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Analysis and Design of Rcc Silo Structure by Considering Indian Seismic Zones

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Abstract –*RCC Silos are used by a spacious range of industries to store bulk solids in quantities ranging from a few tones to hundreds or thousands of tones. The term silo includes all forms of particulate solids storage structure that might otherwise be referred to as a bin, hopper, grain tank or bunker. Silos are very demanding in cement industries. Hence RCC silos are widely used for storage of granular materials as they are an ideal structural material for the building of permanent bulk-storage facilities for dry granular like fillings. Initially concrete storage units are economical in design and reasonable in cost. Concrete can offer the protection to the stored materials, requires little maintenance, is aesthetically pleasing, and is relatively free of certain structural hazards such as buckling or denting.*

In this project, we are designing the RCC silo situated in all seismic zones with the help of structural software Staad Pro. The design concept include, providing all dimensions of structural component based on trial and error method. The Analysis of silo, using Equivalent lateral force method and study the performance of structure located in all seismic regions in term of Comparison of different models of concrete silo for earthquake such as nodal displacement, stress and vertical or horizontal pressure on walls etc. The Presentation of the results is in tabular and graphical look. This method is carried out for volume of 180 m3. All the designs have been based on the recommendations of I.S 4995 -1974 (part 1&2) and I.S 456 – 2000 codes, Based on these designs, that dimension of silos shows least amount of concrete and steel. These findings will be useful for the designers of silos.

I. Introduction

Basic shape of silo is circular but as per requirement it could be square, rectangular or polygonal shape and it is provided with roof and bottom which may be conical, pyramidal or flat. Silos are generally supported with number of column, total structure wall, hopper bottom and column is connected by the ring beam to distribute the load. Silo basically design for both vertical and horizontal pressure. Silos are the frequently used storage structures in production industries such as cement factories, power plant structures etc. When a Silo is used in the Thermal power plant structures it should be capable of storing ashes with high temperature. When compared to the Steel Silos, performances of RCC Silos are better due to its easy construction and maintenance. In this synopsis design and analysis of Fly ash RCC Silo for thermal power plant structures be carried out with the sequence of preparation of plan, calculation of loads & load combinations, analysis using STAAD PRO and design as per Indian Standards. As per the IS code 4995(Part I):1974 Height/Diameter ratio greater than or equal to two for the reduction of lateral pressure over the large height takes place. The exact pressure calculation is difficult due to the many factor acts during the emptying and filling of material. The various load act on the silo structure, during the structural design of silo various load applied according to its intended use, size, structure type, material, design life time, location environment in order to assure life safety and to maintain it essential functions.

There are two methods suggested by IS-4995(Part I):1974 is Janssen’s Theory and other one is Airy’s Theory to calculate silo loads.

Janssen’s Theory

The assumption that portion of the weight of the contained material is supported by friction between material and the wall, and only a small portion of weight is transferred to the hopper bottom. Due to this, Rankin's (1857) or Coulomb’s (1776) lateral pressure theories cannot be directly applied. The vertical walls of the silo are subjected to direct compression as well as lateral pressure.

Airy’s Theory

Airy’s analysis is based on Coulomb’s wedge theory of earth pressure. By this theory, it is possible to calculate the horizontal pressure per unit length of the periphery and the position of the plane of rupture

II. Literature Review

1.Afsal Ansari, Kashif Armaghan and Sachin S. Kulkarni (2014) concentrated on the study of RCC silos which are mostly used for granular materials storage. In their study they stated that concrete storage units are somewhat economical in design and cost. Also it can offer protection to the stored materials needs little maintenance and free of hazards such as buckling or denting to some extent. For the analysis of most economical configuration of

Silos for volume of 125m3 they have been designed twenty eight samples by changing the ratio of height to diameter and finally found out the most economical size. Their designs have been based on the recommendations of IS 4995-1974 (part 1-2) “criteria for design of reinforced concrete bins for the storage of granular and powdery materials” and IS 456-2000 codes. Finally they concluded that by increasing the height by diameter ratio, the total cost of construction will also increase. In detail they concluded that increasing diameter results in high cost & vice versa and increasing height results in reduced cost of construction.

2.Indrajit Chowdhury and Raj Tilak suggested a procedure to incorporate the dynamic pressure due to earthquake in the analysis of circular silos. They carried out this analysis using conventional Jansen’s method with some modifications and they did parametric study about dynamic pressure on wall of silo with different structural configuration. They proposed new mathematical model to apply within a design office frame work which did not need an elaborate FEM analysis and could well adapted in a spreadsheet or shell. They insisted that usual ignorance of vertical component of earthquake in structural design would encourage the lateral dynamic pressure and should not be ignored particularly for the huge capacity silo. Finally they concluded that ignorance of seismic effect would considerably under design the silo wall design procedure.

3.A.Mueller, P.Knoedel and B.Koelle (2012) investigated the critical filling level of silos and bunkers with respect to seismic design. For the seismic design they have considered the lowest natural frequency, response spectra, acceleration function, masses and stiffness. They used response spectra method as per Euro code 8 for the design of coal bunkers in which vibration periods are larger which describes the shape of acceleration function that results in smaller acceleration and base shear. They made different assessment of the column’s bases which are pinned or clamped, might produce model errors but those errors remain moderate due to diagonal bracing. In the response spectrum when the oscillation period is larger than control period, it is assumed that the seismic load will decrease, since the accelerations decrease. They concluded that the base shear cannot be decreased, if the frequencies of the structure are altered by increased mass, which is due to the reduction of acceleration with increasing period does not balance additional mass.

4.Suvarna Dilip Deshmukh and Rathod (2008) made a comparative study on the design and seismic behavior of RCC silo. They have studied about the unusual failure modes and their causes. They have analyzed and designed as per IS 4995, Euro code (EN 1998-4:1999 and EN 1991-4:2006) and ACI code. For the design they have considered static and dynamic pressure exerted by stored materials & seismic loads. Based on their study

they have been concluded that while designing silo wall, pressure due to seismic action must be considered. In their analysis they found out that varying reinforcement along depth of wall & more on the middle portion of wall could perform well.

5.K.Sachidanandam and B.Jose Ravindra Raj (2016) studied the causes for failure of bunkers and silos and illustrated them as, due to design, fabrication & erection error, improper usage and maintenance. They have studied about the powder flow and used that gathering in design of silos and bunkers which can discharge the material free from hang-up. Based on their study and learning from many projects, they listed some practical approach to the upcoming researchers. They are,

A) requirement of flow pattern,

B) Measurement of powder properties,

C) Based on the material to be handled and operational requirements, design models should be utilized.

6.Vandana.CJ,P.Sabarishkumar, M.Alagendran3(2015) Studied Storage is one of the important and vital stages among the marketing and consumption phases. Reinforced cementconcrete (RCC) is an ideal structural material for building of permanent bulk storage facilities. RCC Bin can be flat bottom type or hopper bottom type. Although flat bottom bins can be built more easily than hopper bottom bins but it is desirable that bottom is self cleaning. It is because of this reason that hopper bottom bins are preferred. Specified the various parameters such as diameter of bin,height of bin, properties of the material to be stored (angle of repose and density), grade of steel, grade of concrete, the number of supports, and the components are designed. For every single case, support numbers have been varied in multiple of 2, starting from

4say4, 6, 8, 10, 12etc. Conforming to the normal practice, the supports are assumed to be equally spaced alongside the periphery. For the designed components (ring girder dimensions, column cross-section, thickness of wall), depending upon diameter & height of the bins, influence coefficient matrix is then generated. The, parameters such as fundamental natural frequency and other frequencies in

first 3 modes for bin full and bin empty conditions have been computed and the normalized Eigen values have been computed corresponding to first three modes. Then, static & dynamic analysis of bins has been carried out by taking elements at 2m interval both in bin (full & empty) conditions. Then the values of natural frequencies and elemental matrices along with normalized mode shape values are used in carrying out dynamic analysis.

7.Dharmendra H. PambharandProf. Shraddha R. Vaniya

In this recent era of competition in industries India, which is becoming a rising nation in industries like ceramics,
cement industry and textiles, etc. still there is a requirement of modification of storing raw materials in this product type industry.
Manual design of circular silo for various material and also done .net programming for different material storing in silo & check pressure and design of reinforcement in this paper. Also done a comparison between manual design and.net programming. In both designs, influence of different parameters discussed.

Fig: silo profile

\8. Raj Kumar Janghel1, R. C. Singh2

Thin shell structures have given considerably attention for the at least six decades especially during the war time because of their importance in aircraft and missile applications. Shells of various shapes were investigated such as elliptical hemispherical, conical and cylindrical shells. These structures are mostly failing by bucking under external pressure. Cylindrical steel silos are tall slender structures used for storing materials like cement, grains, fly ash, carbon black, coal saw dust etc. They are special structures subjected to many different unconventional loading conditions, ranging from few tones to hundreds to thousands of tones which results in unusual failure modes. Failure of a silo can be devastating as it results in loss of the containers, contamination of material it contains, loss of materials environmental damages, and possible injuries and loss of life. Silos are subjected to normal pressure and axial compressive loads along with the self-weight. They also carry lateral loads due to wind and seismic forces.

III. Summaryliterature Review

1. A clear and broad learning of recent available international paper on silos.
2. To perform the Analysis of silo using Equivalent lateral force method and to study the performance of structure located in all seismic regions.
3. Comparison of different models of concrete silo for earthquake in terms of nodal displacement, stress and vertical or horizontal pressure on walls etc.
4. To compare the results obtained to assess their potentiality and suitability in understanding the true behavior of such a structure.
5. Presentation of the result in tabular appearance to simply be familiar with the analysis of structure

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