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

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Abstract: -

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. Bunkers and silos are structure that are used as storage tanks.
The storage of raw materials in any industry in large scale is done with the help of large containers these containers are called as silos. The design of silo is given attention and treated as special structure for design as considering its importance in earthquake prone surrounding. Manual design of 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.

Keyword: - **silo, .net (VB), hoop stress, longitudinal stress, silo wall, hopper bottom, STAAD Pro, Earthquake.**

I. INTRODUTION

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.
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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.

Fig. 1 grain bin, concrete silo, harvestore silo

1.1. Objectives

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

1.2. Characteristics Of Silo

- Granular materials can be collected, distributed and stored in bulk efficiently.
- Transportation costs, which influence the costs of raw materials and products, can be reduced.
- Compared with storage on a flat surface, such as a floor, a silo's storing capacity is several times greater in the same space.
- Automatic loading, unloading and control of storage volume are possible.

1.3. Loads Acting on Silos

Silos are subjected to several types of actions or loads. As per Indian Standard Code, IS: 875: 1987 Part I-V, the following list of loads are to be taken for silo:

- Dead load (Self weight)
- Storage load (Material load)
- Live load (Platform area, Roof and Floor load)

- Wind load
- Imposed loads and deformation load

Figure 2: silo image

Figure 3: bunker image

- Few images are displayed below which showing the failure of silos due to earthquake and wind forces. It is essential to consider wind and earthquake effect on silo.

Failure of silo due to earthquake

Failure of silo at segement 1 due to excessive Stresses at Juction

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.
- 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.

- 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.

4. IS 1893: 2002, IS 1893 is the main code that provides the seismic\zone map (Figure) and specifies seismic design force. This force depends on the mass and seismic coefficient of the structure; the latter in turn depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil on which it rests, and its ductility.. Over 70% of India's land under seismic zones III, IV and V**.** The revised 2002 edition, Part 1 of IS1893, contains provisions that are general in nature and those applicable for buildings

5. 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.

6. 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.

III. RESEARCH METHODOLOGY

STEP 1: FIX THE DIMENSIONS

To create a model for the analysis in software dimensions is necessary for the given requirements, Dimension of Silo being drawn based on the requirements.

STEP 2: LOAD CALCULATIONS AND LOAD COMBINATIONS

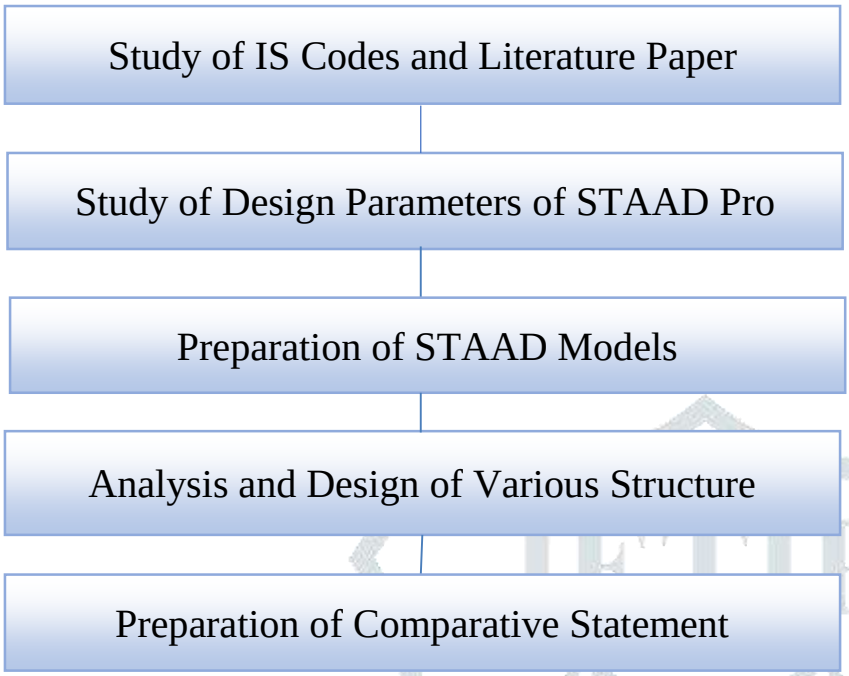
Load calculations are carried out based on various Indian Standards such as IS: 875(Part – 1)-1987 for Dead loads (Unit weight of Building materials and Stored materials), IS: 875(Part –2)-1987 for Imposed loads and IS: 1893(Part 1)-2002 for Seismic loads. Horizontal pressure acting on Silo wall at various depths and forces due to horizontal pressure are calculated based on IS: 4995(Part I)-1974. Temperature stresses and Hoop steel required to resist those stresses are calculated based on IS: 4995(Part II) - 1974. Loads mentioned above are considered to be Primary load cases.

STEP 3: ANALYSIS USING STAAD PRO

The created model in the STAAD has to be analyzed after the assignment of properties of members. Load cases details and definition of loads should be defined carefully based on the calculation of loads and IS codes. Load cases details be in the order of Dead load, Live load, Ash load, & -z, Seismic +x & +z and other load combinations for the analysis.

STEP 5: DESIGN AS PER INDIAN STANDARDS

Design of RC Silos is based on the values obtains from analysis where IS: 456 -2000 and SP are be use for the design procedure and for various checks.



IV.CONCLUSION

This research is carried out to check the behaviour of silos in earthquake and wind load condition. A typical model of silo taken for analysis and checked for static as well as dynamic design. For software data validation, Manual analysis is done for static analysis and checked its result with static analysis of software. Both result are same which give the idea about perfectness of software for analysis and design.

Earthquake and wind load combination taken by refering relevent IS codes such as IS 1893 and IS 456, IS 875. From the analysis it is conclude that stresses on silo is more while applying the earthquake load and wind load as compare to stresses due to static load.

To resist additional stresses during earthquake and high wind, silo shall design for additional earthquake and wind forces. Many silos fail due to lack of earthquake design as shown in above images.This analysis and design is carried out on concrete cyllendrical silo. It can be check for concrete rectangulare silo and steel silos too.

V. REFERENCES

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