Buckling Behavior of Cylindrical Steel Silo with Varying L/D Ratio Subjected To Wind Loading

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Abstract: The cylindrical storage silos are strategically very important structures. Silos are also called steel bins. Steel bin usually rectangular or circular in cross section. Circular steel silos have been widely used in civil engineering to store various bulk solids. Silos are subjected to many different type of loading conditions, which result in failure of the structure. Here the buckling behavior of silo structure subjected to wind loading is studied. For more precise result optimization of varying l/d ratio is carried out and also thicknesses variation is analyzed by considering the minimum buckling behavior. A sandwiched ceramic steel packing is adopted as a new type of material. According to the numerical results, load multiplier, reaction force, critical loads are analyzed.

1. Introduction

India’s economic growth is contingent upon the development of the Indian steel industry. Consumption of steel is taken to be an indicator of economic growth. There is a requirement of modification of storing raw materials in this product type industry. A wide range of applications are there for silos structures in engineering field. It used to store bulk solids in quantities ranging from a few tones to hundreds or thousands of tones. Silos are, may be ground-supported or elevated. Typical elevated silos generally consist of a conical roof, a cylindrical shell and a conical hopper and they could be elevated and supported by frames or reinforced concrete columns or on discrete supports. Silos are special structures subjected to many different unconventional loading conditions, which result in unusual failure modes. It is very difficult to determine the minimum effect of buckling behavior under external pressure like wind load in conventional method. Hence analysis of silo structures has more significance in structural engineering field.

2. Literature Review

P. Iwicki et al (2016) investigated “Application of linear buckling analysis to economic design of cylindrical steel silos composed of corrugated sheets and columns” in this paper he deals with global stability of steel cylindrical silos composed of corrugated walls and vertical columns with loads imposed by a bulk solid following Euro code. The design of thin-walled metal cylindrical silo shells against buckling is one of the most important challenges for civil engineers. So the studies were performed in order to verify a proposed design procedure based on the analysis of a linear buckling. HamdyH.A.AbdelRahim(2014) investigated “Response the Cylindrical Elevated Wheat Storage Silos to Seismic Loading” This paper is concerned with the earthquake response of cylindrical steel silos. A three dimensional finite solid element is used for modeling the cylindrical silo wall and bulk solid. SAP2000structural software package is applied for dynamic analysis of wheat silos. Dr. Alice Mathai et al (2015) investigated “Finite Element Analysis of A Stiffened Steel Silo” In the present study, a steel silo stiffened externally with stringers and rings at equal intervals is adopted for her study. Linear static analysis is conducted to obtain the stresses and displacement occurring in it. In this study she also examines the effect of wind loads on the silo.

Conclusion from literature survey is that cylindrical metal silos are frequently used in the industry to store different bulk solids. They are usually strengthened by vertical stiffeners distributed uniformly around the silo circumference. The buckling behavior of silo can analyze using ANSYS workbench16.2 with varying l/d ratio.

3. Objectives and Scope of the Project

3.1. Objectives of the Study

To analyze the buckling behavior of silo by varying l/d ratio subjected to wind loading using finite element software ANSYS. Optimise the thickness to minimise the buckling load. Introduce a by material layer in such a way that to reduce the predetermined thickness of the silo.
3.2. Scope of the Study

To study the effect of static and dynamic loads on steel silo structure and also analyze the structural features and current practices adopted in the design of silo structure. To find optimum silo dimensions with minimum buckling behavior.

4. Finite Element Analysis

ANSYS Workbench 16.2 is used for finite element modeling. The silo is modeled with 8.05m as initial length. The radius of the silo is 0.8m and cone radius is 0.08m. Stringers are 45x50. In finite element analysis, the structure is divided into finite number of elements (meshing). After meshing, boundary condition is applied. The load applied for the silo is gravity load, wind load, dead load etc. This silo structure is an elevated silo. In FEM analysis load multipliers are the major output parameter.

| Radius of silo | 0.8m |
| Radius of cone | 0.08m |
| Height of silo | 8.05m |

Applying wind load, dead load, hydrostatic load, and atmospheric load we get the deformed shape and load multiplier in the silo.

5. Optimization

After getting the load multiplier, optimization is carried out by varying l/d ratio. And also fix a optimum thickness of the silo depending upon the l/d ratio. 20 trials are carried out. The optimization results are shown below:
5.1. Introduce a by material to minimise the predetermined thickness.

The optimized thickness is 0.85mm. Introduce a refractory ceramic (Alumina-Aluminum oxide) as a by material. It is a sandwiched arrangement. It consists of steel-ceramic-steel (SCS) packing. SCS is tried at various thicknesses. Suitable thickness can be adopted by considering the buckling behavior.

<table>
<thead>
<tr>
<th>Material</th>
<th>Layer thickness (mm)</th>
<th>Reaction force (N)</th>
<th>Multiplier</th>
<th>Critical load (N)</th>
<th>Total thickness (mm)</th>
</tr>
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<tbody>
<tr>
<td>Steel( single layer)</td>
<td>0.85</td>
<td>4.5042 e+005</td>
<td>0.24</td>
<td>1123</td>
<td>79.79</td>
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<td>11350</td>
<td>1.26</td>
</tr>
</tbody>
</table>
6. Conclusions

In this project, the buckling behavior of cylindrical steel silo subjected to wind loading is analyzed. Suitable dimensions are fixed by optimization. By the provision of various thicknesses of SCS the buckling behavior is improved at a greater amount. From the result we obtained that, the ordinary steel of Total thickness 0.85mm exhibit lesser buckling capacity compared SCS (0.2-0.45-0.2) of same thickness. The major advantage is that the thickness of steel is reduced. Buckling load in the silo also increase with increase in the thickness of ceramic layer.

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References


