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Effect of Earthquake and Wind on Silo

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Abstract: **Bulk material handling is key operation in agriculture grain production. It is not only important that attention to be given to the maintenance of grain condition during storage, but also to the design it safely in any whether or natural condition. In past three year much progress has been made in theory and practice of bulk solid handling. Test procedure for determining the strength of structure in various condition have been developed. Conventional method is developed for static design. But the conventional method completely unable the calculate of maridional and circumferential moments. Finite element analysis can easily analyze circular silos to determine stresses at critical zone. This analysis and design give more safty to silo during high wind and earthquake intensity.**

Keywords: **Circular concrete silos, analysis, differentiate between conventional design and finite element, Shell design of silo.**

1. INTRODUCTION

Concrete silos are constructed from small precast concrete blocks with ridged grooves along each edge that lock them together into a high strength shell. Much of concrete's strength comes from its high incompressibility, so the silo is held together by steel/concrete hoops encircling the tower and compressing the staves into a tight ring. The vertical stacks are held together by intermeshing of the ends of the staves by a short distance around the perimeter of each layer, and hoops which are tightened directly across the stave edges.

The static pressure of the material inside the silo pressing outward on the staves increases towards the bottom of the silo, so the hoops can be spaced wide apart near the top but become progressively more closely spaced towards the bottom to prevent seams from opening.

Conventional methods of analysis of silos can deal well with axisymmetric loading due to gravity and stored materials . A silo, being an elevated structure, may be subjected to tremendous lateral loads due to wind and earthquake. The conventional methods cannot incorporate the effect of lateral loads in the design procedure effectively. Meridional and hoop forces developed

Prediction of various stress resultants at critical locations by approximate conventional methods may not always be acceptable .Besides, traditional approach of analysis can not predict any type of moments at all. Despite all such approximations the conventional method of analysis has been used with considerable success in the past. Conservative design approach combined with high factor of safety can be attributed to such success. With the advancement of the versatile and powerful techniques of finite elements it has now become easy to determine more accurately all the design forces at any section of a circular silo

2. CONVENTIONAL METHOD OF SILO DESIGN

Manual design workedout of silos of specific dimension to know exact design requirement of silo for static and dynamic load condition. Model of silo has made by using Etab software and caried out its result for static analysis and dynamic analysis

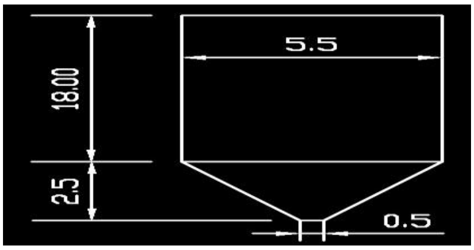

Fig. 1 Geometry of silo

Model was made by using M-25 grade concrete to circular shell. And thickness of sheel is 150 mm Analysis carried out after removing each column one by one. Janssen's theory ussed for for pressure calculations After analysis , Area of steel calculated from result of horizontal pressuire, direct tension in hopper as well as cylender. Area of steel in cylendrical part is as below

TABLE I: Ast req. in wall of silo

H	Ast
3	213.6
6	324,8
9	382.5
12	412.5
15	428.2
18	436.3

Where,

H is height of cylimder. Ast is area of steel in square mm.

Hopper is designed for pressure and hoop tension. After analysis of hopper, Area of reinforcement required in hopper is 529 mm^2

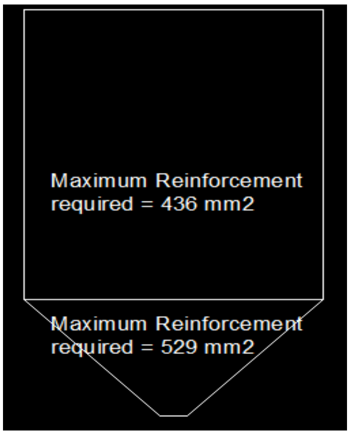

Fig. 2 Area of reinforcement requird by conventional method

Percentage of steel on wall section of silo

= [436 / (18000 x 0.86)] x 100

= 2.81 %

Percentage of steel on hopper section of silo

= [529 / (1649 x 20)] x 100

= 1.60 %

3. ETAB MODEL AND ANALYSIS

Model of the silo has made in Etab. There are wind and earthquake factor applied to the model of silo and designed it for sever load cases to get maximum size of section of reinforce concrete member. Wind pressure and Earthquake forces are assigned by referring basic parameters to check the percentage of steel for static load condition, model analyse and design for static load condition.

To verify result of software, Silo has designd for static load condition and it is compared with manual static design of silo.

Basic data and geometry of silo is same as it is considered in manual design. Fig 3.Showing the geometry of silo.

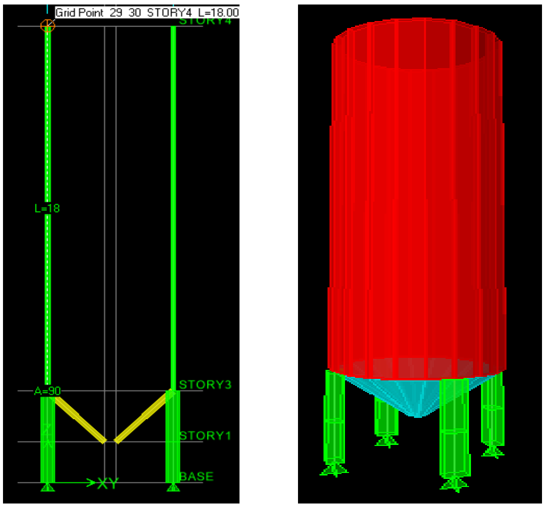

Fig: 3. Etab Model of silo

Thickness of wall is 150mm. 8 m high silo supported with 4 column designed for fill condition. Pressure of wheat is considered to calculate pressure on wall of silo

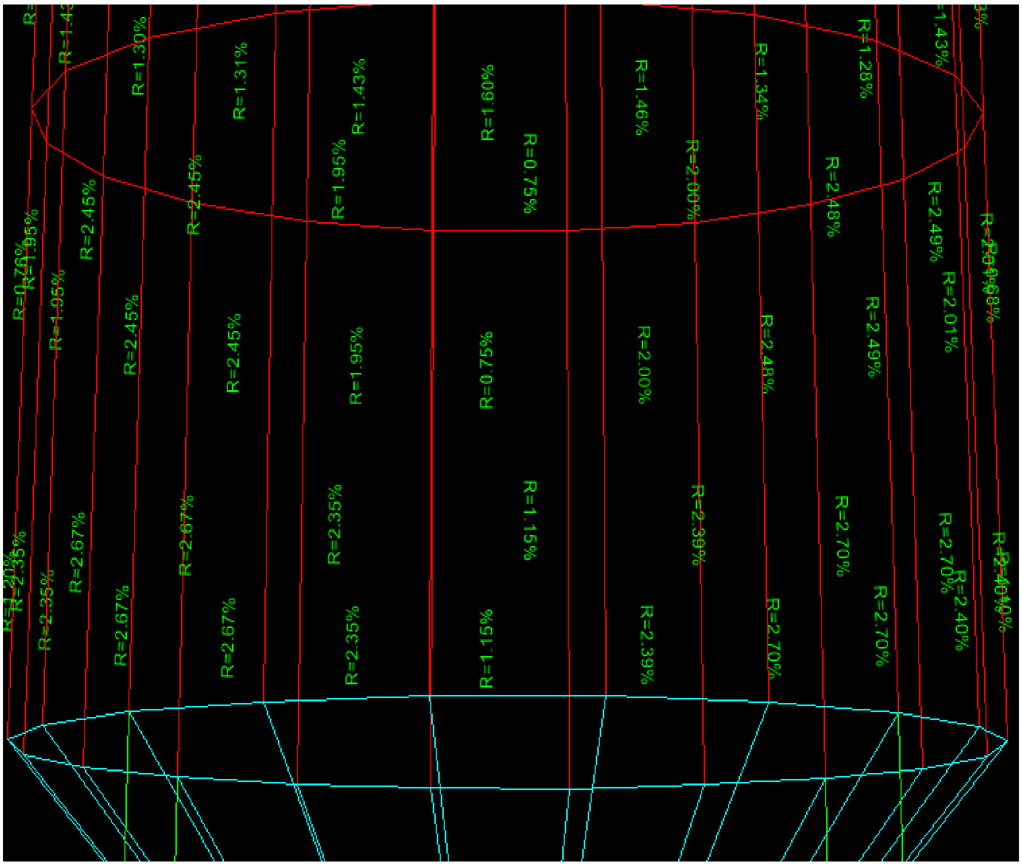

Fig. 4. Result of static analysis of silo

From above manual calcultion it is found that wall of silos required 2.81 % of steel on wall to resist pressure due to grain.

After analysing the model in Etabs with same load intensity, it is come to know that wall required 2.7 % steel to resist pressure due to grain. It is almost equal to 2.81 %.

Etab redistribute the moments and give the optimum solution of the structural element. There for there is diffrence of 0.11% in between manual calculation and software analysis. Maximum Shear force in hopper element = 22 kN/m^2 And moment in hopper element is zero or negligible. From the finite element analysis, Area of steel required in hopper panal is 5 cm2 It is equal to 500 mm2 which is very near to area required of reinforcement calculated mannually.

Hence, from this analysis it can conclude that manual analysis and software analysis is same so we can analyse and study the model for dynamic analysis by using Etabs software.

4. ANALYSIS OF SILO FOR WIND AND EARTHQUAKE

Load combination used for earthquake analysis and wind analysis. As per IS 1893 – 2002 and IS 875-1987 (part 3 & part 5)

1) 1.5(DL+LL)

2) 1.2(DL+LL+EL)

3) 1.5(DL+EL)

4) 0.9DL* 1.5EL

5) 1.2(DL+LL+WL)

6) 1.5(DL+WL)

7) 0.9DL* 1.5WL

Where,

DL = Dead Load

LL = Live Load

&

EL = Earth Load

WL = Wind load

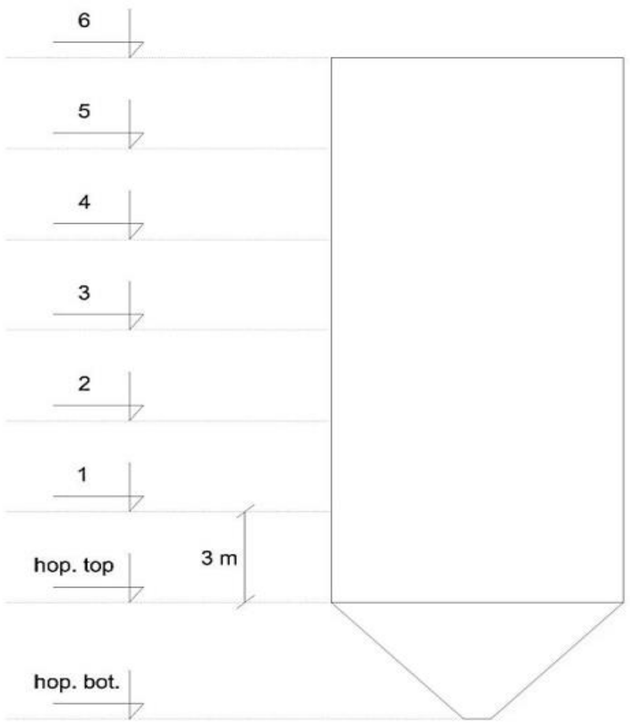

Fig.5 Different segments of silo for FEM

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It can be seen that axial force in very negligible in upper columns after removing column 1 at ground floor. It transfrred the additional load in adjoining column. If coulumn designed as per ductile design code, it could resist the additional load up to certain extent.

The figure below illustrates the positive directions for shell element internal forces F11, F22, F12, V13 and V23.

Note that these shell element internal forces are forces per unit length acting on the midsurface of the shell element. ETABS only reports the value of these forces at the shell element corner points.

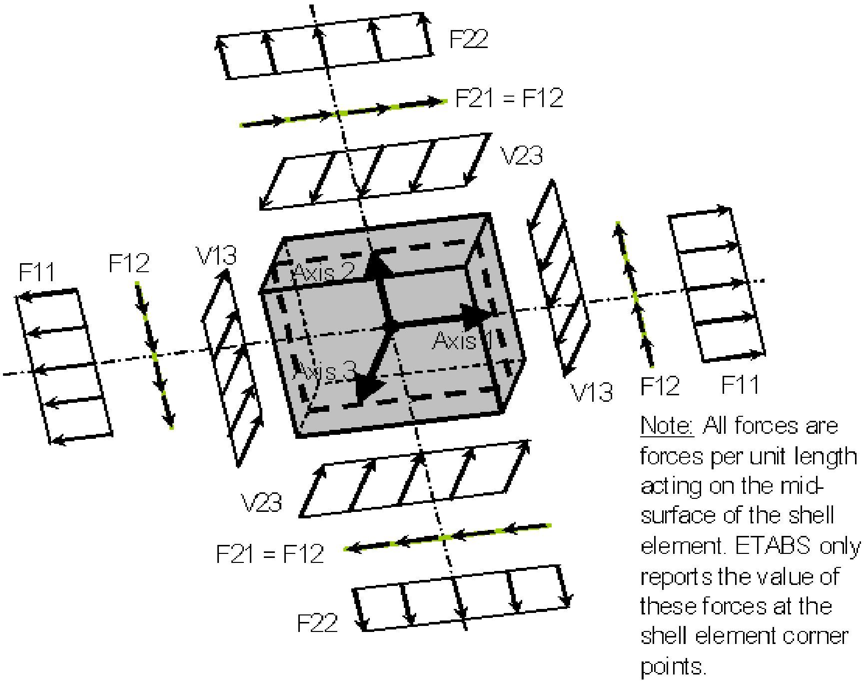

Fig.6 Forces acting shell element.

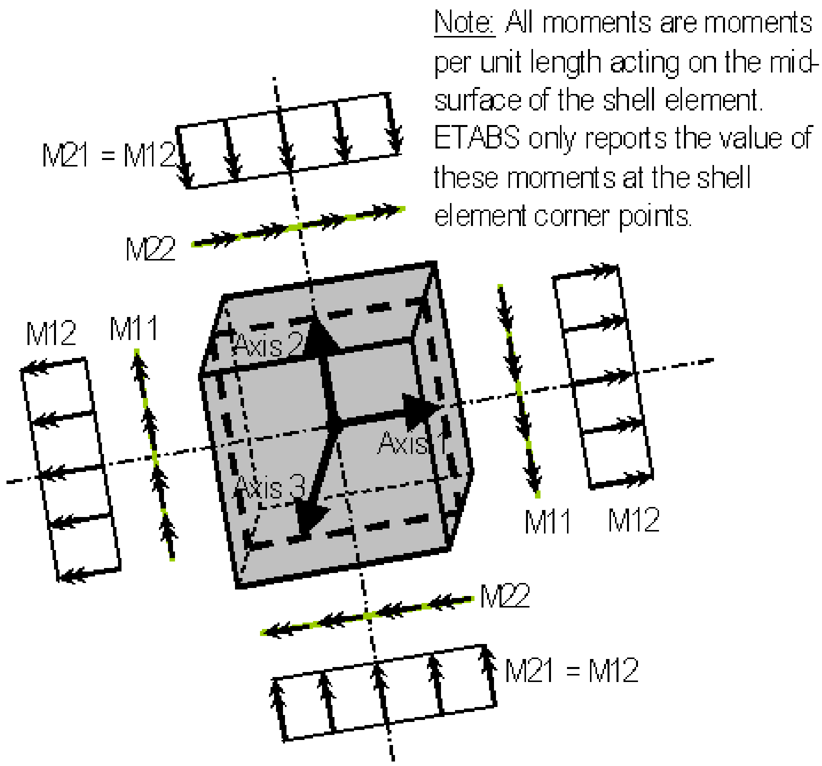

Fig.7 Moments acting shell element.

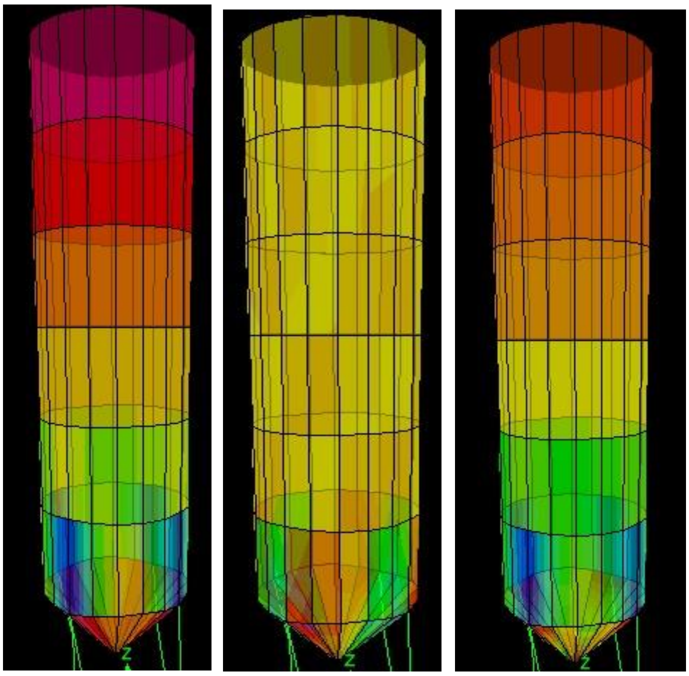

Fig.8. Forces on F11,F11 & F12 plane for wind load case

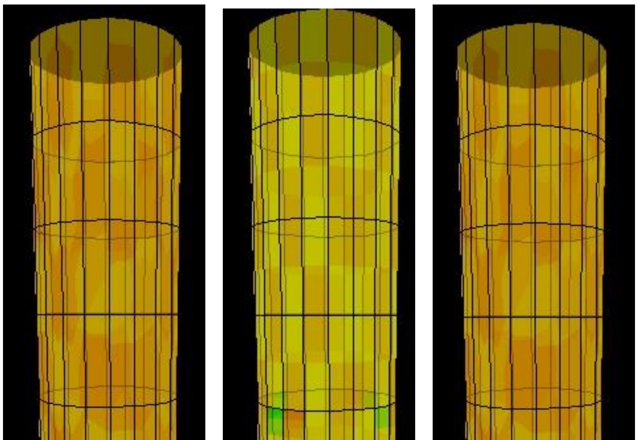

Fig.9 Moments on M11,M22,M12 plane for wind load case.

Stresses for all load combination has been analysed and silo found critical in wind load case.

Maximum percentage of steel required for dynamic analysis is 3.5 % where it was 2.81% for static analysis.

In common silo design based on ACI 313 (1997) wall pressures from earthquake effects are not taken into account and the system is reduced to a cantilever beam with several point masses being situated on top of each other to calculate appropriate additional static horizontal loads, 80 percent of actual mass of stored material should be considered as effective mass for calculating masses. But Eurocode 8 part 4 (2003) considers additional horizontal pressures resulting from earthquake effects with simple relations.

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.

Fig10. Failure of silo due to earthquake

Fig.11 Failure of silo at segement 1 due to exccessive stresses at junction

5. 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.

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