one is a similar structure with relatively shallow height. In case of bins if the plane of rupture strikes the opposite wall before emerging from the top of fill, that type is called deep bins while the other case is termed as shallow bins. Importance of these storage structures has attracted the attention of many researchers worldwide to propose different load calculation methods and design considerations. Working Stress Method IS 5503-2 (1969) is the only available guidelines, for the design of silo and bunkers. In addition to it, different researchers proposed different methods to compute the loads of moving and stacking material inside the silos and bunkers. Silos can be made of steel or reinforced concrete. A typical group silo made of steel corrugated sheets is shown in Fig. (1). Silos are mostly cylindrical or rectangular in shape but can also be made of other shapes depending on the function and storage capacity of the material. The design of silo is based on the density and angle of internal friction of material to be stored. Silo walls are subjected to lateral and vertical pressure caused by the materials. Accurate estimation of these forces and corresponding design of these structures is one of the recent challenges which many designers are facing. These storage structures become more vulnerable when subjected to the lateral earthquake forces. Failure of these structures is highly brittle and catastrophic.

Figure 1: RCC Group Silos

Significant work has been completed in the field of designing the Silos. Most of the researchers have focused on only one of the components of Silo by using analytical and numerical methods. Dinghua and Jiping researched on the lateral pressure acting on the walls of the reinforced concrete silo. The method of calculating the basic as well as the dynamic pressure acting on the wall of reinforced silo caused by the integral flow of granular material within the tower during discharge was also discussed. Zhen and Jin analyzed and calculated the hoop stress in the reinforced concrete deep silo. The analysis results showed that the absolute value of hoop stress at the same height increases with an increase in height-diameter ratio but the absolute value decreases with an increase in the wall thickness. Kivanc and Baki investigated the use of ferrocement in the construction of squat grain silos. It was concluded that ferrocement could be used in place of steel from the perspective of static as well as economy.

OBJECTIVES:

• Earthquake analysis of Reinforced concrete silo by Response spectrum method as per for IS 1893 – 2016 having different diameters and heights as: D3-H25, D5-H25, D7-H25. Design of long Reinforced concrete silo for different diameter and same height by using Staad pro.

• Comparison of different models of long concrete silo for earthquake loads in terms of stress and vertical or horizontal pressure on walls.

• All the nine models are analysed for different load combinations and the concrete design for each element is done for the critical load combination, the concrete design is done with reference to the aspects of IS 456-2000.

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• To determine the loads and forces acting on the silos, such as dead loads, live loads, wind loads, seismic loads, and soil pressures.
• To design the silos based on the material properties and loading conditions using STAADPro software. The design should ensure structural stability, integrity, and durability.
• To analyze the silos for strength, deflection, and stability using STAADPro. The analysis should identify potential failure modes and help optimize the design.
• To evaluate the dynamic response of the silos to seismic and wind loads using response spectrum analysis in STAADPro. The analysis should ensure that the silos can withstand extreme loading conditions.
• To develop detailed construction drawings and specifications for the silos based on the STAADPro design and analysis results.
• To compare the performance of silos with different diameters but same height under different loading conditions, and identify the optimal diameter and height for the storage silos.
• To evaluate the cost-benefit of different silo configurations to determine the most costeffective design

METHODOLOGY:

Introduction

This chapter explains the different methodologies which are carried out for the model development, load calculations and, analysis. All the aspects are taken in according to the Indian standard code procedures, different calculations and their procedures that are done in this study are represented in a step by step representation, the following are the methodologies which are covered in this chapter

• Model development
• Load calculations
• Load combinations
• Analysis Procedure Designing and analyzing storage silos for different diameters and the same height in Staad Pro involves the following steps:

1. Creating the model: The first step is to create the model of the silos in Staad Pro. This involves defining the geometry of the silos, including their diameter, height, and thickness, as well as the material properties of the concrete.
2. Assigning loads: Once the model is created, the next step is to assign loads to the silos. This includes the weight of the silo itself, as well as any additional loads, such as the weight of the stored material, wind loads, and seismic loads.
3. Analysis: After assigning loads, the model is analyzed to determine the stresses and deflections in the silos. This can be done using various analysis methods, including the response spectrum method as per IS 1893-2016.
4. Design: Based on the analysis results, the silos are designed to meet the required strength and stability requirements. This includes determining the required reinforcement and the thickness of the walls. 28
5. Detailing: Finally, the silos are detailed to show the reinforcement layout and dimensions of each component. To design and analyze storage silos for different diameters and the same height in Staad Pro, you can follow the steps outlined above, but with some modifications for

the specific parameters of the silos in question. Here is a more detailed step-by-step process:
1. Create the model: In Staad Pro, create a new model and define the geometry of the silos by specifying their diameters and height. Assume a wall thickness of 150 mm for all silos. Define the material properties of the concrete, such as its compressive strength and density.
2. Assign loads: Assign loads to the silos, including the self-weight of the silos, the weight of the stored material, wind loads, and seismic loads. Assume a stored material density of 2400 kg/m3 and a seismic coefficient of 0.16 for all silos. For wind loads, use the relevant design wind speed for the location and a drag coefficient of 0.6.
3. Analysis: Analyze the model using the response spectrum method as per IS 1893-2016 to determine the stresses and deflections in the silos. Use a soil type factor of 2.5 for all silos.
4. Design: Based on the analysis results, design the silos to meet the required strength and stability requirements. Assume a minimum concrete grade of M20 and a minimum reinforcement grade of Fe415. For simplicity, assume that the silos are unbraced and that the design is governed by bending and shear.
5. Detailing: Finally, detail the silos to show the reinforcement layout and dimensions of each component. Use the relevant design codes and standards for detailing.

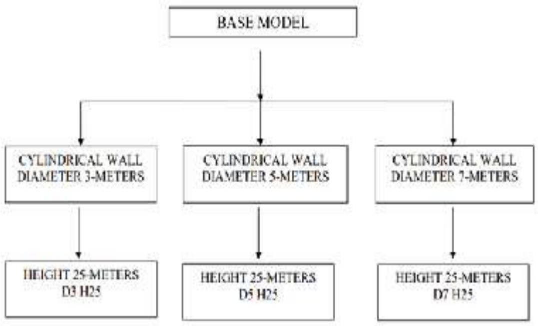

Fig 2. Model Chart

MODELLING :

Introduction

In this chapter all the details of the silo model such as section sizes, thickness, lengths, plan and elevation views are represented, the step by step procedure for the modelling of the structure in Staad Pro software is represented.

4.2 Model data The following table 1 represents the dimensions of each element used in the modelling of base model of reinforced concrete silo. Table 1 Elements Data

Element	location	Width	Breadth	Thickness
Top dome slab	Top of the cylindrical wall	-	-	150mm
Cylindrical wall	Above the girder beam	-	-	300mm
Bottom hopper slab	Below the girder beam	-	-	250mm
Girder Beam	Between the bottom column and cylindrical wall	350mm	400mm	-
Column	At the bottom of the silo	400mm	300mm	-

The following table 2 explain the height, diameter and, volume of each silo used for this study Table 2 Model Data

S. no	Model	Diameter(m)	Cylindrical wall Height (m)	Total height (m)	Volume(m3)
1	D3 H25	3	25	30	176.71
2	D5 H25	5	25	30	490.87
3	D7 H25	7	25	30	962.11

RESULTS:

Table 3 D3 H25 Node Displacements

Max node displacements		
Node no	Height(m)	Node Displacements (mm)
73	30	6.345
55	25	5.664
37	20	4.976
19	15	4.307
1	10	3.689
117	5	3.193
135	0	0

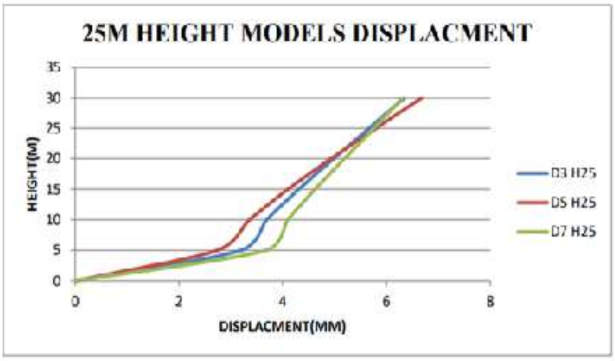

Fig 2 Node displacements of 25M Height Model

Maximum Absolute Stresses of H25-D3, D5, D7 The maximum absolute stresses developed for the critical load case are represented in the form of contour stress diagrams as mentioned below

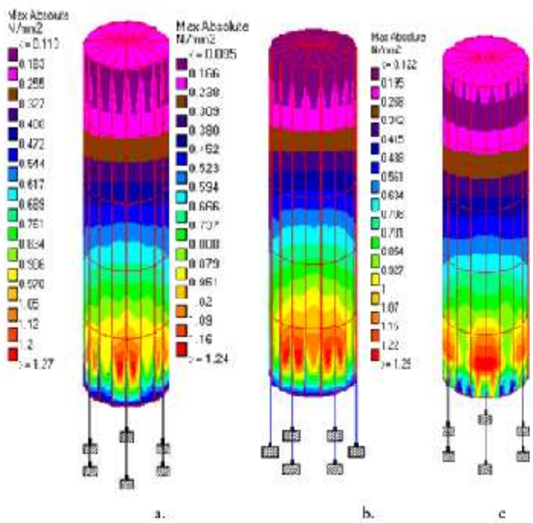

Fig 3 Maximum Absolute Stresses for H25-D3, D5, D7

CONCLUSIONS:

The dissertation provides an idea of considering the earthquake loads for the analysis of circular RCC Silo. Analysis of silo is done using Equivalent lateral force method and Response spectrum method. These silos are studied for varying column height i.e. 3m, 5m, 7m and height as 25m in zone V of seismicity. The analysis is done using Staad Pro as per IS 1893 (Part I): 2016 in order to compute the natural period, displacements and base shear of the silo for different conditions is tabulated. Different methodologies which are carried out for the model development, load calculations and, analysis Different calculations and their procedures were followed and specifications regarding the silo dimension element details and the modelling Loadings and analysis were discussed. The load calculations, load combinations, load assignment, earthquake parameters, and analysis have been represented, and the results from this analysis are represented and compared the result outputs of all the models are displayed, max absolute stresses and max shear stresses developed in each model are represented via contour diagrams, tables, and graphs, the values of minimum required Ast for beams and columns are mentioned.

• The max lateral displacements obtained for the critical load case/combination are noted down for each model at height of H25. the following is the maximum of nodal displacements to height H25 of constant diameter of D3 as 8.311mm at nodal point 73.

• The max lateral displacements obtained for the critical load case/combination are noted down for each model at height H25. the following is the maximum of nodal displacements to height H25 of constant diameter of D5 as 9.133 mm at nodal point 73.

• The max lateral displacements obtained for the critical load case/combination are noted down for each model at different heights of H25. the following is the maximum of nodal displacements to height H25 of constant diameter of D7 as 7.966 mm at nodal point 73.

• The nodal displacement for D5-H25 is maximum compared to D7-H25 @ 9.133 mm >8.311mm >7.966 mm

• The nodal displacement for D3-H25 is maximum compared to D7-H25 @ 8.311mm >7.966 mm. 57

• The Maximum absolute stressesis more for Base Model D7-H25 as 1.02 N/mm2 compared with D3-H25 as 0.995 N/mm2 & D5-H25 as 0.95 N/mm2

• The Maximum absolute stresses is more for Base Model D7-H25 as 1.29N/mm2 compared with D3-H25 as 1.27 N/mm2 & D5-H25 as1.24 N/mm2

• The horizontal pressure intensity on the silo walls and the surcharge pressure on the hopper bottom slab increase with the diameter of the silo. This means that larger silos will experience higher lateral and vertical pressures, which will need to be taken into consideration during the design and construction process.

• The horizontal pressure on the silo walls increases with the height of the silo, with the maximum pressure occurring at the top of the silo. This indicates that the upper sections of the silo will require stronger structural support than the lower sections.

• The surcharge pressure on the hopper bottom slab also increases with the height of the silo, with the maximum pressure occurring at the bottom of the hopper. This means that the hopper and its supports must be designed to withstand the weight of the stored material and the surcharge load.

• The density of the stored material, the angle of repose, and the coefficient of internal angle of friction are important factors that determine the lateral and vertical pressures on the silo walls and the hopper bottom slab.
• The area of steel required for the silos cannot be determined based on the given data, as this depends on various factors such as the design and configuration of the silo, the specific steel materials used, and the load-bearing capacity required for the silo.
• The maximum nodal displacements obtained for the critical load case/combination for all three models D3 H25, D5 H25, and D7 H25 are within permissible limits.
• The maximum absolute stresses and maximum shear stresses for all three models D3 H25, D5 H25, and D7 H25 are also within the permissible limits.
• The concrete design results for all three models D3 H25, D5 H25, and D7 H25 have been done as per the provisions of IS 456-2000. The area of steel required for different elements in all the models is also given.
• The horizontal pressure on the silo walls has been calculated for different depths by changing the height of the silo. The surcharge load on the hopper bottom has also been calculated. 58 Overall, the comparison of manual and STAADPro results indicates that the STAADPro analysis results are consistent with manual calculations. The STAADPro software has been able to provide accurate and reliable results for the silo design analysis. Based on the results you provided, it appears that STAAD design has some advantages over manual design in terms of accuracy, efficiency, and ease of use. However, it is important to note that manual design also has some advantages, such as greater flexibility and the ability to better understand and control the design process. Ultimately, the choice between manual design and STAAD design depends on a variety of factors, including the size and complexity of the project, the expertise of the design team, and the available resources. In many cases, a combination of both manual design and STAAD design may be the most appropriate approach.

REFERENCES:

1. Suvarna Dilip Deshmukh, Rathod S.K (2015) "Comparison of design and seismic behaviour of RCC silo" International journal of science and research, volume 4, Issue 5.
2. Dhanya Rajendran, unni kartha G "Comparison of Lateral analysis of reinforced concrete and steel silo" International journal of civil engineering and technology, volume 5, Issue 12, December (2014) pp 16-24.
3. Krishna T Kharjule, Minakshi B Jagtap "Seismic analysis of RCC and steel silos" International journal of computational engineering research, volume 5, Issue 7, July 2015.
4. Hamdy H.A. Abdel-Rahim "Response the cylindrical elevated wheat storage silos to seismic loading" IOSR journal of engineering, volume 4, Issue 1, pp 42-55.
5. Riya dey, Abhirup bhattacharjee "Comparison between RCC and steel hopper designs" International journal of civil engineering and technology , volume 6, Issue 6, June (2015), pp 114-123.
6. K.Dharani and D. Jeyakumar (2016) "A brief review on bunkers and silos" International journal for research in applied science and engineering technology", volume 4,Issue X, ISSN: 2321-9653.

ISSN-2394-5125 VOL 10, ISSUE 04, 2023

7. Mohamed T. Abdel-Fattah, Ian D. Moore, and Tarek T. Abdel-Fattah, (2006) "Behaviour of elevated concrete Silos filled with saturated Solids", NRC Research Press Web, Vol. 227, pp (33-239).
8. Nateghi F and Yakhchalian M (2012) "Seismic Behaviour of Silos with Different Height to Diameter Ratios Considering Granular Material-structure Interaction", Structural Engineering Research Centre, Iran, Vol. 25, No. 1, pp (26- 37).
9. ACI Committee 318, Building Code Requirements for Reinforced Concrete (ACI 318-83), American Concrete Institute, Detroit, 1983.
10. ACI Committee 313, Recommended Practice for Design and Construction of Concrete Bins, Silos, and Bunkers for Storing Granular Materials, ACI Standard 313-77 and 60 Commentary, American Concrete Institute, Detroit, revised 1983, 38 pp
11 Shadab, A., Singh, Y., Raghuwanshi, S.K., Dilshad Ansari, M., "Comparative Analysis of Horizontal and Vertical Etched Fiber Bragg Sensor for Refractive Index Sensing", Lecture Notes in Electrical Engineering, 2021, Vol. 398, Issue, PP-1367-1374.
12 Ansari, M.D., Gunjan, V.K., Rashid, E., "On Security and Data Integrity Framework for Cloud Computing Using Tamper-Proofing", Lecture Notes in Electrical Engineering, 2021, Vol. 398, Issue, PP-1419-1427.
13 Heena, Koppula, V.K., "Comparison of Diabetic Retinopathy Detection Methods", Lecture Notes in Electrical Engineering, 2021, Vol. 398, Issue, PP-1249-1254.
14 Bhavani, M., Narayana, V.A., Sreevani, G., "A Novel Approach for Detecting Near-Duplicate Web Documents by Considering Images, Text, Size of the Document and Domain", Lecture Notes in Electrical Engineering, 2021, Vol. 398, Issue, PP-1355-1366.
15 Gogineni, S., Pimpalshende, A., Goddumarri, S., "Eye disease detection using yolo and ensembled googlenet", Lecture Notes on Data Engineering and Communications Technologies, 2021, Vol. 53, Issue, PP-465-482.