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SEISMIC ANALYSIS OF CIRCULAR AND RECTANGULAR SILOS

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Abstract - *- This research work provides an idea of effect of shape of silos on seismic behavior on reinforced cement concrete (RCC) rectangular silo as well as circular silo. IS: 4995 (Part-I): 1974 used for calculation of the loading on silo as per Janssen's theory and IS: 4995 (Part-II): 1974 used for design criteria of silo. Equivalent static Method of analysis is use for analysis the rectangular and circular silos. The rectangular silo and circular silo model and analysis is carried out in STAAD Pro. Base shear, Base Moment and displacement are obtained for rectangular and circular silos. Also Base shear, moments in X, Y and XY direction, are obtained for circular and rectangular silos. It is observed that comparatively more base shear and moments developed in rectangular silos than circular silos in different seismic Zones.*

Key Words: Base shear, Lateral displacement, Circular R.C.C silo, Square R.C.C. silo, STAAD Pro

1. INTRODUCTION:

Silo, bins, or bunker are container used for storing bulk solids. Although no specific definition for all these terms, shallow structure use for storing coke, coal, crushed stone, gravel, ore & other similar material are usually called bunkers & bins. Tall structures use for storing grains, cement is often called silos. Most of industries used silos to store bulk solids, quantity ranges from a thousand tones to hundred to few tones. Power station, cement plant, gas work in many more short and big establishments where storage of bulk material is necessary, for the purpose of storing material silo is used.

Silo structure may be elevated or rest on ground have circular, square or rectangular in shape. Rectangular or Square silos usually have single outlet with pyramidal bottom, but sometimes a trough bottom is used with a single elongated outlet or two or more circular or square outlet. Silo which is in circular shape have flat bottom or conical bottom with single outlet. Material used for construction of silo may be RCC & reinforced concrete.

Governing factor in design of silos are the type of material stored in it and there properties. Bulk material density, frictional properties & pattern of material flow varies generously, the applied loads and load caring system different in structure like silo than other traditional structure. Silos are designed as special structure & also design is based on the strength design method.

Storage container and silo fails because of many reasons:

which are as follows,

- Failure due to design
- Failure due to construction
- Failure due to usage
- Failure due to maintenance

Collapse of silo in seismic failure is the major failure; occur because of improper assumptions, wrong analysis and design. In this study consider circular flat bottom silo symmetrical about vertical axis & RCC slab provided at the top and bottom of silo by proving small open able hole to top of silo for filling storage material in it. In this study compare various method of silo design and seismic force calculation by using different code provision like IS, ASCE, AJI, and EURO. The dividers of the storehouses are commonly exposed to both ordinary weight and vertical frictional shear or footing delivered by the material put away inside the storehouse. The size and conveyance of both shear and ordinary weight over the tallness of the divider rely upon the properties of the put away material.

Calculation of seismic load consider silo self-weight and material stored in it as a lumped mass and seismic effect of this mass is considered in design of the silo wall

2. METHODOLOGY:

Dynamic analysis and seismic behaviour of RCC silo and avoid failure of RCC silo during earthquake seismic force calculated by using IS code. Results will cross check by using structure design software.

1. Calculation of pressure acting on the wall of silo using height to diameter ratio and angle of internal friction by using Janssen's theory.

2. Design of silo using IS specifications.

3. Modelling and analysis of different shapes of silo by using software..

4. Calculation and comparison of Base shear, lateral displacement for different shapes.

5. Compare Circular and Square silo in different Seismic Zone

2.1 Types of Silo

2.1.1 Flat Bottom Silos

Fig -1: Flat Bottom Silos

Utilized for long haul stockpiling of huge amounts of grain, seeds and granular items.

Utilized for Storage of grains (oats, seeds, vegetables, mechanical items and different items) that Requires uncommon capacity conditions.

2.1.2Truck load silos

This are used for the storage and subsequent delivery of bulk products

Fig. 2 Truck load silo

2.2 Load Consider For Silo Design

Loads should be applied to the structural design of a silo according to its intended use, size, structure type, materials, design lifetime, location and environment, in order to assure life safety and to maintain its essential functions.

The applied loads should be as follows, and their combinations should be defined considering the actual probability of occurrence.

(i) Dead loads

(ii) Live loads

(iii) Snow loads

(iv) Wind loads

(v) Seismic loads

(vi) Impulse and suction because of substance sloshing, and weight because of substance.

(vii) Thermal stresses

(viii) Shock,

(ix) Fatigue loads

(x) Soil and water pressures

(xi) Others.

Dead Loads: - Dead loads are the sum of the weights of the silo, its associated piping and equipment and other fixed appurtenances.

Live Loads: - Live loads should be considered forces from stored material (including overpressures and under pressures from flow), floor and roof live loads

Snow Loads: - Snow loads should be defined by considering the location, topography, and environment, density of the snow, snow accumulating period, and the shape and temperature of the tank.

Wind loads: - Wind burdens ought to be characterized by thinking about the state of the tank, its basic Characteristics, the area, and condition.

Seismic Loads: - Design seismic loads for above-ground storage tanks should be calculated by either one of the following methods:
(i) Seismic Coefficient Method, or
(ii) Modal Analysis

Thermal loads: - Thermal loads include those due to temperature differences between inside and outside faces of wall.

Shock loads: - Shock load including those due to crane movement, crane use for storing material in silo.

Soil and water load: - If silo situated below the ground then soil load act on silo and water load act on silo depend on water table available.

Other loads: - Other loads include equipment connecting to silo.

3. DESIGN OF SILO

Silos and their supports should be designed to contain all applicable loads taking into account the properties of stored materials, the shape of the silos, methods of material handling. The state of the storehouse ought to be as basic as could be allowed, be symmetrical about its hub, and ought to have auxiliary individuals which are proportioned to give sufficient quality.

In silos the weight of material stored is supported by bottom of silo and side wall of silo resulting reduction in lateral pressure. Vertical weight carried by wall causes direct compression in wall.

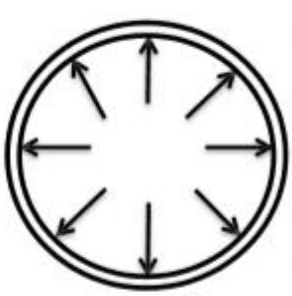

Fig. 3

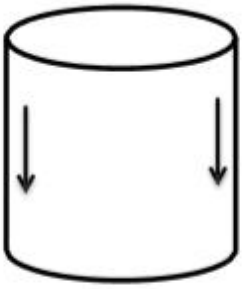

Fig. 4

Fig. 3 Plan of silo showing horizontal pressure acting on the silo wall and Fig. 4 Elevation of silo showing vertical pressure acting on silo wall

3.1 Analysis of Silo

For calculation of static pressure on silo wall parameter consider for silo design as per IS code. While calculation done for seismic force parameter used for calculation of seismic force will varies with their respective code condition that parameter.

Following data consider for calculation of silo pressure

Type	Circuolar	Square
Height	16m	16m
Latral dimension	5m Dia.	4.44 m side
Height from ground	6m	6m
Stored material	Wheat	Wheat
Density of material	7850N/m^3	7850N/m^3

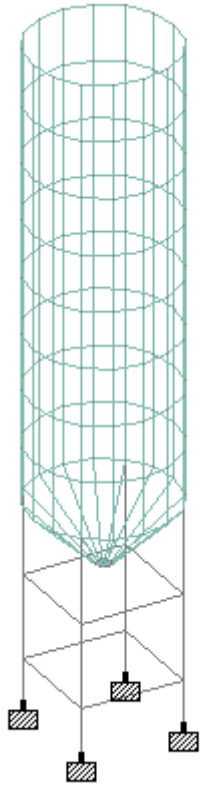

Fig5: Circular silo

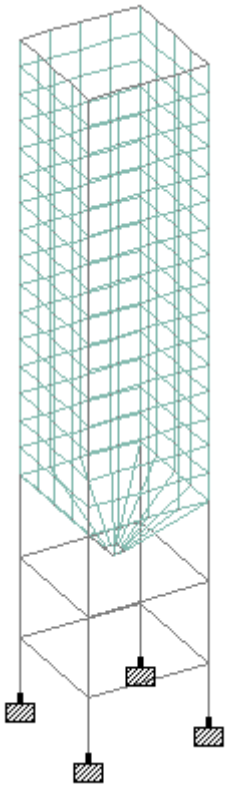

Fig6: Square silo

3.1.1 Method of Analysis

Static seismic analysis is carried out on circular and square silo under different seismic zone

Zone -II Z=0.36

Zone- III Z=0.24

Zone- IV Z=0.16

Zone- V Z=0.10

Soil Type –Hard

Importance factor I= 1

Response Reduction Factor R= 3

Damping ratio= 0.05

4 .RESULT AND DISCUSSION

Result are obtained by using static seismic method in the form of lateral forces Base Shear, Base Moment and Maximum lateral displacement.

4.1 Base Shear

Chart-1 Shows base shear values obtained by seismic analysis on R.C.C circular and Square silo in different seismic zone.

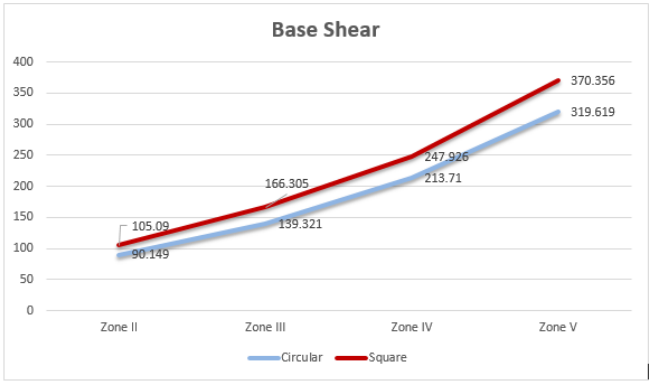

Chart-1 Base Shear in Different Zone

Maximum Base Shear is found to be 370.356KN in Zone –V For square silo. Base Shear value is increasing with Zone-II to Zone-V for Both Circular and Square Silo but It has been seen more in case of square shape for same volume.

4.2 Base Moment

Chart-2. Shows base Moment values obtained by seismic analysis on R.C.C circular and Square silo in different seismic zone.

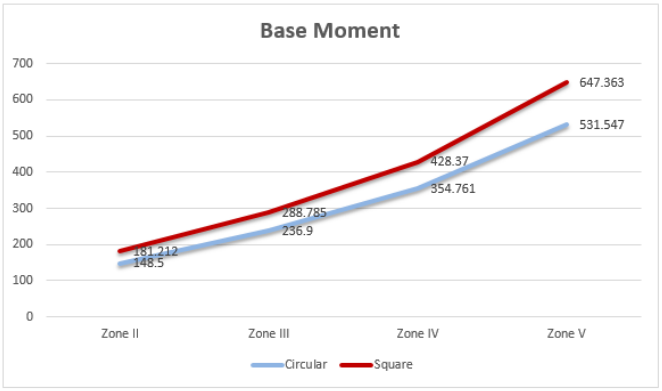

Chart. 2 Base Moment

Maximum Base Moment is found to be 647.363 KN-m in Zone-V for square silo. Base Moment value is increasing with Zone-II to Zone-V for Both Circular and Square Silo but it has been seen more in case of square shape for same volume.

4.3 Lateral Displacement

Chart-3 Shows Maximum Displacement values obtained by seismic analysis on R.C.C circular and Square silo in different seismic zone.

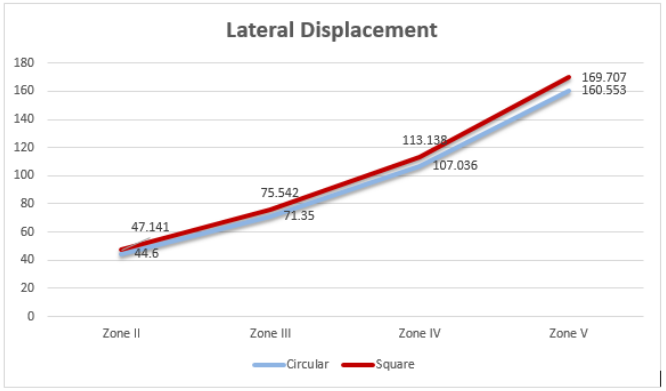

Chart-3 Lateral Displacement in Different Zone

Maximum Lateral Displacement is found to be 169.707mm in Zone –V For square silo. Lateral Displacement value is increasing with Zone-II to Zone-V for Both Circular and Square Silo but it has been seen more in case of square shape for same volume.

5. CONCLUSIONS

1. It is observed that Base Shear is increasing with different seismic Zone from Zone-II to Zone-V i.e. values is higher for higher zone.
2. Lateral displacement increasing with higher seismic Zone in both cases for R.C.C. Circular silo as well as Square silo, but it has been observed comparatively more in square R.C.C. silo in all seismic zone.

3. Also Base Moment value found more in case of Square silo among all Base moment for Zone-V and it has least value for circular silo in Zone-II
4. Comparing the Base Shear, Base Moment and Maximum Lateral Displacement it is found that circular silo performs good compared to square silo in all seismic zone.

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