DYNAMIC RESPONSE AND FAILURE ANALYSIS OF INTZE STORAGE TANKS UNDER EXTERNAL BLAST LOADING

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Abstract - *In the present work, an attempt has been made to carry out the parametric study for analysis of blast load on an Elevated INTZE Type Water Tank with frame and shaft staging structure and Study about what effects occurs on tank with full and empty condition and tank with different height changes and compare the results. The Water Tank will be analysed using the software SAP2000. The parameters like displacement and reactions and stresses will be studied for applied blast loads. This will be analysed for Different blast charge in Tones at ground zero distance of Different Levels. Blast load will be applied to the front face of the structure considering it as a triangular load.*

Key Words: **INTZE TANK, BLAST LOAD ANALYSIS, FAILURE ANALYSIS, SAP2000**

1. INTRODUCTION

A bomb explosion within or around a Structure can have catastrophic effects, damaging and Destroying internal or external portions of the Structure. The impact from the blast causes debris, fire and smoke and hence can result in injury and Deal to occupants. Bomb damage to Structure depends on the type and layout of the structure, material used, Range of the located explosive device and the charge weight. If a Structure is not designed for a "blast", a steel frame might be better under reasonably small bomb scenarios since steel has equal capacity in tension and compression and concrete has capacity only in compression in at one face and tension is taken by the reinforcement at the other face. One doesn't know in which direction the blast effects will occur. If a Structure is designed for a blast, the concrete components do better. They have more mass and more damping and energy-absorbing capacity. In the United States, the state department allows only reinforced-concrete Structure in high-risk areas. The objective of this work is to study the dynamic response and failure analysis of the storage tank due to blast loading with different geometry. Preparing software based structure model, performing linear dynamic analysis and identifying the key load carrying elements by applying blast load. Subsequently storage tank is subjected to a specified blast, at specified distance and altitude. Conclusions and recommendations derived from comparative study.

1.1 Failure Analysis

When the blast load apply on structure, sometimes some elements can damage or fail and sometimes whole structure can collapse due to blast load. When the shock wave reaches the surface of the storage tank, the pillars located at the front surface of the explosion are subjected to a large stress with plastic deformation So, there is need to analyse the failure part in structures and carry out what are the preventing measures to resist this type of failure. The failure modes of these types of tanks classified as following:

- Shear failure modes in beams
- Bending-shear failure in beams
- Axial failure in columns
- Cracks in connections
- Torsion failure

Since significant stress concentration under blast loading is generated at the connections between the pillars and Tank dome. The supporting system plays an important role in controlling the structural damages to the storage tank. So, Failure analysis in terms of blast loading on storage tank, the shock waves through which components fail and amount of failure can be analyse and study out what are the remedial measures is to be select for preventing the structure against blast charge.

2. BLAST LOAD CALCULATION

Based on the specifications conforming to IS 4991; 1963, blast load pressure on the building in form of a triangular load is calculated as follows:

Characteristics of the Blast

Scaled Distance, X = D / W
Where, D = Distance of the Building from Ground Zero
         W = Explosive Charge in Tonne
Here, assuming Pa = 1.00 kg/cm2 (Ambient Air Pressure)

Blast Parameters

For the value of scaled distance, various blast parameters are selected from the Table 1 of IS 4991: 1968
These parameters are;

- Pso = Peak Side-on Overpressure (kg/cm2)
- Pro = Peak Reflected Overpressure (kg/cm2)
- Qo = Dynamic Pressure (kg/cm2)
- Td = Duration of Equivalent Triangular Pulse (Milliseconds)
- To = Positive Phase Duration (Milliseconds)
- Td = Value corresponding to $X/W^{1/3}$ (Milliseconds)
- To = Value corresponding to $X / W^{1/3}$ (Milliseconds)

3. ANALYSIS OF WATER TANK

In the present task, a 27m height of water tank has been used. Software SAP2000 has been used for performing interactive as well as non- interactive analyses of this structure. The details for generating the structural model in the software are as given below:

Capacity of tank is 1,000,000 liters,
Type of staging is Frame and Shaft Footed,
Heights of staging is 18m,
Container thickness 300mm,
Column 750mmX1050mm
Bracings 500mmX500mm
Loading: DL, LL, EQ, BL, WL

Load Combinations for Blast Load:

1) DL+0.35LL+BL
2) 1.2DL+LL+BL

Same as for other models with height change and shaft footed tank is consider.
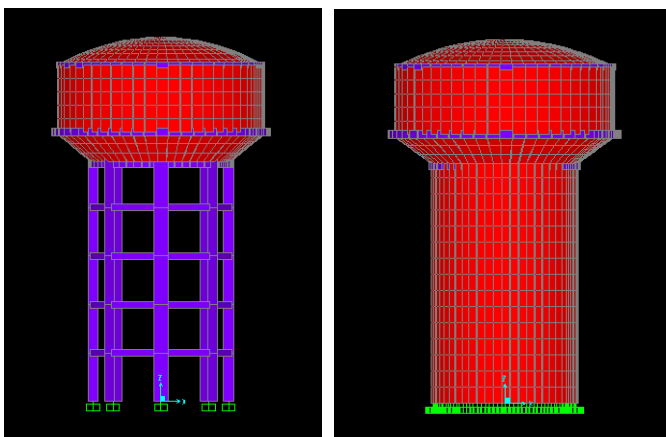
Fig-1: Elevation of Selected Water Tanks

4. EXPERIMENT RESULTS

Compare the results for different geometries with different loading condition for base reactions and maximum displacements.

4.1 Base Reaction:
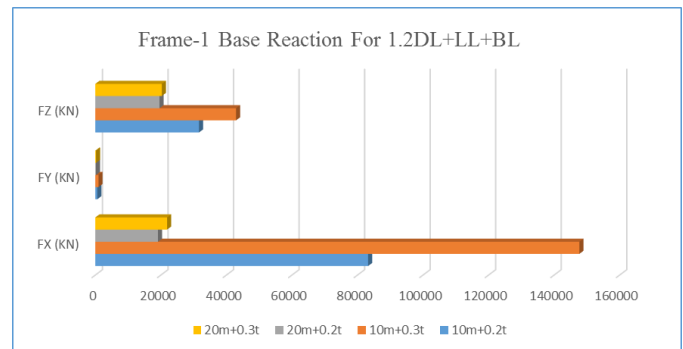
Chart-1: Frame-1 Base Reaction Force
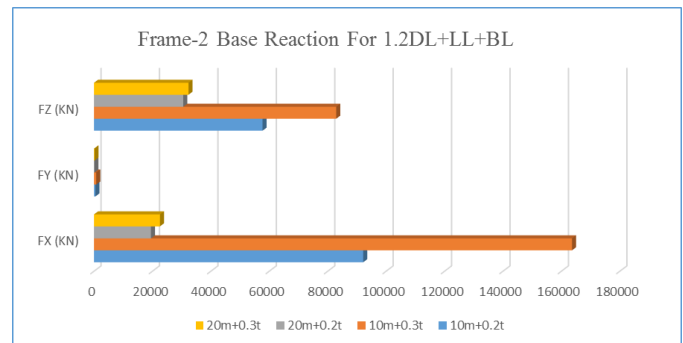
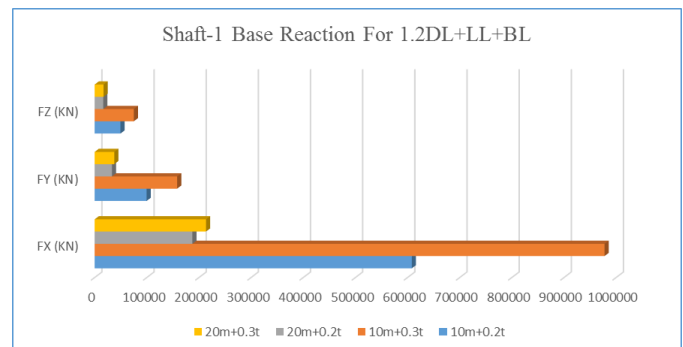**Chart-2:** Frame-2 Base Reaction Force

Chart-3: Shaft-1 Base Reaction Force
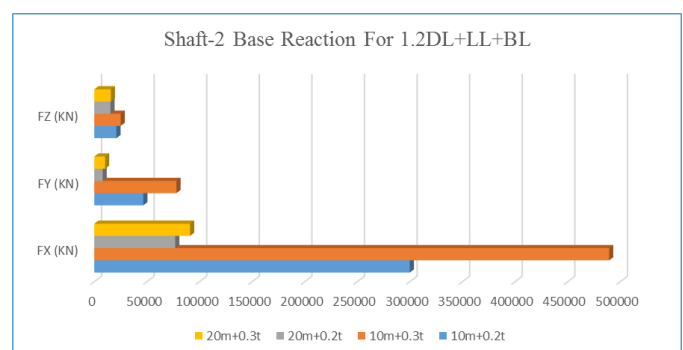
Chart-4: Shaft-2 Base Reaction Force
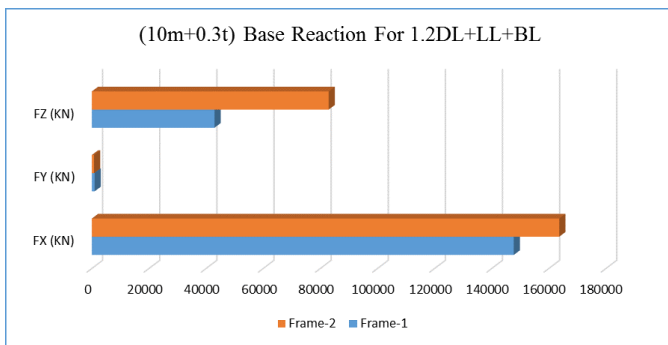
Chart-5: Frame-1 & Frame-2 Base Reaction Force

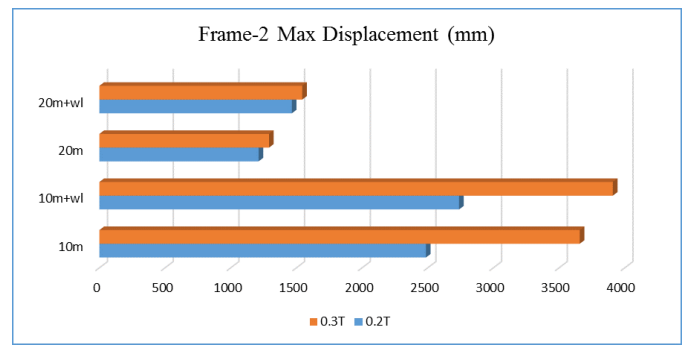**Chart-6:** Shaft-1 & Shaft-2 Base Reaction Force

4.2 Displacement

Chart-7: Frame-1 Maximum Displacement

Chart-8: Shaft-1 Maximum Displacement

Chart-9: Frame-2 Maximum Displacement

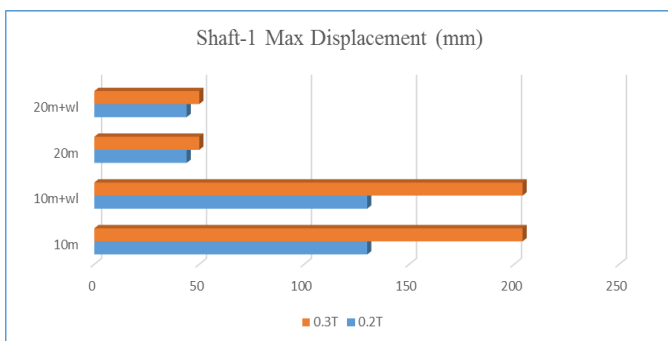**Chart-10:** Shaft-2 Maximum Displacement

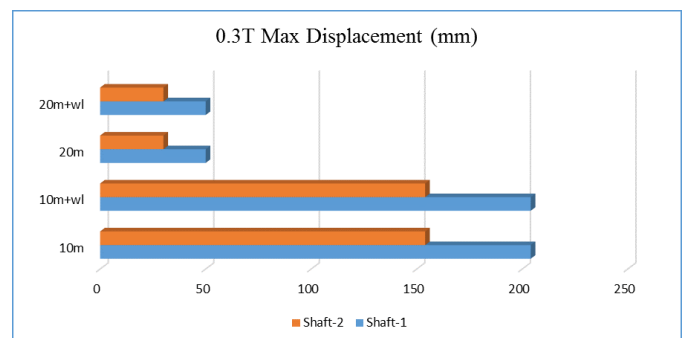**Chart-11:** 0.3T Frame-1 & Frame-2 Maximum Disp.

Chart-12: 0.3T Shaft-1 & Shaft-2 Maximum Disp.

5. FAILURE ANALYSIS AND RESULTS

5.1 Failure Analysis

Fig. shows the representative failure process of the INTZE storage tank under the explosion shock wave. When the shock wave reaches the surface of the storage tank, the pillars located at the front surface of the explosion are subjected to a large stress with plastic deformation.

At the initial stage of the failure process, the maximum effective stress was observed at the connection of the pillar and the shell due to the effects of the stress concentration at step-1.

Then significant deformation occurred at the first row of the pillars facing the explosion at step-2. During the shock wave propagation, significant bending deformation and shear breakage were observed in the pillars facing the explosion, and concaved buckling of the shell was also found at step-3.

The final failure mode shows that global damage of the structure occurs. At the step-4, some of the pillars lost the support for the shell under the blast loads. A significant amount of concaved deformation was observed at the surface of the shell.
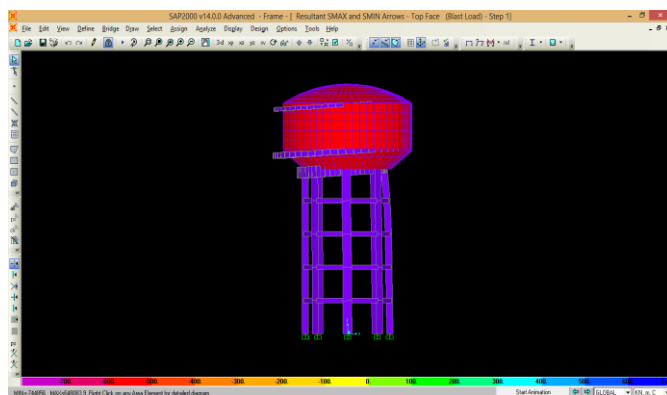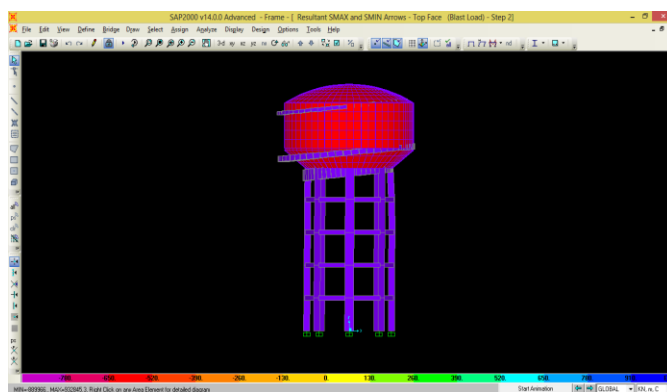

Fig-2: Resultant Stresses at Step-1

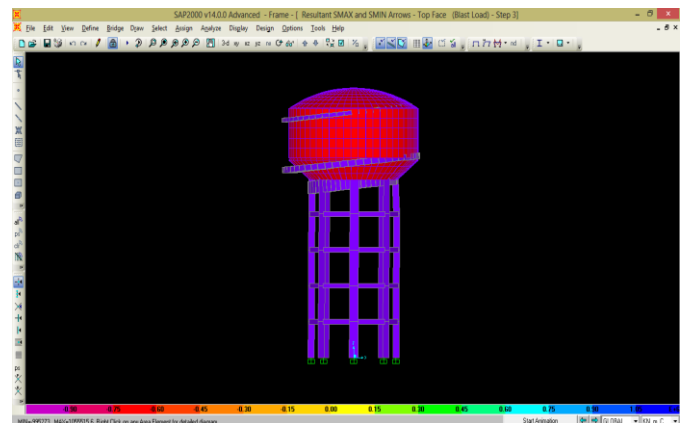
Fig-3: Resultant Stresses at Step-2
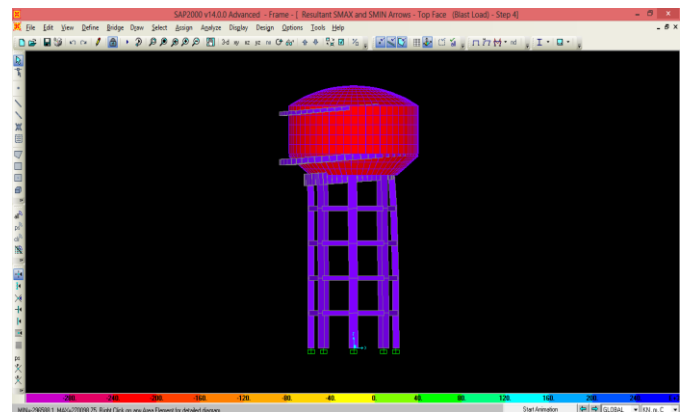

Fig-4: Resultant Stresses at Step-3

Fig-5: Resultant Stresses at Step-4

5.2 Compare Results

Compare the results which is related to maximum stresses occurs on tank with time intervals for different blast load with different geometries for failure analysis.
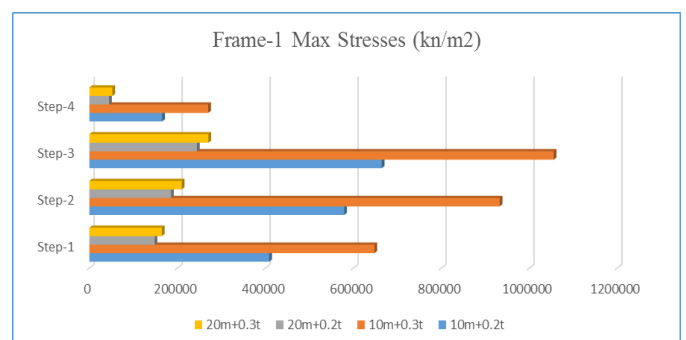

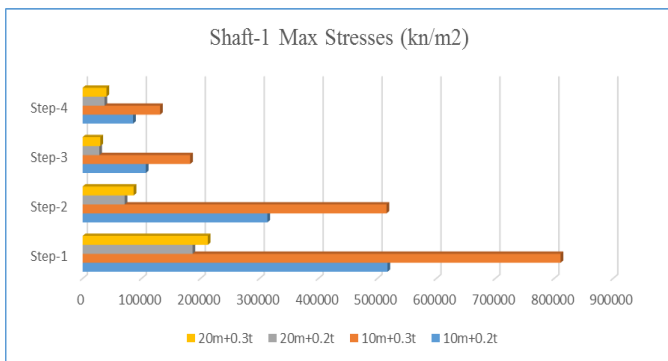**Chart-13:** Frame-1 Maximum Stresses
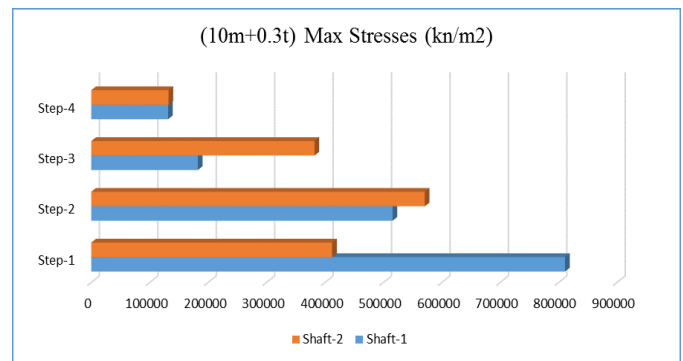
Chart-14: Shaft-1 Maximum Stresses

Chart-15: Frame-2 Maximum Stresses

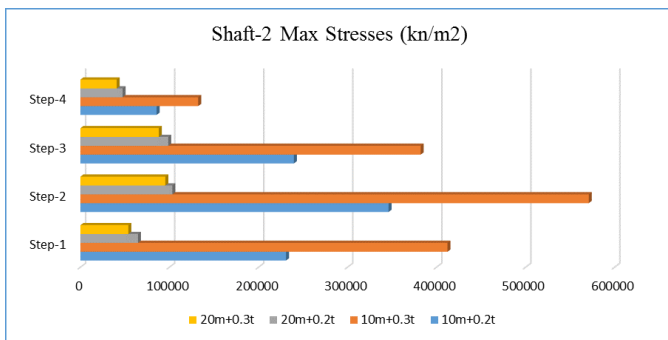**Chart-16:** Shaft-2 Maximum Stresses

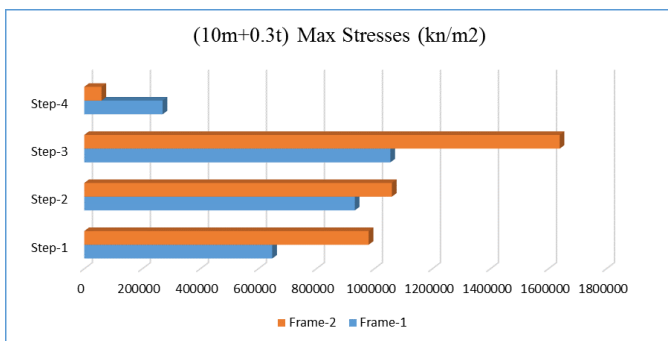**Chart-17:** Frame-1 & Frame-2 Maximum Stresses

Chart-18: Shaft-1 & Shaft-2 Maximum Stresses

6. CONCLUSIONS

According to results we can conclude that the highest charge 10m with 0.3 tonne can deform whole structure of tank, with comparison the shaft footed tank have more strength as compare to frame footed tank because of mass concrete.

For the displacement part frame footed tank have more value of displacement as compare to shaft footed tank because of shaft footed tank have more mass concrete. For inner comparison displacement value is increase with height increase in frame footed tank and decrease in shaft footed tank.

According to results, in stresses part the stresses should be increase with increasing height of tank staging in both the cases. Frame footed tank have more stresses as compare to shaft footed tank. So, shaft footed tank can resist more blast charge as compare to frame footed tank.

According to all the comparison and results we can conclude that the shaft footed tank with maximum heights can resist more blast load as compare with all other cases. So, the shaft footed water tank is best solution in blast prone zone.

It is recommended that proper take care of explosion should be taken for the important structures, or proper security should be managed so that explosion should be away as far as possible from the structures and tree plantation and any other obstacles are should be placed in front of structure to resist blast load and protect the structure.

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