COMPARATIVE STUDY ON DESIGN AND ANALYSIS OF VARIOUS TYPES OF REINFORCED CONCRETE SILOS BY CONSIDERING DIFFERENT SEISMIC ZONES

[1]Mr. Sugat S. Mohod, [2]Dr. Nina R. Dhamge

[1]P.G. Student, Structural Engineering, K. D. K. College of Engineering, Nagpur, India
[2]Professor, Department of Civil Engineering, K. D. K. College of Engineering, Nagpur, India

Abstract: This article Summaries a comparative study of seismic analysis of various types of reinforced concrete silos. We are analyzing Circular silos, rectangular silos & square silos structures, considering different seismic zones. Whole Design and analysis of all Structures has been done in STAAD Pro Software. The total Six numbers of models are included in this project where the model 1 & 2 are designed as Square Silo, Model 3 & 4 designed as Rectangular Silo and Model 5 & 6 are designed as Circular Silo.

Index Terms - Reinforced Concrete Silos, Seismic analysis, Circular Silo, Rectangular Silo & Square Silo

I. INTRODUCTION

Silos are the structures used for storing materials like food grains, cement, coal, crushed stone, gravel, clinker etc., in large quantities. In general, bunkers or bins are used to store gravel, stone and coal whereas cement and grains are stored in silos. they'll be constructed as either ground supported or elevated. With the appearance of revolution, there's a requirement for the right storage of giant quantity of crops for future use after it's been harvested. to satisfy this demand of storing crops and grains, the development of silos became essential. The silo plays an important role in agricultural, industrial and military domain for the aim of storing materials. The materials for construction of silos comprises of steel or concrete.

1.2 COMPONENTS OF SILO

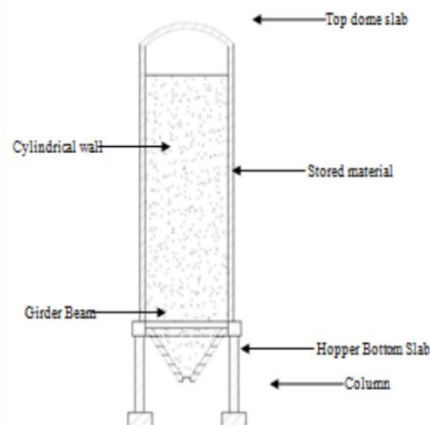Figure given below shows a typical reinforced concrete or steel silo:

Fig.1.1 Components of a typical concrete silo.

II. AIM

Comparative Study on Design and Analysis of various types of Reinforced Concrete Silos by Considering different Seismic Zones.

III. OBJECTIVE

The objectives of this project are to do a detailed design of types of Silos & analyze the behaviors of the same, in various seismic zone by using software STAAD.Pro and compare all the structural models and to give a fine conclusion.

The main Objectives of this project are;

- Study of Literature review
- To plan, analyze and design various types of silos and their structural elements as per Indian Standards.
- To check the stability of the structures against lateral loads.
- To Design & analyze the structures with the help of software like Auto CAD and STAAD Pro.

IV. METHODOLOGY

- Detailed study of Literature review from various research papers related to need of these projects aim and objectives and to basically to acknowledge the research work done in this field.
- In depth Study of IS Codal provisions such as IS 456-2000, IS 1893-2016 and IS 875 part 1 to part 5 regarding the needs of project and to carry out work accordingly. Designing of Reinforced Concrete Silo Structure is to be done in the STAAD Pro Software and those structures will be analysed for the parameters which are mentioned in the objectives of this project work.
- In the end after comparing results of various parameters mentioned in objective, the structure which will give best and efficient results in terms of mentioned parameters will be considered as the suitable one for the given condition.

V. DESCRIPTION OF BUILDING

- In this work the structure which is taken into account for the purpose of analysis has been designed as a practical Cement Silo in nature.

VI. STRUCTURAL PARAMETERS

- The geometrical shape of the silo structure are taken as Square, Rectangular and Circular.
- All the Silos are consisting of columns which are at height of 5 meters from the ground.
- Square and Rectangular Silos are having four columns which is having total height of 10m.
- Circular Silo is having Eight Columns which is also having total height of 10 m.

Table 6.1 Constants considered for calculation as a part of parametric study.

Sr. No.	Quantity	Constant Considered
1	Seismic Zone	II & V
2	Importance Factor	1.0
3	Response Reduction Factor	5
4	Rock & Soil Site Factor	2
5	Damping Ratio	5 %
6	Base Condition	Fixed Base
7	Concrete	M-20
8	Plate Thickness	200 mm
9	Material to be Stored	Cement
10	Density	1550 kg/ cum
11	Angle of Repose	25 degree

VII. MODELLING AND ANALYSIS

This Silo Structures has been modelled as 3D Space Frame Model with using STAAD Pro, Software for stimulation of behavior under gravity and seismic loading.

So basically, in the Silo structure to understand the behaviors under gravity and seismic loading it was subjected to the nodal analysis. Then by considering the output values came from software the analysis was done accordingly. For the parameter enlisted below.

For the Calculation of Base Shear of the Silo Structures, the data has been extracted from the post processing unit particularly from the reactions given for the nodes.

On the basis of data obtained from the above analysis the comparison study has been proceeded.

All Silo Structures has been compared with the bare model for the following parameters as mentioned below –

[1] Design Base Shear

[2] Shear Force & Bending Moment

[3] Displacement

Here in this study, we have considered total three models for the study. First model is designed as a Circular Silo, second model is designed as Square Silo whereas third model is design as Rectangular Silo. All the Silos are Designed as Reinforced concrete Silo. analysis is done for the all models shown below,
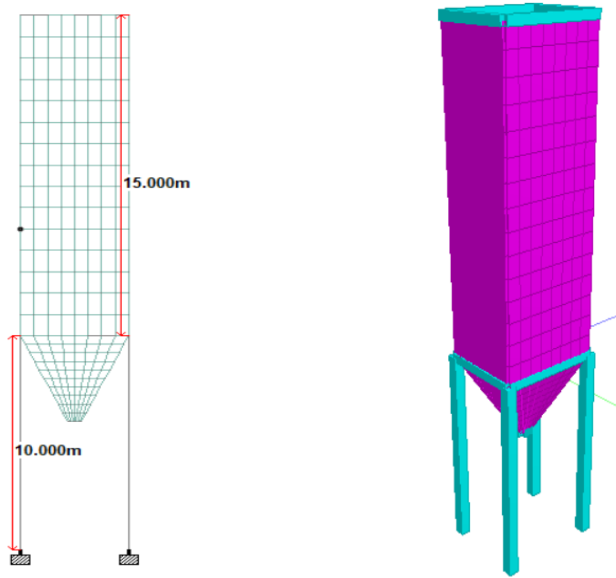
Fig. 7.1 Circular Silo

Fig. 7.2 Square Silo
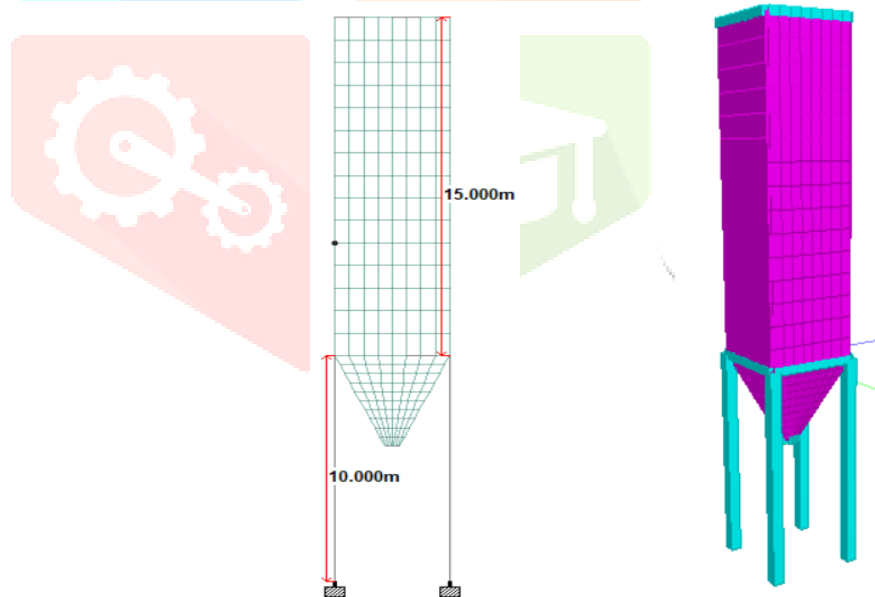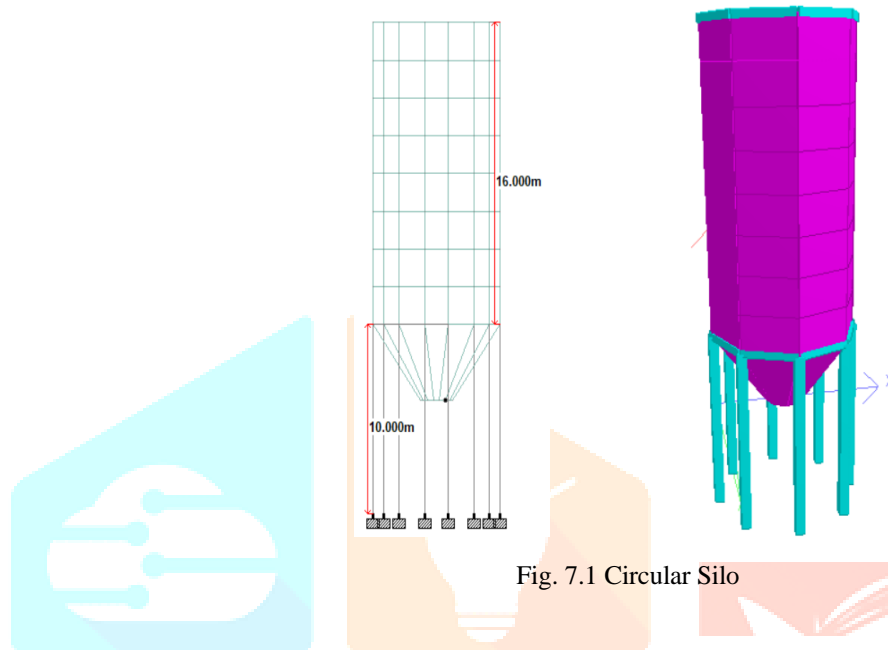
Fig. 7.3 Rectangular Silo

VIII. RESULTS AND CONCLUSION

8.1 Base Shear

Due to motion of ground during the earthquake maximum total lateral force acts at the base of the structure is estimated in terms of base shear. Which is influenced by various factors like height, acceleration response of structure, its mass, natural period and soil conditions According to IS 1893 (Part I): 2002 the parameter base shear can be calculated

using formula,

$V_B = A_h \times W$

$A_h = (Z/2) \times (I/R) \times (S_a/g)$

Where,

Z = Zone factor

I = Importance factor

R = Reduction factor

(S_a/g) = Average response acceleration coefficient

The obtained results of various models of silo are tabulated as below.

Table 8.1 Base Shear in Silos

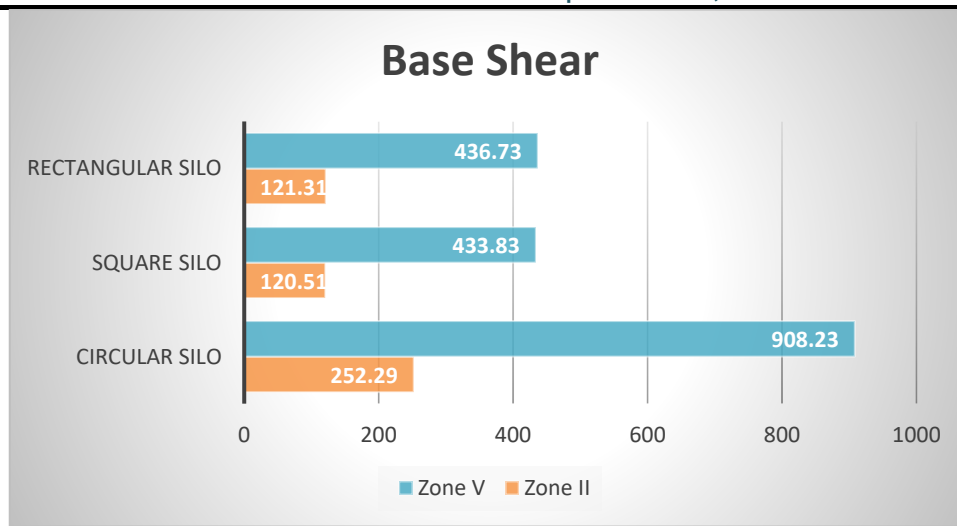| Base Shear		
Zone / Silo	Zone II	Zone V
Circular	252.29	908.23
Square	120.51	433.83
Rectangular	121.31	436.73

Fig 8.1 Graph of base shear in silo

- In the above Fig. 8.1, we can see that the Base Shear of Circular Silo is maximum in both cases i.e. Zone-II & Zone-V than that of Square and Rectangular Silos.
- Base Shear for Square and Rectangular Silos is nearly same.
- It is found that Base Shear of circular silo is nearly 52 % more than that of square silo and rectangular silo in both the seismic zone.

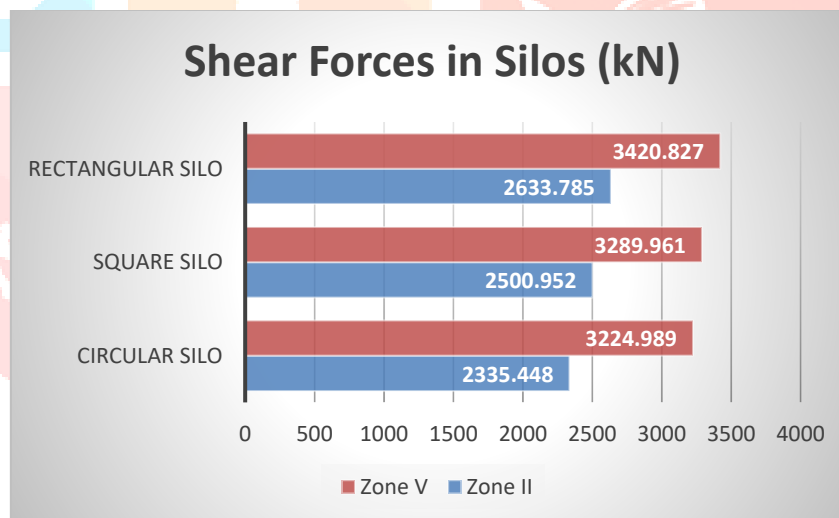### 8.2 Shear Force & Bending Moment

Fig 8.2 Graph of Shear Forces in silos

- Fig. 8.2 Shows graph of Maximum Shear Force values obtained by seismic analysis on R.C.C circular, square and rectangular silo in different seismic zones.
- Shear Force of circular silo in zone II is 2335.448 kN & in zone V displacement is 3224.989 kN.
- Shear Force of square silo in zone II is 2500.952 kN & in zone V displacement is 3289.961 kN.
- Shear Force of rectangular silo in zone II is 2633.785 kN & in zone V displacement is 3420.827 kN.
- Among all silos Maximum Shear Force is found to be in rectangular silo and Minimum Shear Force is found to be in circular silo in both zone i.e. zone-II & zone-V.

Moments in Silos (kN-m)

RECTANGULAR SILO: 998.199 (Zone V), 294.359 (Zone II)
SQUARE SILO: 943.586 (Zone V), 274.035 (Zone II)
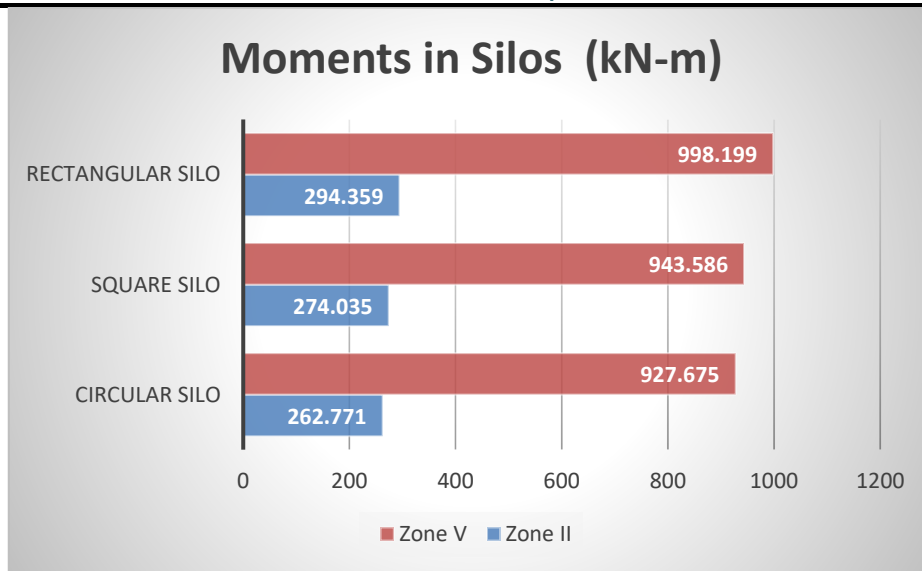CIRCULAR SILO: 927.675 (Zone V), 262.771 (Zone II)

Fig 8.3 Graph of Bending Moments in silos

- Fig. 8.3 Shows graph of Maximum Bending Moment values obtained by seismic analysis on R.C.C circular, square and rectangular silo in different seismic zone.

- Bending Moment of circular silo in zone II is 262.771 kN-m & in zone V displacement is 927.675 kN-m.

- Bending Moment of square silo in zone II is 274.035 kN-m & in zone V displacement is 943.586 kN-m.

- Bending Moment of rectangular silo in zone II is 294.359 kN-m & in zone V displacement is 998.199 kN-m.

- Among all silos Maximum Bending Moment is found to be in rectangular silo and Minimum Bending Moment is found to be in circular silo in both zone i.e. zone-II & zone-V.

8.3 Displacement

Average displacement is calculated for each Silo Structure in this project so basically to understand which model proves to be stable and efficient in X as well as Z direction motion we have given a comparison chart of all models below:

Displacement in Silos

RECTANGULAR SILO: 77.157 (Zone V), 21.687 (Zone II)
SQUARE SILO: 71.748 (Zone V), 20.161 (Zone II)
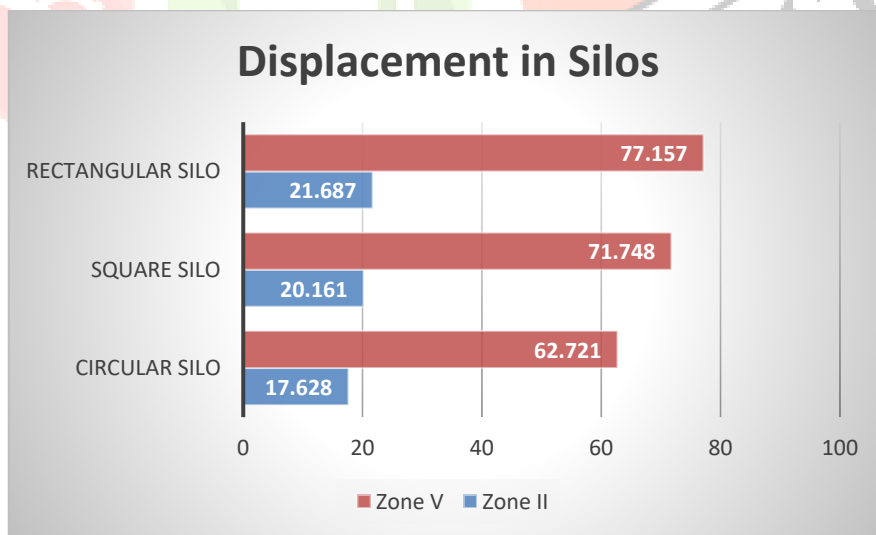CIRCULAR SILO: 62.721 (Zone V), 17.628 (Zone II)

Fig 8.4 Graph of displacements in silos

- Fig. 8.4 Shows graph of Maximum Displacement values obtained by seismic analysis on R.C.C circular, square and rectangular silo in different seismic zone.

- Displacement of circular silo in zone II is 17.628 mm & in zone V displacement is 62.721 mm.

- Displacement of square silo in zone II is 20.161 mm & in zone V displacement is 71.748 mm.

- Displacement of rectangular silo in zone II is 21.687 mm & in zone V displacement is 77.157 mm.

- In the above Fig. 8.4, we can see that the displacement of Circular Silo is minimum in both cases i.e. Zone-II & Zone-V than that of Square and Rectangular Silos.

- Among all silos Maximum displacement is found to be in rectangular silo and Minimum displacement is found to be in circular silo.

IX. CONCLUSION

- After all designing and analysis of Silos Structure it is found that the base shear of the silo structures increases as the Zone of seismicity increases from zone II to zone V.

- Base shear of Silo structure in zone V increases by 72% when compared to Silo structure Zone II.

- It is found that Base Shear of circular silo is nearly 52 % more than that of square silo and rectangular silo in both the seismic zone.

- Shear Force and Bending Moment of Rectangular silos is maximum in all cases while Shear force and Bending Moment of Circular Silos is minimum in all.

- Displacement of the silo structure increases as the zone of earthquake is increases.

- Maximum displacement is found to be in rectangular silo and Minimum displacement is found to be in circular silo.

X. REFERENCES

[1] SUVARNA DILIP DESHMUKH, RATHOD S. T, "comparison of design and seismic behavior of RCC silo" international journal of science and research, issn (online): 2319-7064 index volume 4 issue 5, may 2015

[2] Indrajit Chowdhury and Raj Tilak, "Dynamic pressure on circular silos under seismic force", 14th Symposium on Earthquake Engineering Indian Institute of Technology, Roorkee, December 17-19, 2010

[3] C.Y. Song, "Effect of patch loads on structural behaviour of circular flat bottom steel silo", International Journal on Thin-Walled Structures, (2004) 1519-154

[4] K. Guo, C. Zhou, L. Meng, and X. Zhang, "Seismic vulnerability assessment of reinforced concrete silo considering granular material structure interaction", International Journal on 'Tall and Special Building', vol. 25, no. 18, pp. 1011-1030, 2016.

[5] L. Dinghua, and H. Jiping, "Research of lateral pressure upon wall of reinforced concrete silo", J. Build. Struct., vol. 16, pp. 57-63, 1995

[6] F.ayuga, P. agudo, E. gallego, A. ramirez "New steps towards the knowledge of silos behaviour", Int. Agrophysics, 2005,19,7-17

[7] FuatTinis, Fatih Bazman,"Stiffening of thin cylindrical silo shell against buckling loads. ", Industrial plant manufacturing and erection corp, 06791, turky-2006

[8] D. Briassoulis, "Finite element analysis of a cylindrical silo shell under unsym- metrical pressure distributions Computers and Structures", 78 (2000) 271-281

[9] Dr.John W.Carson, "Silo Failures: Case histories and lessons learned", Presented at the Third Israeli Conference for Coveying and Handling of Particulate Solids, May 2000

[10] IS 9178, "for Design of Steel bins for storage of bulk materials", Part 3 Bins design for mass flow And funnel flow", 1980

[11] IS 875 Part 3, "Code of practice for design loads (other than earthquake) for building and structures. ", 1987

[12] IS 4995 (part 1 and part 2), "code of practice for Design of reinforced concrete bins for storage of granular and powdery materials",1974