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# A Review on Analysis of Different 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

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.

***Keywords:*** *Silo Structure; Shell, Hopper; RCC, Steel.*

* *Corresponding author*

## 1. Introduction

Silos are an inclusive term of all structures for the storage of bulk solids common use, may be ground-supported or elevated. Typical 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 or on discrete supports. Silos are lifeline structures and strategically very important, since they have vital use in industries. Silos are special structures subjected to many different unconventional loading conditions, which result in unusual failure modes. Silos are cantilever structures with the material stacked up very high vertically. The walls of different type of silos are subject to earthquake loads from the stored mass, and these may substantially exceed the pressures from filling and discharge. The elevated silos response is highly influenced by the earthquake characteristics and is depending on the height to diameter ratio. In the earthquake analysis of such structures is to consider the silo and its content as a lumped mass and seismic effect of this mass is considered in design of the supporting frame only. Failure of a silo can be devastating as it can result in loss of the container, contamination of the material it contains, loss of material, replacement costs, environmental damage, and possible injury or loss of life. Silos and bins fail with a frequency which is much higher than almost any other industrial equipment. Sometimes the failure only involves distortion or deformation which, while unsightly, does not pose a safety or operational hazard.

## 2. Literature Review

Mueller et. al. (2012) [1], investigated the critical filling levels of silos and bunkers in relation to seismic design. For seismic design, they have considered the lowest natural frequency, response spectra, acceleration function, mass, and stiffness. They used the response spectra method according to Euro 8 code for the design of coal bunkers in which the vibration duration is longer, which describes the size of the acceleration function resulting in acceleration and base shear smaller.

Dash and Raju (2012) [2], studied the buckling behavior of compression-loaded composite cylindrical shells with reinforced cuts by ANSYS. They consider composite cylindrical spherical spheres loaded with composite materials for analysis.

Hamdy and Rahim (2013) [3], studied the seismic load in silos and its effect on structure. They used seismic response of elevated wheat silos such as peak displacement, normal forces, shear forces and bending moments on silo support to record earthquakes.

Zhao et. al. (2013) [4], analyzed the buckling design of large steel silos subjected to air pressure according to Euro code. In case of load we (wind and empty silo) and WF (wind and full silo) were considered. The buckling deformation corresponding to the critical point in terms of loading is controlled by the circumference compression that arises in the curved direction of the hull.

Bindari and Vishwanath (2014) [5], analyzed the effects of seismic and wind loads on the structures of steel silos. They performed an analysis on a high-rise steel building frame with reinforced and unmodified support with the help of the SA 2000 2000 software package. Equivalent static method and method, for dynamic analysis under selected seismic zone V. Reaction spectrum. Based on their study, they came to the following conclusion,

Rajendran and Kartha (2014) [6], compared to lateral analysis of reinforced concrete and steel silos. Normal pressure and axial compression load due to stored materials were considered together with the self-weight of the superstructure. Lateral loads due to wind or seismic forces are also considered.

Iwicki et. al. (2014) [7], investigated the stability process in silos made of thin-walled isotropic plain roll sheets using a static and dynamic finite element analysis taking into account both geometric and physical non-linearity during eccentric discharge. After Eurocode 1.

Deshmukh and Rathod (2015) [8], conducted a comparative study on the design and seismic behavior of RCC silos. He has studied abnormal failure modes and their causes. They have analyzed and designed according to IS 4995, Euro code (EN 1998-4: 1999 and EN 1991-4: 2006) and ACI code.

Sondej et. al. (2015) [9], studied the stability of cylindrical steel silos made of corrugated walls and vertical open sectional beams. Complete three-dimensional finite element analyzes were performed using a linear buckling approach with true thin, semi-thin and squat silos.

Kothiya et. al. (2015) [10], was concluded that the pressure variation is directly proportional to the hydraulic mean radius, which ultimately depends on the number of compartments. The lateral pressure from the ACI approach gives more conservative results, but the ACI code does not give any idea about the overpressure factor, especially for bin silos.

Pambhar and Vaniya et. al. (2015) [11], rectangular silos were studied and spherical hopper RCC silos were analyzed under their own weight, pressure on the vertical wall, and seismic load. The velocity, displacement and acceleration in the x direction compared to y and z were also seen to be maximum.

Ding et. al. (2015) [12], was effectively used to predict the flow patterns of solid particles in silos during discharge. There were qualitative agreements between the calculation results and established observations. The agreements verified that this FE program is suitable for investigating flow patterns in silos.

Kharjule and Nayak (2016) [13], have concluded that the lateral pressure for granular material gives maximum pressure during flow conditions in the Janus method. The lateral pressure for the powder material provides the maximum pressure in the ventilated method.

Sachidanandam and Jose (2016) [14], studied the causes of bunker and silo failures and illustrated them due to design, construction and assembly errors, improper use and maintenance. They have studied the flow of powder and used it in the design of silos and hoppers that can discharge materials without clogging.

Belagaonkar and Kadam (2016) [15], studied the design of silo and bunker walls, evaluated the maximum levels of silage juice, while the current guidelines showed heightened forces possibly arising from silo juice. Generated with silo juice. Wall over 3 meters.

Goodey et. al. (2017) [16], the model presented for predicting the pressure distribution shows that the values of a simple expression to identify the pressure variation, give a good comparison with the data. Apparently two similar granular solids have shown some different behavior and indicate that the values used in the model need to include the parameters that differentiate these stiffness characteristics.

Raeesi et. al. (2017) [17], studied and presented as a result of a large-scale field. Lateral displacements and deformations at the bottom of the silo due to grain loading were measured and test data were used to validate the finite element model.

Saleem et. al. (2018) [18], was studied in a detailed and numerical analytical way on various types of silos to evaluate existing load calculation procedures and design methodology. Silo height, diameter and stored the unit loads of the material were the parameters studied.

Meshram and Bhadke (2019) [19], studied the performance of structures located in all seismic zones, such as nodal displacement, stress, vertical or horizontal pressure in walls, compared to different models of solid silos for earthquakes. The presentation of results is in tabular and graphic form. This method is performed for a volume of 180 m3..

Rotter et. al. (2019) [20] investigated that the structure of rectangular silos were factors that affect the pressure distribution of the wall in the silo. A valid finite element model is used for parametric studies. The hardness of the wall and the importance of concrete are demonstrated. A relation between wall pressure and stiffness is presented.

Zeybek et. al. (2019) [21], explores the resulting stresses in a closed section annular beam of practical dimensions that are less rigid than the ideal stiffness through finite element parametric study of flexible annular beams and associated silo shells.

Matiaskovaa et. al. (2019) [22], a result has been shown, that one of the main factors affecting the mobility of silos are related to temperature-induced cracking. However, predicting a suitable heat load can be a fairly complex task and does not fully emphasize the importance of thermal cracking in silo design guidelines. As a result, engineering practice can ignore or minimize this effect.

Maleki et. al. (2019) [23], presented linear and non-linear wind buckling analysis in 3D. In which three steel silos with walls made of flat sheets adopted the distribution of air pressure from EN 1991-1-4 and EN 1993-4-1 Annex C. The effect of different wind patterns on the buckling behavior of these structures was evaluated.

## 3. Conclusion and Proposed Work

Thin-walled cylindrical steel silos are one of the key structures for storage of materials in many industries and agricultural sectors. They are susceptible to instability under wind pressure and earthquakes conditions when they are empty or partially filled. This present work investigates the buckling behavior of various cases on steel as well as concrete silos with and without stepped walls composed of isotropic rolled shells. Wind load vertical and circumferential distributions pressure have been adopted from Indian Standard (IS) code. Six proposed circumferential pressure distributions for an isolated silo and a silo in a group with an open roof has been taken into consideration. Accordingly, comprehensive 3D finite element analysis has been used and detailed non-linear buckling analyses has been conducted. In addition, the finite element analysis has been performed for undertaking wind analysis to obtained the effect of different parameters such as different geometric, dimensions on the wind-induced buckling strength of silos made of steel and concrete.

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