ANALYSIS OF RC SILO FOR DIFFERENT LOAD COMBINATIONS IN VERTICAL DIRECTION USING SAP

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***Abstract*— A silo is a storage structure used to store food grains, cement and other bulk materials in a large quantity. behavior of the RCC circular silo storage structure studied under two methods i.e. Equivalent static method and Response spectrum method as per the code IS 1893 Part II 2002. A FEM based software (SAP 2000) used for seismic analysis of silos which gives the earthquake induced forces on the storage systems. For the assessment of the silos for bulk density and angle of internal friction of various stored materials the IS 4995 (Part I) 1974 is preferred. Poorly designed silos have buckled and even collapsed due to earthquakes. Silos usually fail due to design errors, construction errors and utilization errors. Elevated silos should be competent of keeping the expected performance during and after earthquake. It has a large mass concentrated at the top of slender supporting structure hence extremely vulnerable against horizontal forces due to earthquake. The sectional dimension of the beam and column should be strong to hold the total mass of the silo. In this research work three models are considered with the different heights of the column keeping the H/D ratio of the cylinder constant and the analysis is carried out. The results are in the terms of displacement at different heights is presented here.**

Keywords*: *silo, displacement, response spectrum, equivalent static method.

I. INTRODUCTION

This Silo is a bulk storage structure is also known as deep bin. It is usually constructed of steel or concrete used for storage of chemicals, grains and mining operations. In the developing countries like India, villages and farms have insufficient storage of grain which leads into wastage of grains in large quantity at post-harvest stage. Therefore in order to store the large quantity of grains economically an alternative is required. The small precast concrete blocks which is of high strength shell with corrugated grooves along each edge that lock the blocks together and it is of high incompressibility, therefore the silo is held together by concrete/steel hoops surrounding the tower and the staves are compressed in to a tight ring. The upright stacks are held jointly by intermeshing of staves at ends by a small distance around each layer of the perimeter and the hoops are tightened the stave edges across directly. The material inside the silo creates more static pressure, thus the pressure pressing outer the staves increases to the bottom of the silo, so that the hoops should be spaced broad apart close to the top and to prevent opening the hoops are closely spaced progressively. Axisymmetric loading is due to stored materials and gravity is the conventional method of analysis of silo. A silo is a superior structure it is subjected to terrific lateral loads due to earthquake and wind. The effect of lateral loads in the design procedure cannot incorporate in the conventional methods effectively. Hoop and Meridional forces were developed. Calculation of variety stress resultants at significant location may not always be acceptable by conventional method. Moreover the traditional approach analysis cannot expect several types of moments at all.

II. LITERATURE REVIEW

Krishna T. Kharjule[5] (2015) have experimented on different types of silos know as R.C.C and Steel silos of a circular cross section, considering with and without shear wall dynamic analysis is carried out. The stability of the Reinforced concrete circular silo increases when the shear wall is adopted rather than the columns, while in the steel silo earthquake stability increased by using steel panel on both the sides. Without the shear walls the R.C.C and Steel silo deflects more. Stiffness increases and the displacement decreases in case of shear wall panel.

Afzal Ansari[6] et.al (2016) conducted research on silos in order to store the material for economical configuration, by changing the H/D ratio for storing the bituminous coal the silos have been designed for twenty eight samples. In this analysis, for volume of 125m^3, H/D ratio is varied and the most cost-effective size is found out and designed. This technique was carried out for volume of 125m^3. According to the IS 456-2000 and IS 4995-1974 (Part 1and 2) "Criteria for Design of Reinforced Concrete Bins for the Storage of Granular and Powdery Materials" had been designed. As per designs those silo dimensions which lead to steel and smallest amount of concrete and the total cost to given amount to store the quantity of material have been found out.

Ummidi Mohan Satish Kumar[7] (2016) had conducted nonlinear analysis on the Silos. Most of the finite element analysis applications were limited to linear analysis undertaken by the engineers. Under gravity loads the ultimate strengths of the two-story planar frames 10 to 30% higher by inelastic analysis than the first-hinge elastic approach. The height is of 6.4 and 12.8m respectively. Considering the nonlinear properties of the model as M25 grade concrete properties and the values of step module changed and analysis has done on that silo. In case of nonlinear analysis varies of stresses has explained.

III. OBJECTIVES OF THE PRESENT WORK

1. Analysis of Silo for different column heights using Equivalent static method and Response-spectrum method.
2. Analysis of Silo for different Load combinations in Y direction using Equivalent static method and Response-spectrum method.
3. Comparison of displacement for various column heights for different load combinations.

IV. METHOD OF ANALYSIS

To study the lateral performance of the RCC circular silo two various types of structural analysis is done. They are

i. Equivalent static method.
ii. Response spectrum method.

Equivalent static method:

This technique is a smooth method to alternative the effect of dynamic loading of a predicted earthquake by using a static pressure disbursed tangentially on a structure for design functions. The earthquake load is considered in both the directions i.e. X and Y.

Response spectrum method:

For analysing and the performance of structures response spectrum is one of the useful tools especially in earthquakes, since numerous systems behave as single degree of freedom systems. Thus the natural frequency of the structure is found and from the ground response spectrum the appropriate frequency value of the peak response of the building is noted.

V. PROBLEM FORMULATION

A. Data

Diameter of Silo=6m
Depth of cylindrical portion=20m
Depth of hopper bottom = 2.5m
Diameter of the opening in hopper bottom = 1m
Density of Wheat=8.5kN/m^3 (**As per IS: 4995:1974**)
Coefficient of friction between wall and material=0.444
The ratio of horizontal to vertical pressure intensity = 0.40
Angle of repose = 28 degrees

1. Circular silo with column height of 5m.
2. Circular silo with column height of 7.5m.
3. Circular silo with column height of 10m.

B. Sectional properties of Silo (assumed)

TABLE 1

SECTIONAL PROPERTIES

NO	MEMBER	SECTION
1	BEAM	300 X 300 mm
2	COLUMN	300 X 600 mm
3	SHELL	200 m

VI. LOADS CONSIDERED FOR ANALYSIS OF STRUCTURE

Once the modelling is completed the next step is loading. The loading consists of various types of loads and the pressure due to the stored wheat on the walls of the silo with the appropriate direction of the load

The various loads considered for the analysis are as follows:

Horizontal pressure on cylindrical walls = 26.02 kN/m2.

Vertical pressure on cylindrical portion = Pv = (Ph / n) = 26.02/0.4 = 65.05 kN/m^2.

On hopper bottom = surcharge load at hopper bottom = 242.96 Kn

VII. SAP 2000 MODEL AND ANALYSIS

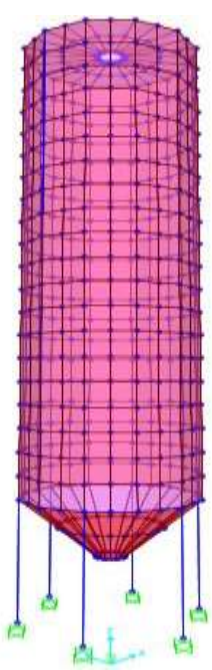

Fig. 1 5m column model

Fig. 2 7.5m column model

Fig. 3 10m column model

VIII. RESULTS

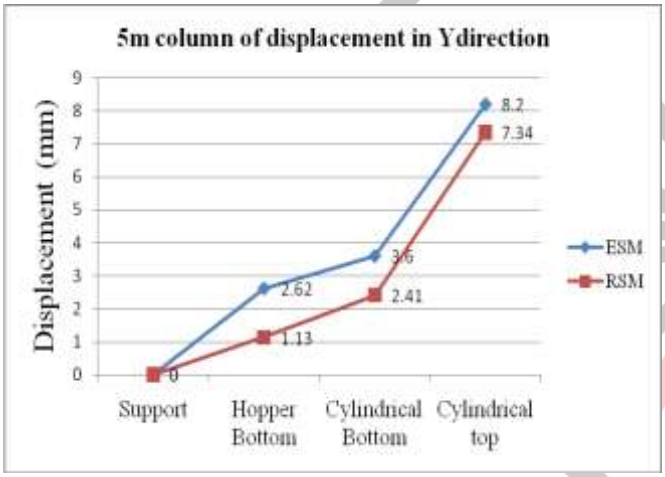

Fig. 4 Displacements (mm) of 5m column model for seismic analysis combination 1.2of DL+LL+EQY & 1.2of DL+LL+RSPY

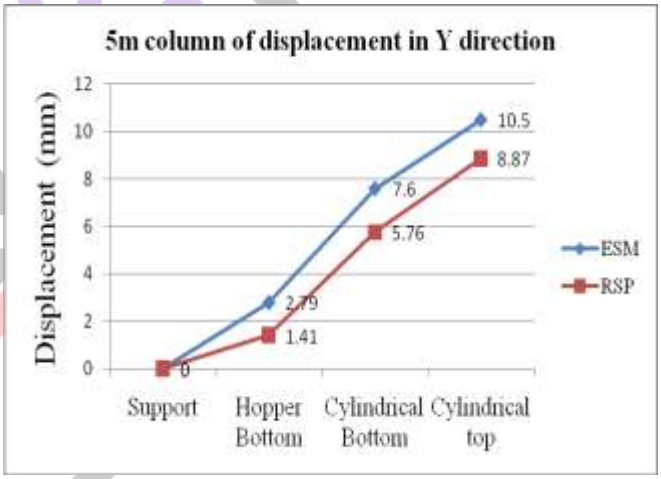

Fig. 5 Displacements (mm) of 5m column model for seismic analysis combination 1.5(DL+EQY) & 1.5(DL+RSPY)

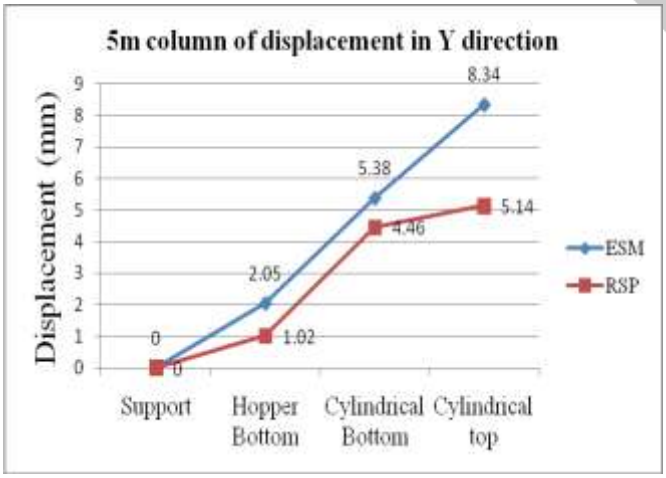

Fig. 6 Displacements (mm) of 5m column model for seismic analysis combination of (0.9DL+1.5EQY) & (0.9DL+1.5RSPY)

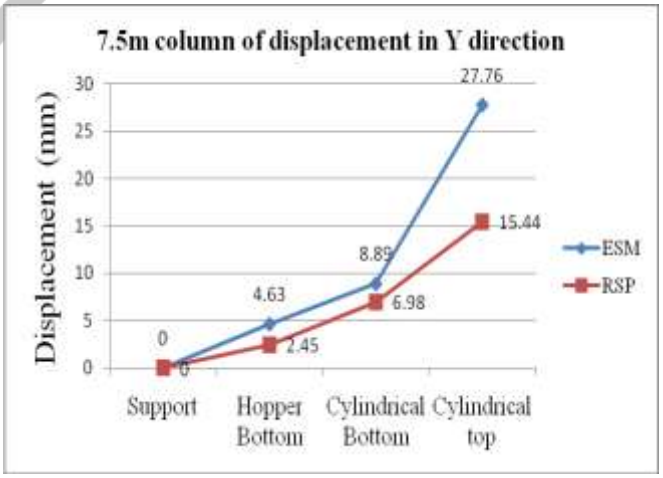

Fig. 7 Displacements (mm) of 7.5m column model for seismic analysis combination 1.2of DL+LL+EQY & 1.2of DL+LL+RSPY

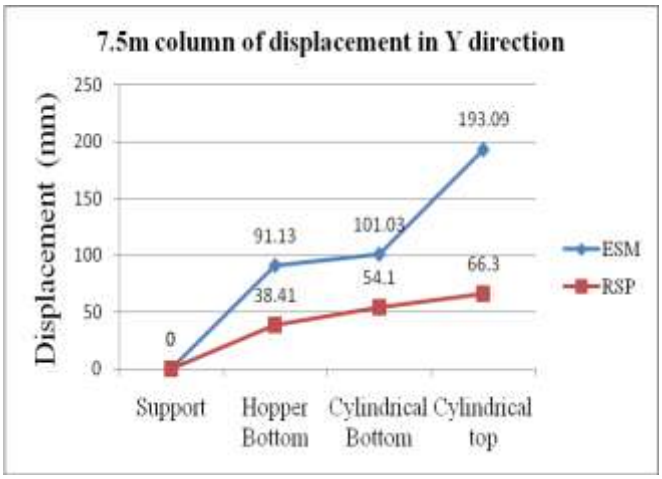

Fig. 8 Displacements (mm) of 7.5m column model for seismic analysis combination 1.5(DL+EQY) & 1.5(DL+RSPY)

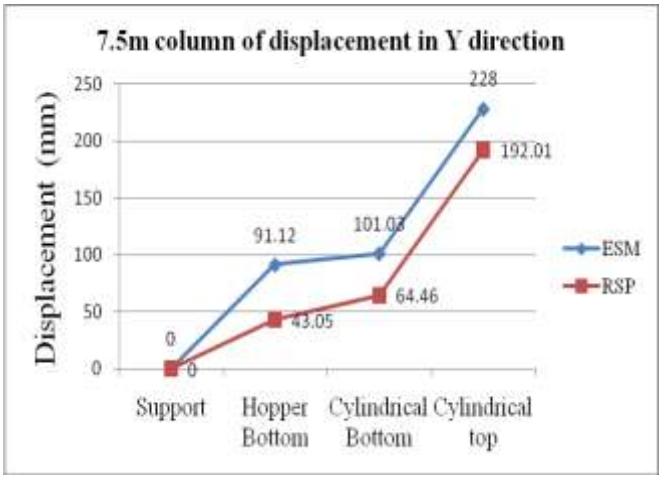

Fig. 9 Displacements (mm) of 7.5m column model for seismic analysis combination of (0.9DL+1.5EQY) & (0.9DL+1.5RSPY

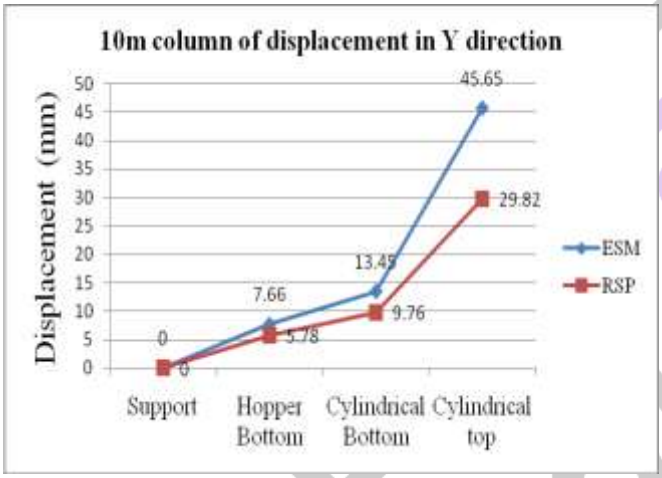

Fig. 10 Displacements (mm) of 10m column model for seismic analysis combination 1.2of DL+LL+EQY & 1.2of DL+LL+RSPY

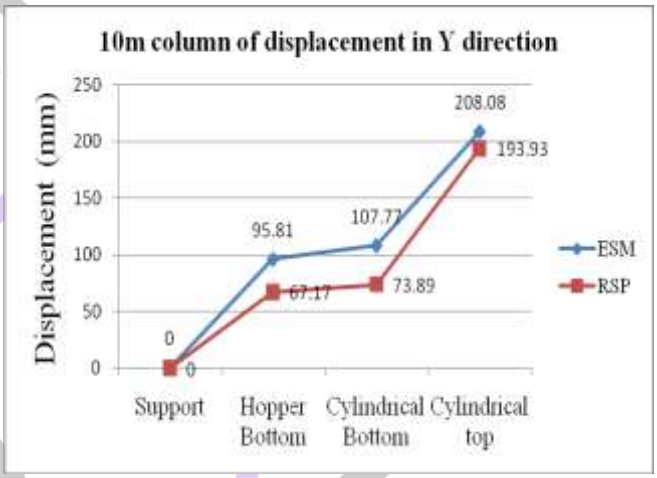

Fig. 11 Displacements (mm) of 10m column model for seismic analysis combination 1.5(DL+EQY) & 1.5(DL+RSPY)

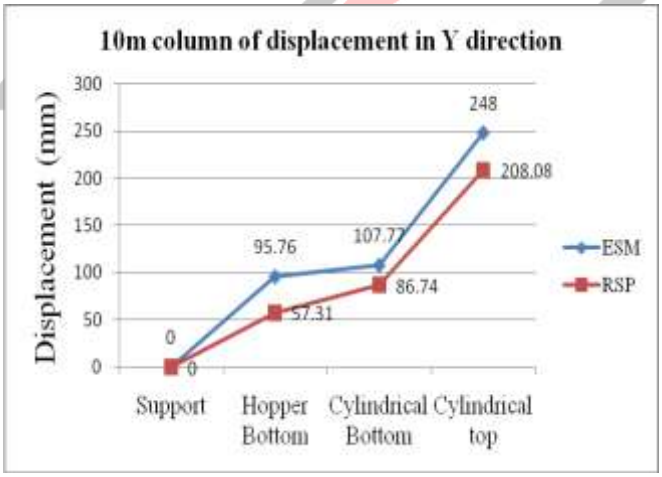

Fig. 12 Displacements (mm) of 10m column model for seismic analysis combination (0.9DL+1.5EQY) & (0.9DL+1.5RSPY)

IX. CONCLUSIONS

The Silo is analysed for various heights of column under the action of load combination. The cylindrical portion of all the 3 models kept constant. Equivalent static and response spectrum analysis were carried out for each model located in medium soil for the seismic zone factor of 0.36.

Results are summarized as follows:

1. The maximum displacement observed was at the cylindrical top of 248mm.

2. The maximum displacement is a result of slender column, where the height was more compare to the other sectional dimension.
3. Due to the increased height of the silo the displacement will be more at the top portion of the structure these is because of the fact that the increased mass attract more seismic energy.
4. The maximum displacement of the silo of all the models is well within the permissible limits as per the design code.

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