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Comparison of Base Isolation Techniques for Reducing Seismic Vulnerability of Elevated Steel Silos

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Abstract

Silos are tall massive structures for the storage of bulk materials like cement, grain, coal, carbon black ,.etc. Cylindrical silos with three different type of isolators and pile foundation were modelled. These were provided at the base of the silo and static and transient analysis were conducted in ANSYS 16.0.Deformation and Equivalent stress are found to be lower for silo with base isolator no.3 in static analysis. But Directional deformation and Equivalent stress are less for silo with pile foundation.

Keywords: *Silos, Isolators, Pile Foundation, Static analysis, Deformation, Equivalent stress, Directional deformation*

1. Introduction

Silos are special structures which are subjected to many different unpredictable loading conditions, which results in unusual failure modes. Silos are cantilever structures where the material is filled up vertically. The walls of different type of silos are subjected to earthquake loads from the stored mass, and this may cause increase in pressure on the walls of silos. The elevated silos are highly influenced by the earthquake characteristics, depending on the height to diameter ratio. The seismic analysis is essential for carrying out the structural design, assessment and retrofitting of the structures in the regions where earthquakes are prevalent. In order to carry out the seismic analysis of the structures, different seismic data are necessary.Major seismic input includes ground acceleration, ground velocity, ground displacement,..etc. Hence seismic analysis is necessary for the design and stability of silos.

Therefore, in this paper the seismic response of silos with base isolation techniques are analysed.Finite element software, ANSYS 16.0 has been used for conducting the analysis.

2. Methodology

The following procedure was adopted for doing analysis:

1.Silos having height 9m and diameter 2.5m with three different type of isolators and pile foundation were modelled.

2. Static structural analysis is done.

a)Results obtained were compared in terms of Deformation and Equivalent stress.

3.Transient dynamic analysis is done.

a)Results obtained were compared in terms of Directional Deformation and Equivalent stress.

4.Obtained results from both analysis were compared.

3.Elevated Steel Silos

Silos may be of ground supported or elevated silos. Silos are mainly used for the storage of cement,calcite,industrial materials, chemicals,..etc. Materials which are used in different fields such as carbon black and ceramic powder, suitable for pneumatic conveying and handling are also stored in silos. They are used for the storage of coal, gypsum, wood chips,..etc. Silos give protection against any dust on the environment, bacteria, and insects by forming debris shedding to stored materials. Concrete silos are generally constructed taller than that of steel silos but they have bigger diameters so that total capacity is high. When the space is limited for construction, concrete silos are very suitable. Steel silos are easier to erect. Steel structures are more flexible, so that they have better performance in earthquake, Steel and concrete silos are generally airtight if the openings in them are properly sealed. Steel silos give greater storage capacity. Steel silos are more cost-effective due to high storage capacity. Aeration is more effective and easier in steel silos. Steel silos do not require firm soil

to support the weight of the structure. Sometimes steel silos can be built on land-bearing capacity that need for concrete. Elevated steel silos were highly susceptible to seismic effect. The components of elevated silos are cylindrical shell, conical hopper and supporting column.

Fig 1 Elevated steel silo

4.Modelling and Material Property

One of the important criteria that allows solution of physical problems in ANSYS is element type. The element type defines the shape of element, degrees of freedom and capability in modelling the structure. Silos are modelled as Solid 186 element. This is a higher order 3D 20 node solid element that exhibits quadratic displacement behaviour. The element is having three degrees of freedom per node: translations in the nodal x, y and z directions. It is well suited to model irregular meshes. Indian standard steel sections had been used as supporting structure. I sections are used as supporting columns. Channel sections are used as x bracings. The silo is having length of 9m and diameter 2.5m.The isolators provided were of circular shaped, surface curved shaped and side curved shaped. The isolators were having a rubber material sandwiched by two steel rectangular plates. Along with this four piles having length 8m and dimension 300mmx300mm is adopted.

5.Finite Element Analysis

Finite element analysis is one of the best tools for analyzing the structures. There are many methods for analyzing and designing. Among them the most popular one is ANSYS Workbench 16.0.It is an engineering simulation software. It is a easiest learning software. It is user friendly.

Static structural analysis is done to determine the deformation,stress,strains and forces in structures. This analysis is done to check the stability of silo in its static condition. It determines the stability of silo under static loads.

The static analysis showed that the deformation is less for silo with pile foundation. Among the isolators, the isolator no.3 is better. But on comparing with results from silo with pile foundation, it is further more better in performance. Table 1 shows the results of static analysis.

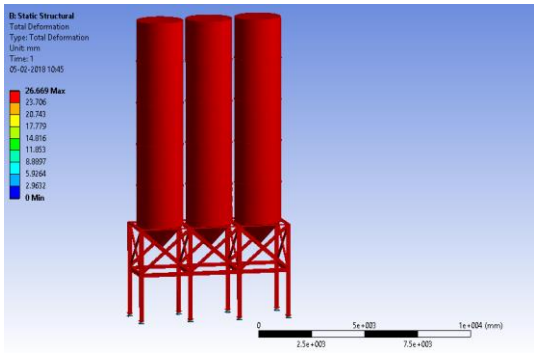

Fig 2 Deformation diagram of silo with isolator 3

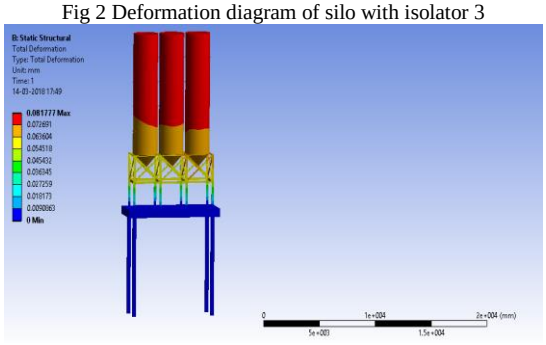

Fig 3 Deformation diagram of silo with pile foundation

Table 1 Results of static structural analysis

RESULTS	SILO WITH ISOLATOR			SILO WITH PILE FOUNDATION
	1	2	3	
DEFORMATION (mm)	63.5	48.8	25.7	0.08
EQUIVALENT STRESS (VON-MISES) (MPa)	74.1	86.7	70.3	82.3

Transient analysis is conducted on silo with isolator 3 and silo with pile foundation. Transient analysis is used to determine the dynamic response of structure to time dependent loads. Three methods were used for doing transient analysis: full, reduced and superposition. ANSYS allows only superposition modes. This method accepts modal damping. The results of transient analysis

were directional deformation in x,y and z directions. Also equivalent stress corresponding to directional deformation in three directions. Table 2 shows the results of transient analysis.

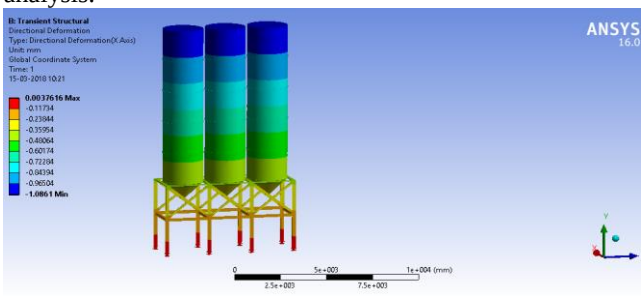

Fig 4 Directional deformation in x axis of silo with isolator 3

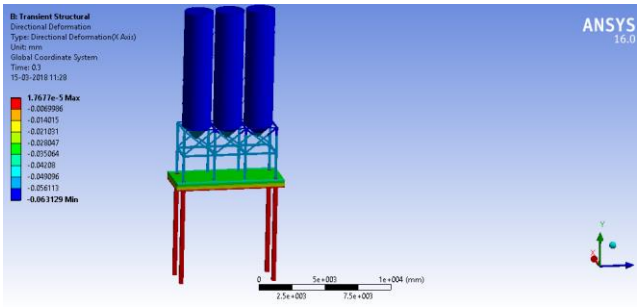

Fig 5 Directional Deformation in x axis of silo with pile foundation

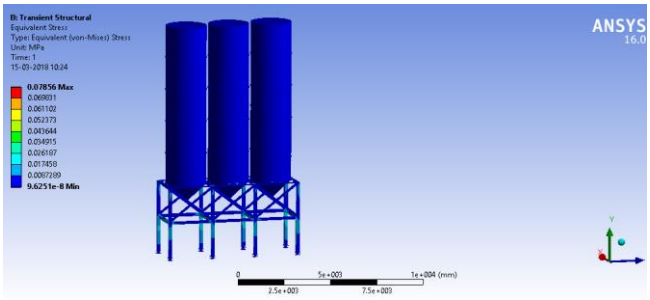

Fig 6 Stress diagram in x axis of silo with isolator 3

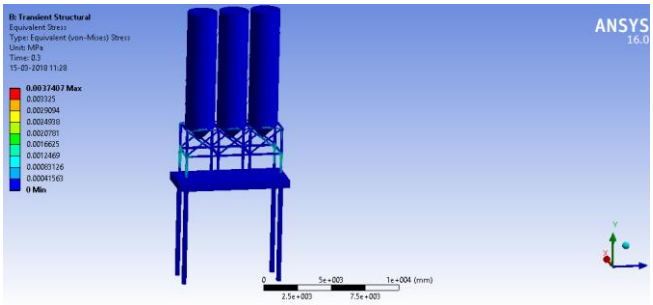

Fig 7 Stress diagram in x axis of silo with pile foundation

Table 2 Results of transient analysis

RESULTS	SILO WITH ISOLATOR 3	SILO WITH PILE FOUNDATION
DIRECTIONAL DEFORMATION (X AXIS) (mm)	3.76×10^{-3}	1.76×10^{-5}
EQUIVALENT STRESS (VON-MISES) (MPa)	7.85×10^{-2}	3.74×10^{-3}

Table 3 Comparison of results of static and transient analysis

RESULTS	SILO WITH ISOLATOR 3	SILO WITH PILE FOUNDATION
DEFORMATION (mm)	25.7	0.08
EQUIVALENT STRESS (VON-MISES) (MPa)	70.3	82.3
DIRECTIONAL DEFORMATION (X AXIS) (mm)	3.76×10^{-3}	1.76×10^{-5}
EQUIVALENT STRESS (VON-MISES) (MPa)	7.85×10^{-2}	3.74×10^{-3}

6. Conclusions

Silos are very important structures and are vulnerable to seismic activity. Therefore isolation of silo is necessary. Base isolation techniques were an effective solution for this problem. The results of static and transient analysis showed that base isolation of silo with pile foundation is a better base isolation technique.

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References

[1] Alper Kanyilmaz,Carlo Andrea Castiglioni,Reducing the seismic vulnerability of existing elevated steel silos by means of base isolation devices, Engineering structures, Volume 143,July 2017,pp 477-497.

[2] Aysegul Durmus,Ramazan Livaoglu,A simplified 3 D.O.F model of a FEM model for seismic analysis of a silo containing elastic material accounting for soil-structure interaction, Soil Dynamics and Earthquake Engineering, Volume 77,October 2015,pp 1-14.

[3] Krishna .T. Kharjule,Minakshi .B. Jagtap,Seismic analysis of R.C.C and steel silos,International Journal of Computational Engineering Research(IJCER),Volume 05,Issue 07, July 2015 .

[4] Daniel Bitca,Emilian Ursu,Seismic base isolators for a silo supporting structure,Mathematical Modelling in Civil Engineering,Volume 11,No.2,2015,pp 1-9.

[5] Sagar .K. Kothiya,Hiten .L. Kheni,A review on parametric study on design of silo,International Journal of Advance Engineering and Research Development,Volume 2,Issue3, March 2015.

[6] Hamdy .H..A.,Abdel Rahim,Response of cylindrical elevated wheat storage silos to seismic loading,Journal of Engineering Sciences,Vol.41,No.6,November 2013,pp 2079-2102.

[7] Emre Abali,Eren Uckan,Parametric analysis of liquid storage tanks base isolated by curved surface sliding bearings,Soil Dynamics and Earthquake Engineering,Volume 30,Issue 1-2, January - February 2010,pp 21-31.