Available online: www.ijsrmes.com

International Journal for Scientific Research in Modern Engineering and Science

International Journal for Scientific Research in Modern Engineering and Science, 1(5): 24–31 (2020)

Structure Analysis of Different Profile Shape of Concrete and Steel Silo Structure under Seismic Condition

Ritesh Kumar Kaushik[1]*, Vijay Kumar Shukla[2]

[1]*M. Tech. Scholar, Department of Civil Engineering, Vishwavidyalaya Engineering College, Lakhanpur (C. G.) 497116*
[2]*Assistant Professor, Department of Civil Engineering, Vishwavidyalaya Engineering College, Lakhanpur (C. G.) 497116*

Abstract

The structure used for storage of bulk solids is called bunkers, silos, or tanks. A commonly accepted definition for these terms is, shallow structures with coal, crushed stone, gravel, and similar materials are called bunkers, and tall structures with materials such as grain, cement, and wheat are usually it is called as silo. In the present work a detailed Finite Element Analysis and simulation (STAAD.Pro) has been conducted on different types of silos to evaluate different results in which the results with respect to different structure types are mentioned which are total displacement, lateral displacement, axial displacement, transverse displacement, von-mises stress, bending moment in the x, y, z direction, lateral force, axial force and transverse force included. The present work takes into account six types of silo structure, including shape and ring beam parameters, with different profile shapes for analysis, including both concrete and steel. Additionally, work has also studied the effect of structure with ring beams ranging from 0 to 5 and without ring beams.

Keywords: *Silo Structure; Finite Element Analysis; STAAD.Pro; Displacement, Stress; Base Moment; Force.*

** Corresponding author*

1. Introduction

Steel silos in common use are usually circular in cross section, and may be ground-supported (Fig. l) or elevated. Typical elevated silos generally consist of a conical roof, a cylindrical shell and a conical hopper (Fig. 1-2) and may be supported on a load-bearing skirt (Fig. l-2) or on discrete supports. The junction between the vertical wall and the hopper is termed the transition. A stiff ring is usually provided at the transition. Typical forms of the transition junction are shown in Figure 1-3. In practice, there are many forms of support, which locally contact the shell, and which may be described as discrete supports. Columns of various widths have been widely used as supports and these may terminate below the transition junction, extend to the eaves or engage into the shell for a short distance (Fig. l – 2). In this thesis, the term 'discretely supported silo' is used to mean that the silo cylinder is directly supported on local supports of a defined width.

There are different types of cement silos such as the low-level mobile silo and the static upright cement silo, which are used to hold and discharge cement and other powder materials such as PFA (Pulverised Fuel Ash). The low-level silos are fully mobile with capacities from 100 to 750 tons. They are simple to transport and are easy to set up on site. These mobile silos generally come equipped with an electronic weighing system with digital display and printer. This allows any quantity of cement or powder discharged from the silo to be controlled and also provides an accurate indication of what remains inside the silo. The static upright silos have capacities from 200 to 800 tons. These are considered a low-maintenance option for the storage of cement or other powders. Cement silos can be used in conjunction with bin-fed batching plants.

2. Methodology

From the collecting information from all literatures, it is observed that the structural performance of silo depends some many factors which includes, material stored, wind interaction, type of supports, wall flexibility, staging height, stiffeners etc. In this chapter will discussed about the mathematical and software evaluation in the field of silo structure analysis. The analysis is done using Finite Element Method and the simulation is done using STAAD.Pro. The advantage of using the FEM methodology is that unlimited number of beam and column can be added to the model, which can be placed at any direction inside the plate element. The formulation accepts eccentric and concentric beam and column of different cross-sections in different levels.

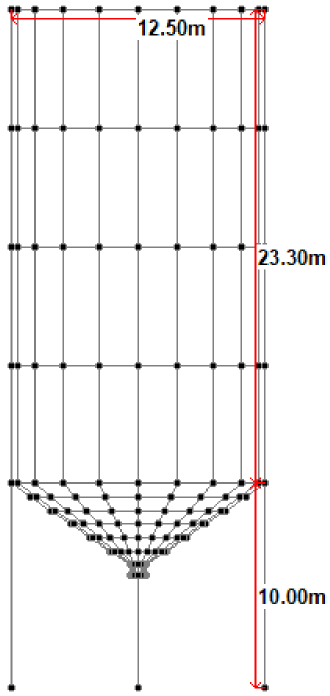
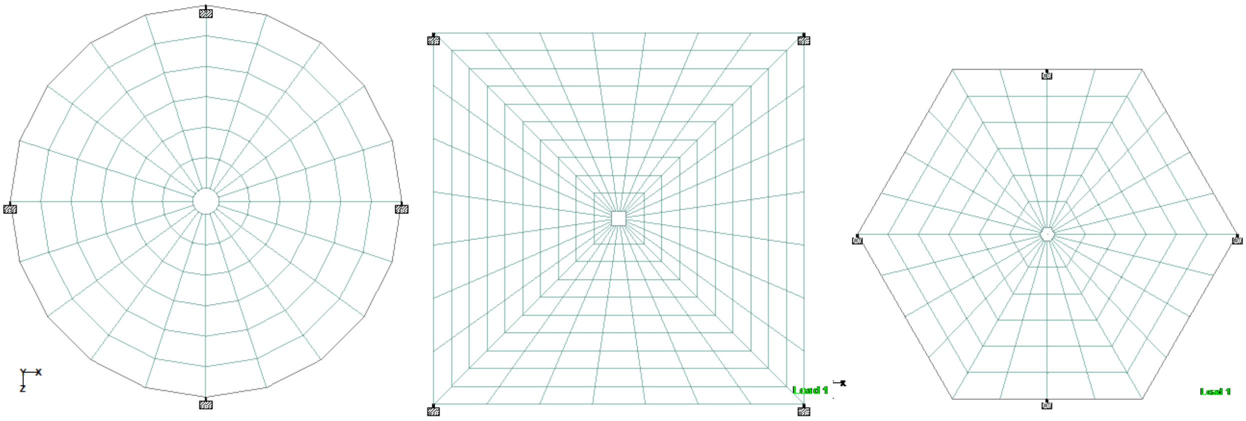


Figure 1. Wireframe model of silo structure



(a) (b) (c)

Figure 2. Profile or cross-sectional view of proposed silo models (a) Circular, (b) Rectangular, (c) Hexagonal

3. Results and Discussion

Present work a detailed Finite Element Analysis and simulation (STAAD.Pro) on the various types of silos has are conducted to evaluate the different results of the silo structure. Silo shape and ring beam is the parameters of the work. Present work various results have been obtained viz. total displacement, lateral displacement, axial displacement, transverse displacement, von-mises stress, bending moment in X, Y and Z direction, lateral force, axial force and transverse force with respect to different structure types respectively as shown in figures below:

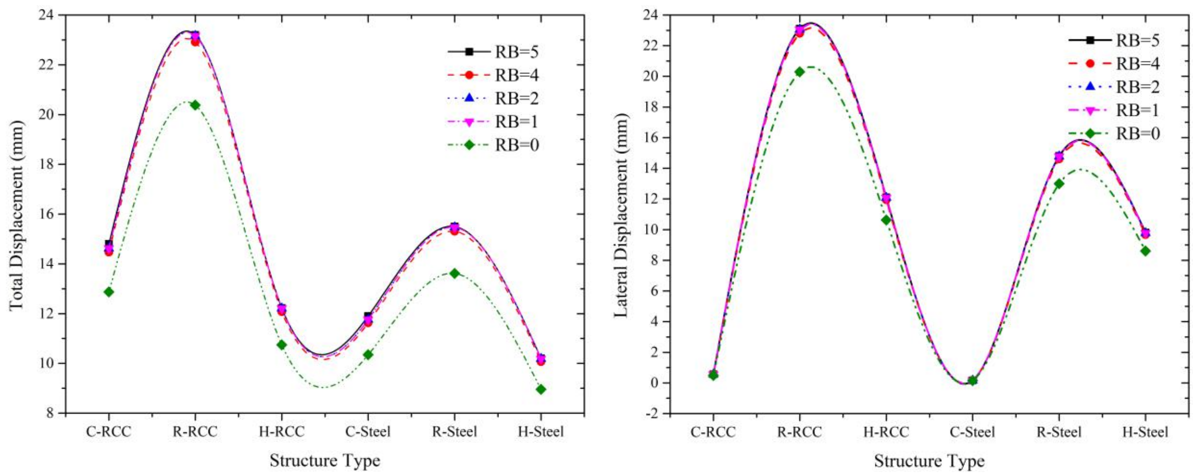


Figure 5.1 Effect of total and lateral displacement in different silo model consideration of with and without ring beam (RB) in range from 0 to 5

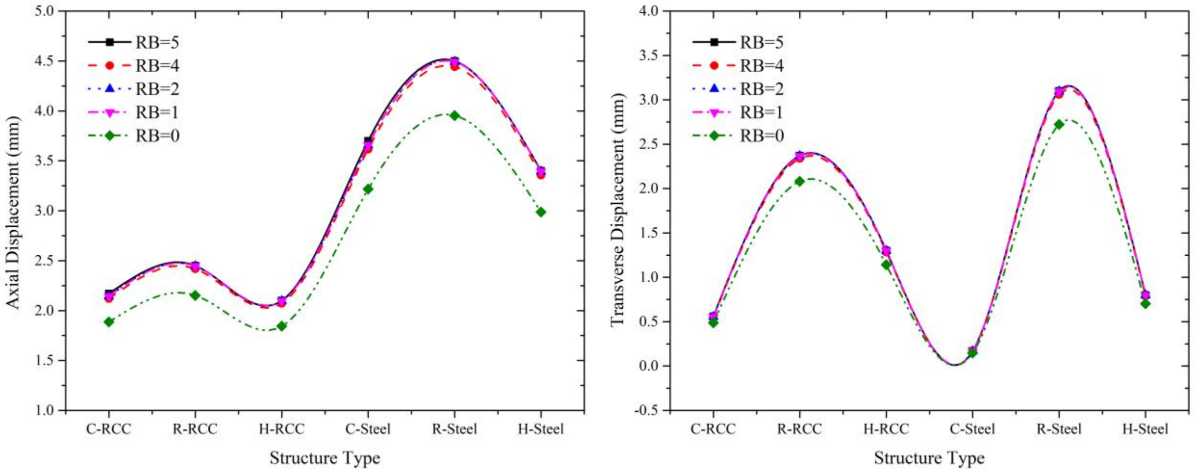


Figure 5.3 Effect of axial and transverse displacement in different silo model consideration of with and without ring beam (RB) in range from 0 to 5

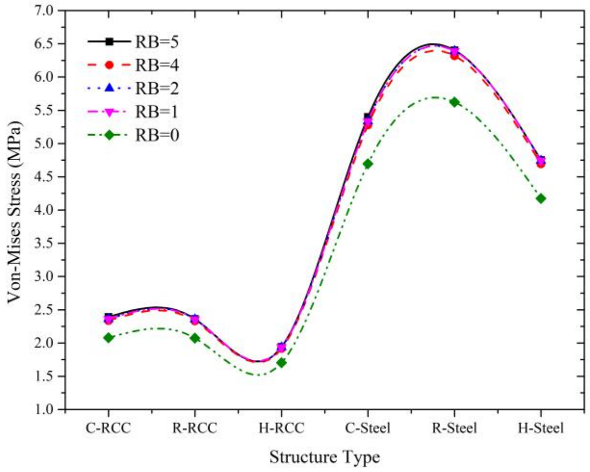


Figure 5.5 Effect of von-mises stress in different silo model consideration of with and without ring beam (RB) in range from 0 to 5

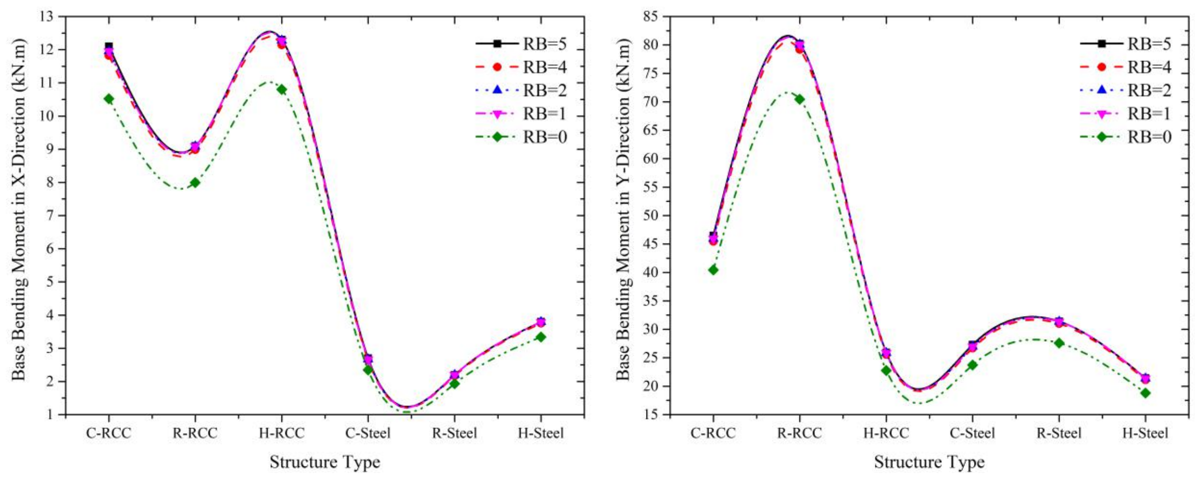


Figure 5.6 Effect of base bending moment in X and Y-direction in different silo model consideration of with and without ring beam (RB) in range from 0 to 5

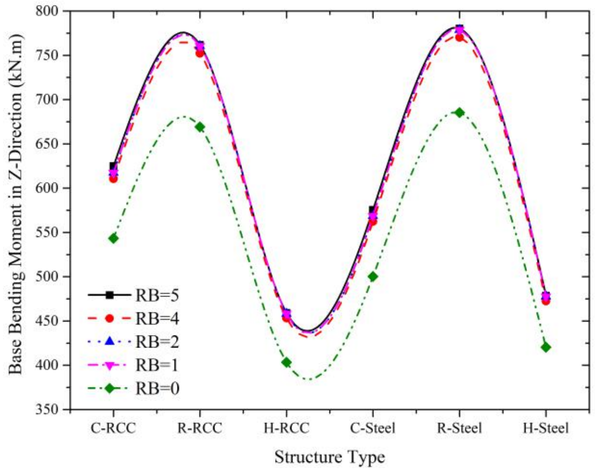


Figure 5.8 Effect of base bending moment in Z-direction in different silo model consideration of with and without ring beam (RB) in range from 0 to 5

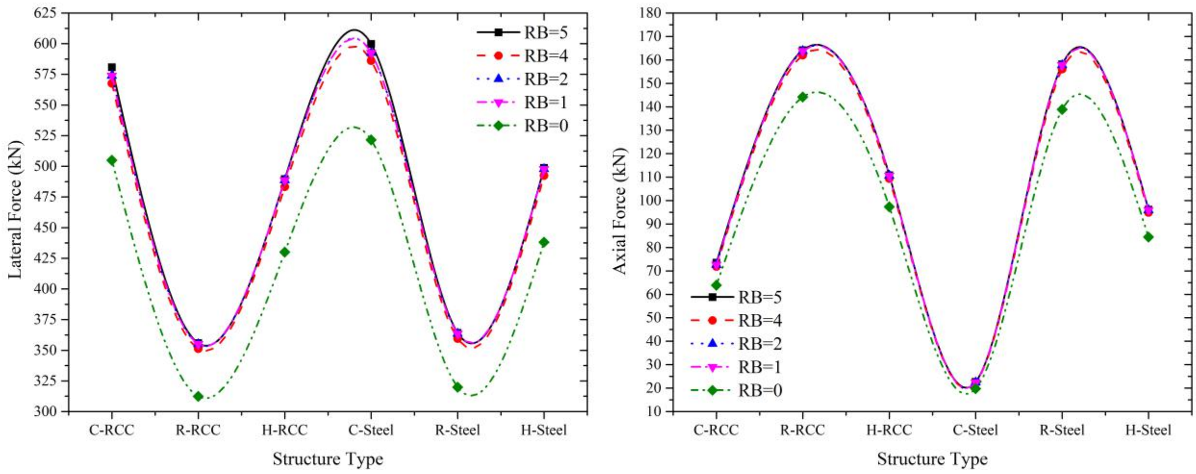


Figure 5.9 Effect of lateral and axial force in different silo model consideration of with and without ring beam (RB) in range from 0 to 5

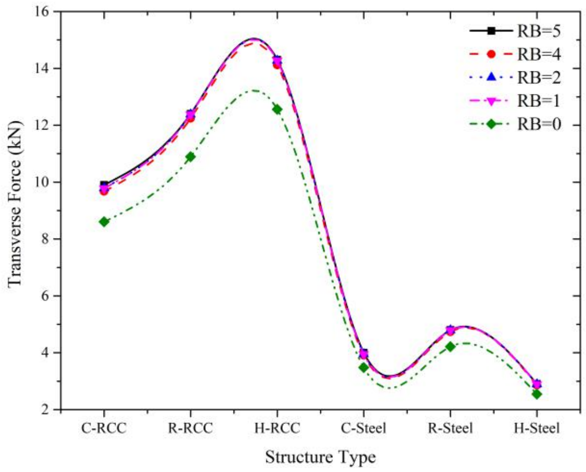


Figure 5.11 Effect of transverse force in different silo model consideration of with and without ring beam (RB) in range from 0 to 5

4. Conclusions and Future Scope

Following are some of the key findings of the work:

- A careful selection of silo geometry plays an important role as deeper silos results in higher values of lateral forces acquiring thicker silo walls and deep foundation for the column or walls.
- From analysis it has been concluded that the total displacement is changing up and down and the maximum total displacement is found in RCC rectangular (R-RCC) and minimal on steel hexagonal (H-Steel) models.
- The maximum lateral displacement is found in R-RCC model and minimum at steel circular (C-Steel) model. Also, the maximum axial displacement is found in C-RCC model and minimum at R-RCC model.
- The maximum transverse displacement is found in R-Steel and minimum at C-Steel model.
- The maximum von-mises stress is changing up and down and the maximum stress is found in R-Steel model and minimal on H-RCC models. Also, it has been noticed that the minimum stress found in without ring beam (RB=0).
- The maximum base moment in X, Y and Z-direction is found in C-RCC, R-RCC and R-Steel respectively. And the minimum base moment in X, Y and Z-direction is found in R-steel, H-RCC and H-RCC respectively.
- The maximum lateral force found in C-Steel model and minimum at R-RCC model, the maximum axial force found in R-RCC model and minimum at C-Steel and the maximum transverse force is found in H-RCC and minimum in H-steel model.
- Also, it has been noticed that the minimum displacement, stress, bending moment and forces found in without ring beam (RB=0).

Future Scope

- This evaluation of more precise results can be further enhanced with experimental or prototype in the future.
- This work can be done in future with a theoretical solution as well as with finite element or analytical method.
- An additional work for expansion of new technologies in construction such as slim-floor slabs with semi continuous connection, new steel sheet, composite sheet to minimize time and creation.
- The idealizing statement of column-to-beam contacts as hinged or entirely rigid owing to absence of more realistic supervision in view of modeling activists for further research on non-linear response of links/joint considering rotational stiffness, moment of resistance and rotational capacity.
- The research of strategies for modeling dissimilar type of connections may also demonstrate very helpful.

References

[1] Mueller.A, P.Knoedel and B.Koelle, "Critical Filling Levels of Silos and Bunkers in Seismic Design" in 15WCEE, LISBOA, 2012.

[2] Ramnatha Dash and Anand Raju, "Buckling behavior of compressive loaded composite cylindrical shell with reinforced cut outs", "International journal of engineering research and application", vol2, Issue 5, pp 2044-2048, 2008.

[3] Hamdy H.A and Abdel-Rahim, "Response of cylindrical wheat storage silo to seismic loading", Journal of engineering science, pp 2079-2102, 2013.

[4] Yang Zhao, Qing-shuai Cao, Liang Sunand Lukasz Skotny, "Buckling design of large circular steel silos subject to wind pressure", Thin-Walled Structures, Vol 73, no: 337-349, 2013.

[5] Ashwini Bindari and K.N.Vishwanath, "Analysis of Seismic and Wind effect on Steel Silo Supporting Structure", International Journal of Research in Advent Technology, Vol.2, No.9, 2014.

[6] Dhanya Rajendran, "Comparison of lateral analysis of reinforced concrete and steel silo", International journal of civil engineering and technology" Vol 5, pp 16-24, 2014.

[7] P. Iwicki, J. Tejchmann, and J. Chróścielewski, "Dynamic FE simulations of buckling process in thin-walled cylindrical metal silos", Thin-Walled Structures, Vol 84, no: 344-359, 2014.

[8] Suvarna Dilip Deshmukh and Rathod S.T, "Comparison of Design & Seismic Behaviour of RCC silo", International Journal of Science and Research, Vol.4, Issue 5, ISSN: 2319-7064, 2015.

[9] Mateusz Sondej, PiotrIwicki, Jacek Tejchmannand Michał Wójci, Critical assessment of Eurocode approach to stability of metal cylindrical silos with corrugated walls and vertical stiffeners, Thin-Walled Structures, Vol 95, no: 335-346, 2015.

[10] Marek Piekarczyk, Tomasz Michałowski, Dawid Kowalczyk, "Examples of designing steel shell structures according to eurocodes", Technical transition, 2015.

[11] Eutiquio Gallegoa, Angel Ruizb and Pedro J. Aguadob, "Simulation of silo filling and discharge using ANSYS and comparison with experimental data", Computer and electronics in agriculture, Elsevier, Vol 118, pp. 281-289, 2015.

[12] John W. Carson, "Limits of Silo Design Codes, Practice Periodical on Structural Design and Construction", ASCE, Vol. 20, Issue 2, 2015.

[13] Jeroen Hillewaerea, Joris Degrooteb,n, Geert Lombaerta, Jan Vierendeelsb, Geert Degrandea, "Wind-structure interaction simulations of ovalling vibrations in silo groups", journal of fluids and stuctures, vol 59, pp 328-350, 2015.

[14] M. Wojcik and J. Tejchma, Simulation of buckling process of cylindrical metal silos with flat sheets containing bulk solids, Thin-Walled Structures, ELSEVIER, Vol 93, pp 122-136, 2015.

[15] Afzal Ansari, Kashif Armaghan and Sachin S.kulkarni, "Design and Optimization of RCC Silo", International Journal for Research in Applied Science and Engineering Technology, Vol.4, Issue 6, ISSN: 2321-9653, June 2016.

[16] Syamili V, Laju Kottaliln, "Buckling Analysis of Thin Shells", International Journal of Civil Engineering (IJCE), Vol 5, pp 11-18, 2016.

[17] Arne Jansseune, Wouter De Corte, Jan Belis, "Elasto- plastic Failure of localy supported silos with U shaped longitudinal stiffeners" International Engineering failure analysis,ELSEVIER Vol 70, pp 122-140, 2016.

[18] Nicola Zaccari, Michele Cudemo, "Steel Silo Failure and reinforcement proposal", Engineering failure analysis, vol 66, pp 1-12, 2016.

[19] Jozef Horabik, Piotr Parafiniuk and Marek Molenda, "Experiments and discrete element method simulations of distribution of static load of grain bedding at bottom of shallow model silo" Elsevier, Vol 149, pp 60-71, 2016.

[20] A. Raeesi, H. Ghaednia, J. Zohrehheydariha, and S. Das, "Failure analysis of steel silos subject to wind load," Eng. Fail. Anal., vol. 79, pp. 749–761, 2017.

[21] Ö. Zeybek, C. Topkaya, and J. M. Rotter, "Analysis of silo supporting ring beams resting on discrete supports," Thin Walled Struct., vol. 135, pp. 285–296, 2019.

[22] L. Matiaskova, J. Bilcik, and J. Soltesz, "Failure analysis of reinforced concrete walls of cylindrical silos under elevated temperatures," Eng. Fail. Anal., vol. 109, p. 104281, 2019.

[23] S. Maleki and A. M. Mehretehran, "3D wind buckling analysis of steel silos with stepped walls," Thin Walled Struct., vol. 142, pp. 236–261, 2019.

[24] P. Iwicki, K. Rejowski, and J. Tejchman, "Determination of buckling strength of silos composed of corrugated walls and thin-walled columns using simplified wall segment models," Thin Walled Struct., vol. 135, pp. 414–436, 2019.