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SEISMIC ANALYSIS OF STORAGE STEEL TANKS WITH STRENGTHENING TECHNIQUES

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Abstract: The seismic event is certainly one of the most critical external events to the safety of industrial plants, as demonstrated by recent earthquakes. If industrial facilities store large amount of hazardous materials, accidental scenarios as fire, explosion, or toxic dispersion may be triggered, thus possibly involving working people within the installation, the population living in the close surrounding or in the urban area where the industrial installation is located. Actually the study of seismic behavior of storage steel tank is possible with two different approaches: the first based on lumped mass models and second based on the use of finite elements. Here in this study the second approach - finite element approach with the aid of ANSYS software is taken.
Increase in the height of tank beyond its certain limit in earthquake prone areas can badly affect the stability parameters of the tank that is deformation, stress and strain. In the case of tank installation, now a day the main problem we face is space restriction. In order to maintain the stability even after increasing the height, the only option we have is to adopt tank strengthening techniques along with the design.
Keywords: Seismic event, ANSYS,Finite element approach

I. INTRODUCTION

Research is a process of arriving at an appropriate solution to a problem through a systematic approach. There may be various reasons for conducting research. Nowadays civil engineering is a very vast field of engineering in so many researches and development. So many software have been developed in the field of civil engineering .And one among the important software's is ANSYS which was used in this study. The topic I adopted for my study is "Seismic analysis of steel tanks for oil storage in industrial facilities. On seismic analysis of buildings, so many researches have been already carried out. Seismic analysis of heavy structures is very important for areas where oil tanks are constructed. So I thought of doing my project on Seismic analysis of oil tanks. The susceptibility of steel and concrete tank, under /above and elevated, rigid or flexible to earthquake has been shown in numerous earthquakes. The seismic performance of storage tanks is of major importance not only for the economic value of the structures and their contents but also because they are crucial for management and functioning of emergency services after seismic event.

A. Objective of the project

The main objective of this study is to familiarize the state-of-the-art in seismic analysis, design of tank with strengthening technique. At the end of this research it should be able to:

- Understand the variation of seismic elements in different height of tank by seismic analysis with an advanced software called ANSYS.
- Understand the analytical view of seismic effect on tank and design of tank
- Understanding modern approaches to seismic analysis and design of tanks
- Understand the effect of tank strengthening techniques
- Knowledge about the vertical development of tank
- Understanding modern approaches to seismic analysis is valuable to structural engineers and researchers

B. Scope of the project

- Knowledge on effect of earthquake on tank

- Determining the variation of seismic elements on different heights of tank
- The safety of the plant was computed
- Introducing remedial measures for avoiding tank deformation
- Helps for the future research

C. Scheme of project

Seismic event is certainly one of the most critical external events to the safety of industrial plants. The first step was to study many journals according to seismic events and its effect. Seismic analysis of buildings is common, but when we come to heavy structures especially composite structures; it is not so common. But it is very essential for this type of structure which carry heavy loads like highly flammable products (petrol, diesel ect).Hence the topic "Seismic analysis of steel tanks for oil storage in industrial facilities" was chosen.

Several journals were studied. In a space restricted area to increase the capacity of tank, the only thing which we can do is increasing the height, but this will affect the stability of the tank. This limitation is included in my study. For that the entire thesis is divided into two phases. In the first phase, 3 tanks with same diameter and different height are analyzed through analytical approach and the seismic elements and then variation was compared. Second phase include how can we promote the vertical development of tank. The only way to increase the height of the tank safely is by introducing tank strengthening techniques. Analysis of each technique is included in second phase. In the last stage the thesis is concluded by comparing the techniques provided for strengthening the tank.

II. METHODOLOGY

Increasing the height of tank beyond its certain limit in earthquake prone areas can badly affect the stability parameters of the tank that is deformation, stress and strain. In the case of tank installation, now a day the main problem we face is space restriction. In order to increase the capacity of tank, there are two options. One is to increase the diameter and other is to increase the height. When we take the case of increase the diameter, the problem which we face is the restriction of space. Then we have only one option, increasing the height of the tank. But increasing the height of the tank beyond the certain limit affects the stability of the tank badly. In order to maintain the stability even after increasing the height, the only option we have is to adopt tank strengthening techniques along with the design.

Project is divided into two phases.

1) Seismic analysis of three tanks with same diameter and varying height

2) Adopting tank strengthening technique

III. MODELLING AND ANALYSIS

In order to increase the capacity of tank in a limited area, the tank height should increase. To check the variation of stability parameter with increase in height, three tanks with same diameter and varying height is analyzed by transient analysis with Ahmadabad motion records. 23.2 m diameter (constant) with 15m, 10m, 17m varying height is taken for the analysis.

A.CASE 1

Tank with 23.2 m diameter, 15 m height and 32 mm thickness modeled by CATIA and analyzed by ANSYS workbench

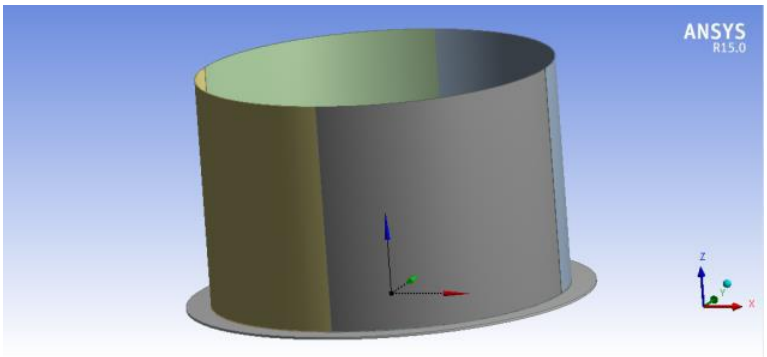

Fig 1 Tank modeled in CATIA

This modelled tank by CATIA is imported to ANSYS workbench. And Ahmadabad seismic value considered here. The variation in stability parameters is analysed with the Ahmadabad seismic value 0.21 m/s2frequency in 3 seconds.

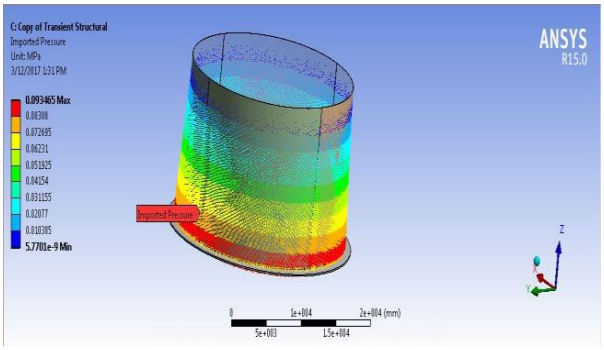

Fig 2 Pressure developed in tank

Pressure developed in tank obtained by CFD. And it is imported to ANSYS workbench for further analysis. By seismic analysis the stability parameters are calculated.

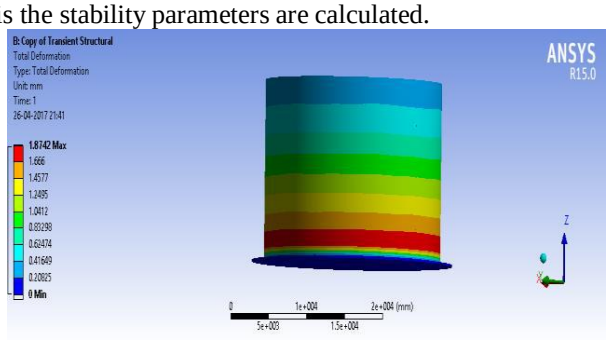

Fig 3 Total deformation

The maximum deformation analysed at the base of tank, about 1.8742 mm. Zero deformation at the top of the tank.

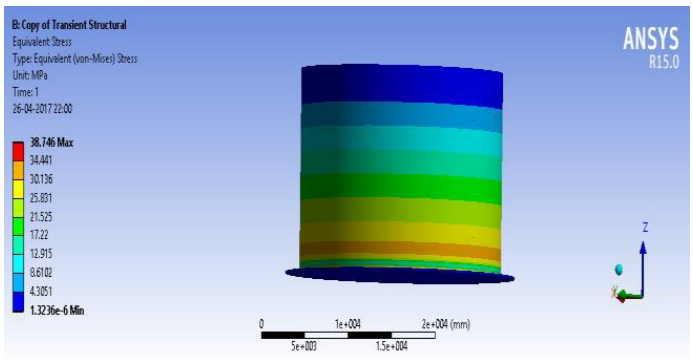

Fig 4 Stress

Maximum stress developed is 38.745 Mpa

B.CASE 2

Here the tank height decreased upto 10 m with same diameter (23.2 m) and 32 mm thickness.

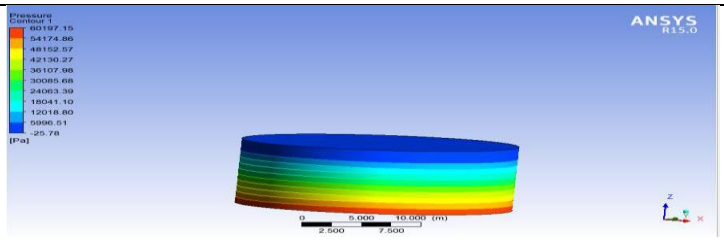

Fig 5 Pressure developed in tank

The maximum pressure is about 0.060197 Mpa at the base.

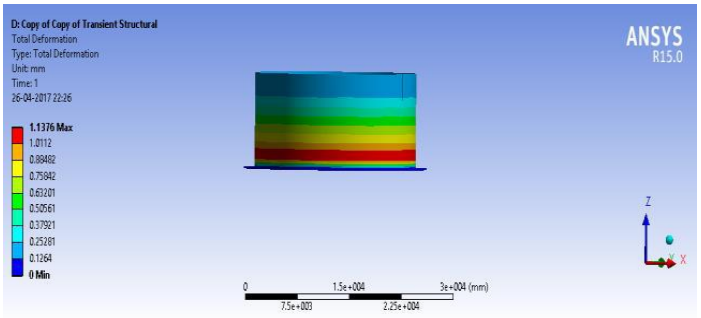

Fig 6 Total deformation

The maximum deformation analysed is about 1.1376 mm. That means the deformation decreased with decrease in height.

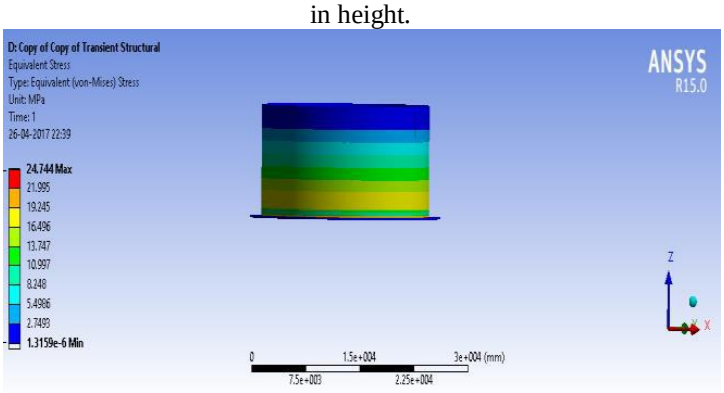

Fig 7 Stress

Maximum stress developed is about 24.744 Mpa.

C. CASE 3

Now the tank height increased upto 17 m with same diameter (23.2 m) and 32 mm thickness.

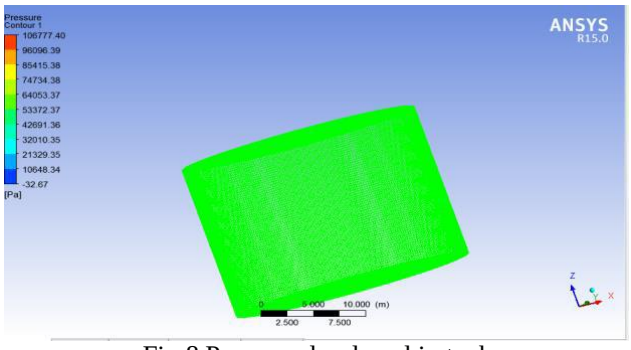

Fig 8 Pressure developed in tank

The maximum pressure is about 0.10677 Mpa at the base.

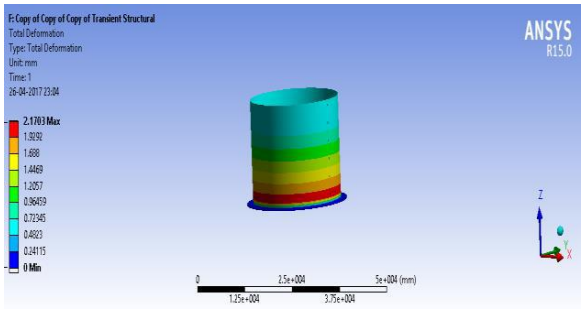

Fig 9 Total deformation

The maximum deformation analyzed is about 2.1703 mm. That means the deformation increased with increase in height.

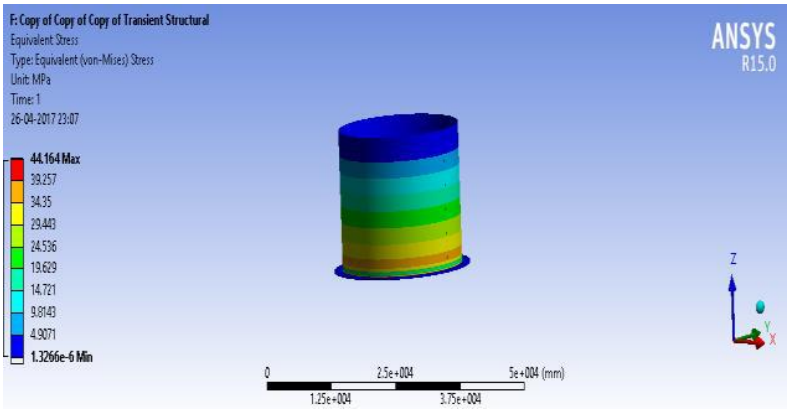

Fig 10 Stress

Maximum stress developed is about 44.164 Mpa.

IV. RESULT STUDY

From the analysis we can see that, the pressure developed inside the tank is higher for case 3 compared to case 1 and case 2.Also, there is a large variation in deformation and stress developed inside the tank and strain for case 3.

This shows that the stability parameter value increases with increase in height which affects the stability of tank. That means we can't increase the height of tank for increasing the capacity In this situation the only thing we can do is decreasing the effect of seismic on tank and it is only possible with introducing tank strengthening techniques to arrest the stress developed in tank and decreasing deformation.

V. STRENGTHENING TECHNIQUES

- GFRP
- TPP
- Cover slab
- Angle section
- Mat foundation

A.GFRP

GFRP is extremely popular in different areas of the aerospace, automotive, marine, O&G (oil and gas) and civil construction industries. When the combination of low material and production costs and advances fabrication of members, finally make polymer production economical and diffused to other fields.

Moreover, GFRP presents very flexible design solutions, due to its extraordinary fabrication adaptability, high durability and structural efficiency and its usage also benefits from increasingly low production and erection costs.

GFRP is provided around the tank with a thickness of 2mm.Now the steel tank modelling and analysis done along with 2mm thickness GFRP in case 3 steel tank.

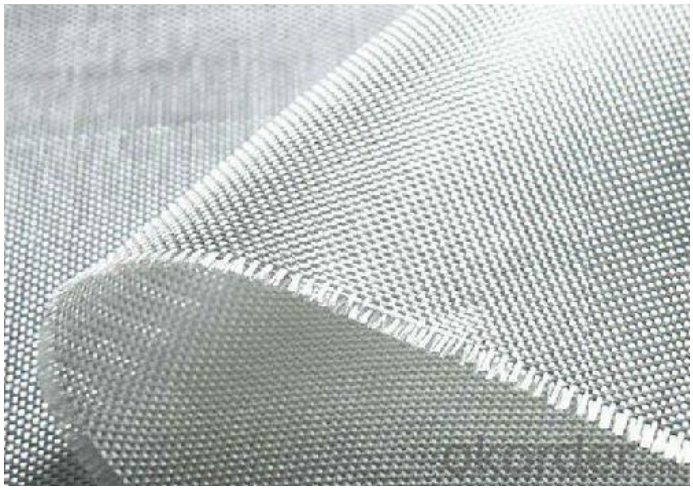

Fig 12 GFRP

B.TPP

A thermoplastic is a plastic material that becomes pliable or moldable above a specific temperature and solidifies upon cooling. It is the most common plastic. Ultra-high molecular weight polyethylene (UHMWPE) is tough and resistant to chemicals. It is used to manufacture moving machine parts, bearings, artificial joints and some bulletproof vests.

The steel tank modelling and analysis done along with 2mm thickness TPP in case 3 steel tank.

Fig 13 Polyethylene

C. STEEL BARS AS COVER SLAB

Providing 8 numbers of steel bars having diameter 32mm around the steel tank. The development length 2.063 m (From manual design).Diameter of concrete slab increased to 28.8 m. (By manual calculation)

D. ANGLE SECTION

Steel angle sections are commonly used as beams to support distributed loads which cause biaxial bending and torsion. However, the recommendations of many design codes are unnecessarily conservative when applied to the bending of angle section beams, or are of limited application, or fail to consider some effects which are thought to be important.

E. MAT FOUNDATION

Mat foundations are used to distribute heavy column and wall loads across the entire building area, to lower the contact pressure compared to conventional spread footings. Mat-slab foundations can be constructed near the ground surface, or at the bottom of basements. Here ring foundation is provided as tank strengthening techniques.

VI. CONCLUSION

From the analysis with strengthening techniques among GFRP and TPP, GFRP is good since it reduces the deformation and its market coast is less compared with TPP. Provision of foundation is a good technique to

maintain the stability of tank. But economically it is not so favourable. But when we look for stability where soft soil and high earthquake prone area exists, cost is not a matter considering stability. For more stability foundations can be adopted. Also the steel bar and steel plate with angle section reduces the deformation.. Steel bar and angle section with steel plate acts as a good arresters for seismic effect. Economically the provision of angle section with steel plate is more suitable. Kerala is situating in zone III, so here the seismic effect is very less. Even though oil storage steel tanks are situated in Cochin, we can adopt steel angles with base plate and steel bar which will reduce the deformation and is cost effective. Also GFRP can be adopted since it is easily available in market which reduces the seismic parameters. Provision of Foundation gives a better performance. It can be adopted where stability is prominent than costs.

VII. ACKNOWLEDGMENT

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