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Seismic Analysis of Spherical Vessel Containing Liquefied Petroleum Gas

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Abstract: ***The Liquefied petroleum Gas (LPG) Spherical vessel is supported by a column type rigid structure. Highly pressurized LPG is stored in these spherical tanks. LPG spherical vessel has some environmental constraints like earthquake, wind, etc. These constraints had the effect of highest failure rate of the tanks. This Project is to analyze column supported spheres having 20,000 barrel capacity, especially used in Indian Oil Co-corporations Limited, on natural frequency under seismic condition and also to find the redundant structure of the columns and L section. A seismic analysis is one of the crucial procedures of column supported spheres used in LPG plants. A finite element model of the column supported sphere is designed using commercial design software, CATIA. Six different models of the column supported sphere are designed. The seismic analyses of these models are carried out by using ANSYS software. The analysis results of various models are then compared and the model with the minimum displacement is identified.***

Keywords: LPG, seismic analysis, spherical vessel, column, finite element.

1. Introduction

The column supported sphere is to store high pressure liquefied petroleum gas (LPG). LPG may be liquefied by moderately increasing the pressure or by reducing the temperature. Refrigerated storage is used by gas suppliers to store large volumes of LPG. The main form of LPG storage is in special tanks known as pressure tanks. Spherical tanks are economical for the storage of volatile liquids and gases under pressure, the design pressure being based on some marginal allowance above the vapour pressure of the contents. The type of vessel is column supported sphere of 20,000 barrel capacity. Twelve columns and cross L angles are welded together to give a big support to sphere. Analysis of column supported spheres of 20,000 barrel capacity under seismic condition is to be carried out in this project.

In literature there exist a number of papers concerning the seismic analysis of various structures used in different applications. For instance, Jianqun Tang [1] carried out a fundamental research on corrosion properties and remanufacturing technology for LPG spherical tank. Konstantin Meskouris et al. [2] performed seismic analysis of liquid storage tanks. Lee et al. [3] performed seismic analysis of axial blower for nuclear power plant use. ManzoriIman et al. [4] carried out Dynamic analysis of concrete dam due to seismic forces .NicolaeZemtev [5] performed seismic analysis of a vertical water tank. WaqasAnjum et al. [6] carried out seismic analysis of electronic cabinet using ANSYS. Zasiah Tafheem et al.[7] performed a seismic analysis of a three-span deck girder bridge.

In this work the focus is given to the design of various spherical vessels arrangement for containing LPG. The seismic analyses of column designs are then carried out using analysis software. The analysis suggests the arrangement which can withstand the earthquake effectively.

2. Design of the Spherical Vessel

The spherical vessel is made of SA516-Gr70 having an internal diameter of 18288 mm and thickness of 69.85 mm. Corrosion allowance for the vessel is 3.2 mm. The column material is also SA516-Gr70 having a size of 762 mm.The corrosion allowance for column is 1.6 mm.

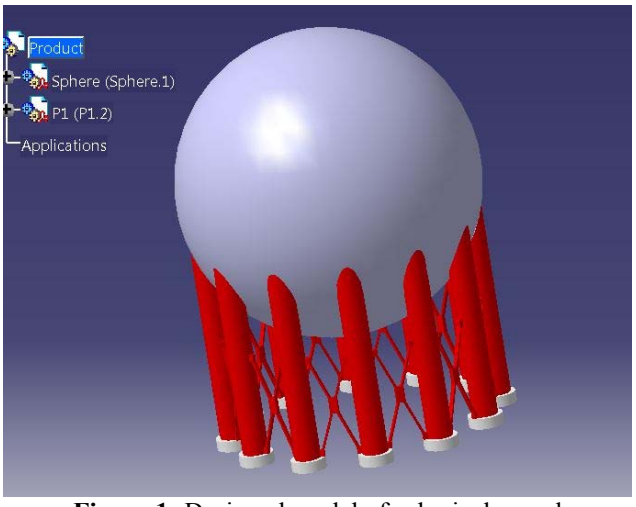

Figure 1: Designed model of spherical vessel

3. Load Calculation

The load calculation involves evaluating and finding out the load on a single column support. The load takes into consideration the load imposed by the sphere, LPG. The calculations are done as follows

Weight of LPG = Mass of LPG*9.81 (1)
Mass of LPG = Volume of LPG* Density of LPG (2)
Weight of the sphere =mass of the sphere * 9.81 (3)

Mass of the sphere=volume * density (4)
Total load = weight of LPG + weight of sphere (5)

The sphere is supported by 12 columns, so the load acting on a single column can be calculated from the ratio of the total load on the columns to the number of columns.

4. Software Analysis Results

The applied loads and frequencies are shown in this section. The analysis is done using ANSYS software and the results are potted. Figure 2 shows the load and frequency applied on to the Model 1. The magnitude of the load at each column: $1.6x10^6$ N and frequency range is 0 to 100 Hz.

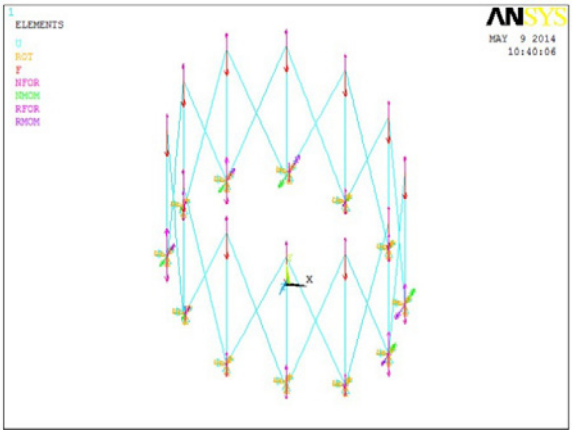

Figure 2: Model 1

Figure 3 represents the displacement of the model 1in the X direction.

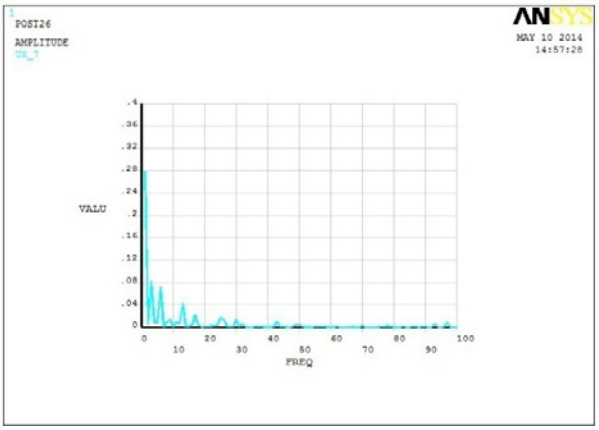

Figure 3: Displacement in X direction (Model 1)

Figure 4 represents the displacement of the model 1in the Y direction.

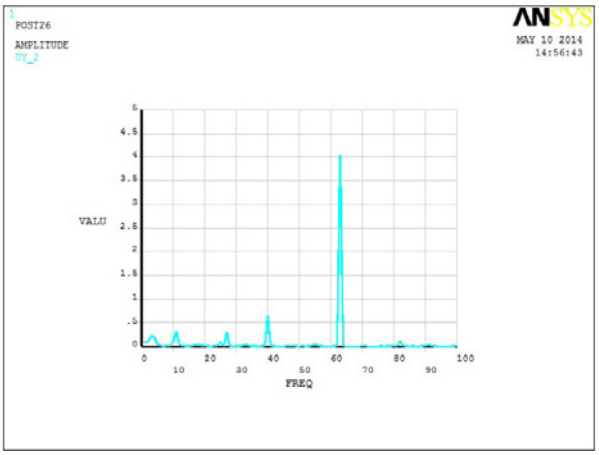

Figure 4: Displacement in Y direction (Model 1)

By giving a support at the middle of the column the existing model is been modified and is the Model 2. The same loading conditions are applied again to get the displacement of the new model. Figure 5 shows the 2D representation of model 2.

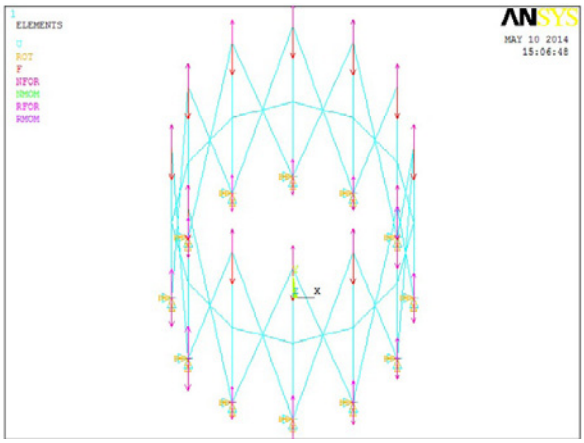

Figure 5: Model 2

Figure 6 represents the displacement of the model 2in the X direction.

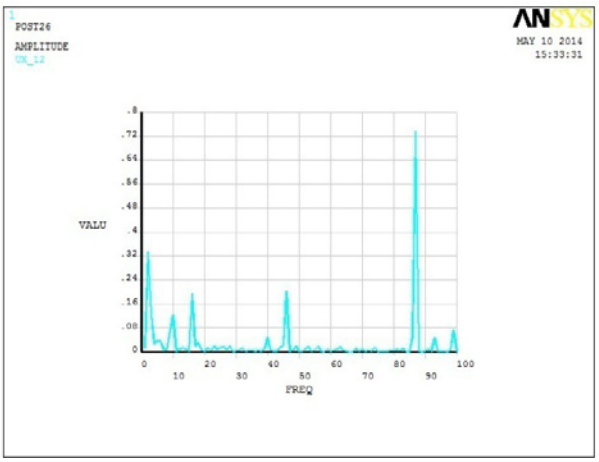

Figure 6: Displacement in X direction (Model 2)

Figure 7 represents the displacement of the model 2 in the Y direction.

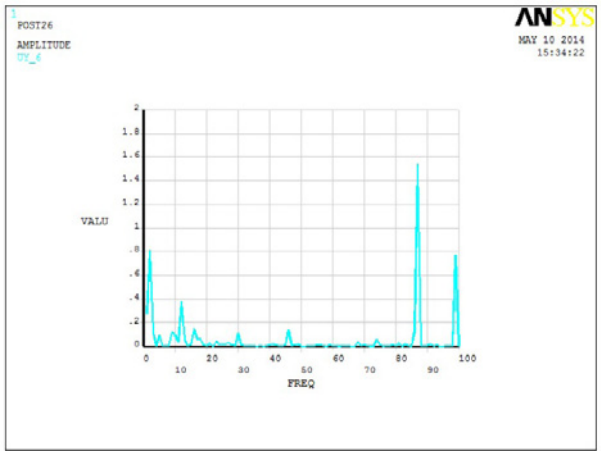

Figure 7: Displacement in Y direction (Model 2)

Similarly by changing the supports of the columns, six different models are prepared and analyzed using ANSYS software. The results are then plotted as a graph and shown in figure 8 and 9.

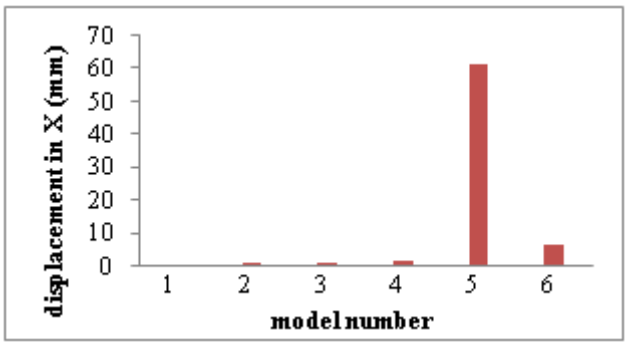

Figure 8: Displacement in X direction

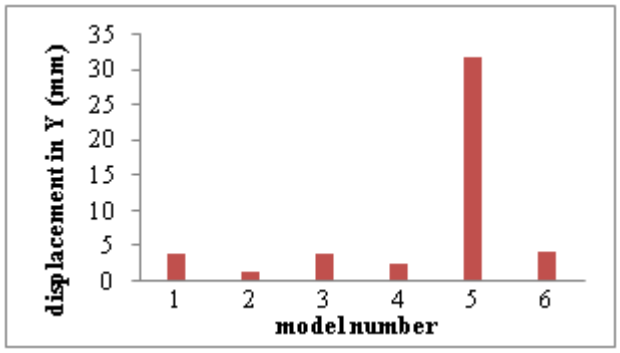

Figure 9: Displacement in Y direction

5. Conclusion

The seismic analysis of the spherical tank provides knowledge of the various tank support arrangements. The analysis shows the best support arrangement. This arrangement can reduce the effect of earthquake on the LPG spherical vessels.

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