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International Journal for Scientific Research in Modern Engineering and Science

International Journal for Scientific Research in Modern Engineering and Science, 3(1): 71-77 (2022)

DYNAMIC ANALYSIS OF RC CIRCULAR AND HEXAGONAL ELEVATED WATER TANK WITH DIFFERENT CONDITIONS

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Abstract

Reinforcement Concrete Elevated Tanks are very important and useful structures. An elevated tank behaves like an inverted pendulum with a huge amount of water on top staging. As is known from the very troubling experience of tank collapses in many places of the world and this causes huge damages during earthquakes. Made for the dynamic behavior of water containers, most of them belong to cylindrical tanks. The economic life of these RCC tanks is usually in the range of 40-70 years. Staging is responsible for the lateral resistance of the entire structure. The aim of this study is to understand the behavior of different water tank systems under different tank conditions. Most of the damages observed during the earthquakes arise from the causes like unsuitable design of supporting system, mistakes on selecting supporting system. Therefore, supporting structural elements of elevated water tanks are extremely vulnerable under lateral forces due to an earthquake. The behavior of elevated water tanks. In present work, dynamic analysis and performance of different elevated RC Intze water tank has been presented and obtained various results viz. base shear, deformation, von-mises stress, tresca stress, bending moment at X and Y direction for different types of tanks i.e., circular with 12 columns (C-12 C), circular with 10 columns (C-10 C), circular with 8 columns (C-8 C) and hexagonal tank. The present work also performs the analysis with various height of column, wind speed.

Keywords: *Elevated Water Tank, Earthquake, Modal Analysis, Seismic Analysis; Staad.Pro.*

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1. Introduction

Elevated water tanks are considered to be vital lifeline elements and are expected to remain functional after severe ground motions to serve, as a provider of potable water, as well as firefighting operations. The failure or malfunction of this essential infrastructure disrupts the emergency response and recovery after an earthquake has occurred. There have been numerous studies carried out, regarding fluid-structure interaction and improvement of performance of water tanks. However, minimal study has been conducted on the investigation and improvement of the reinforced concrete shafts. The elevated water tank, supported by the reinforced concrete (RC) shaft, commonly has two main configurations. The first type being the "Elevated Concrete Tank" (Figure 1.1.), where both the shaft and tank are constructed from reinforced concrete. However, the second type "Elevated Composite Steel-Concrete Tank" or simply a "composite elevated tank", consists of a RC shaft and welded steel tank. The welded steel tank is mounted on top of the RC shaft. The lower section of the tank is cone shaped, whereas the upper part is cylindrical.

2. Methodology

The present work is based on numerically investigation of reinforced concrete elevated water tank under tank full, empty and different geometric conditions including the effect of fluid-structure interaction. The main aim of the present work is to performed the dynamic analysis to investigate the effect of various responses of proposed elevated water tank models.

2.1 Dynamic Analysis

Elevated water tanks are top-heavy structures; the entire system could be approximated as a single degree of freedom without much loss of accuracy. Certain fraction of weight (usually 1/3rd) of columns and braces may be assumed to be added to the weight at top and the columns may be treated as weightless springs to facilitate the calculations. (Is 1893). In present work 800KL capacity of water tank has been taken for study.

From the design,

Imposed Load (IL) + Dead Load (DL) of superstructure = 11769.8 kN

Water load only = 8026.8 kN

DL of staging only = (62.60 + 23.63) x 18 = 1552.1 kN (column and braces)

DL of container portion = (11769.9 – 8026.8 – 115.6 – 156.5) = 3470.1 kN

Condition 1: Tank Empty

Equivalent weight at C.G $W_e = 3470.9 + \left(\frac{1552.1}{3}\right)$

Base shear

W_s= 3988.3 kN

V_b = 0.066 x 3988.35 = 263.2 kN

Condition 2: Tank Full

Equivalent weight at C.G

Base shear

W_s=11915.1 kN

V_b = 0.066 x 11915.1 = 786.4 kN

The sectional details of Elevated water tank are shown below. Capacity of tank= 800 KL and supported on R.C. frame staging of 18 columns with horizontal bracing. Details of sizes of various components and geometry are shown below Table 4.1:

Table 1. Sizes of various components

S. No	Component	Size (mm)
1.	Top Dome	100 Thick
2.	Top Ring Beam	400 x 300
3.	Cylindrical Wall	200 Thick
4.	Bottom Ring Beam	600 x 550
5.	Circular Ring Beam	400 x 850
6.	Bottom Dome	200 Thick
7.	Conical Dome	200 Thick
8.	Columns	400
9.	Density of concrete	25 kN/m^3
10.	Grade of concrete	M40
11.	Grade of steel	Fe 415

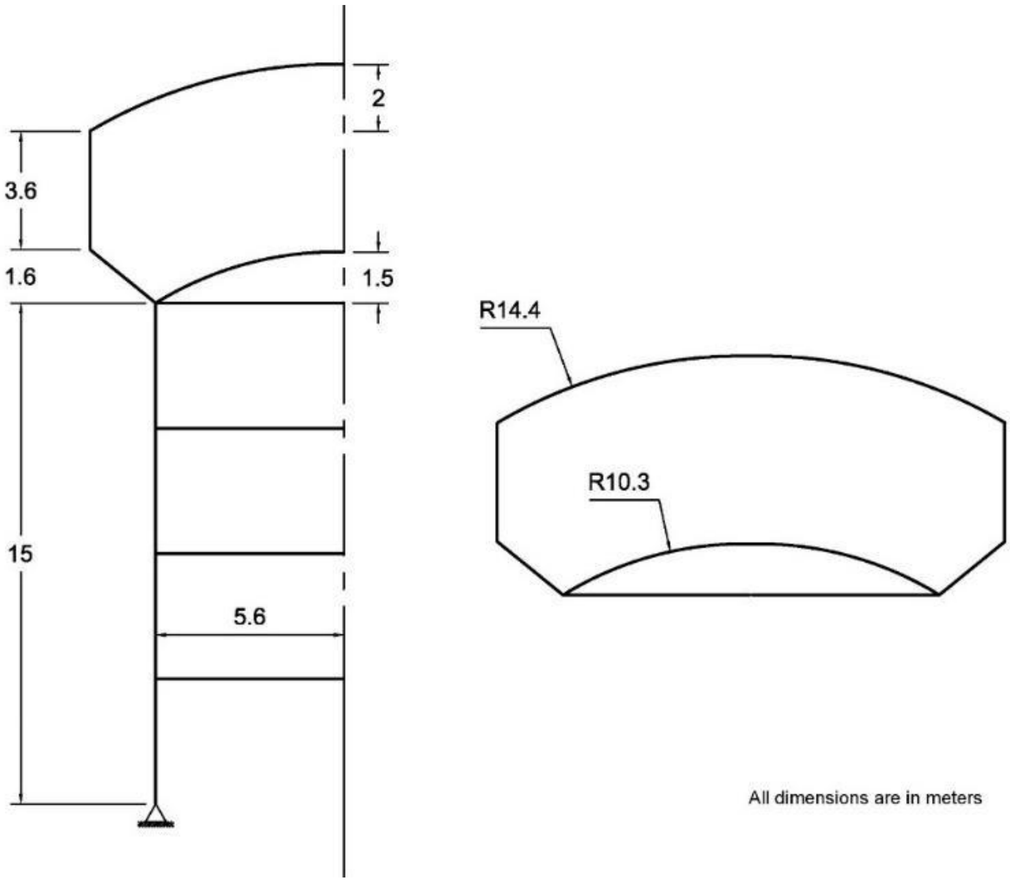

Figure 1. Dimensional view of intze water tank

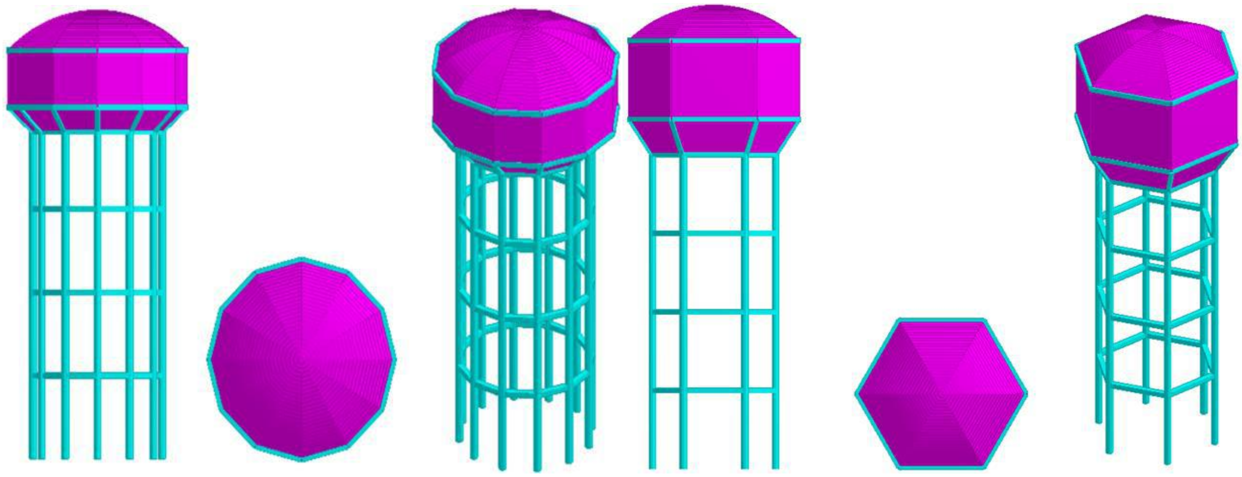

Figure 2. Front view, top view and 3D model of circular and hexagonal intze water tank

3. Results and Discussion

Water tanks are very important components of life line. They are critical elements in municipal water supply, firefighting systems and in many industrial facilities for storage of water. A reinforcement concrete tank is a very useful structure which is meant for the storage of water, for swimming bath, sewage sedimentation and for such similar purposes. Reinforced concrete overhead water tanks are used to store and supply safe drinking water. With the rapid speed of urbanization, demand for drinking water has increased by many folds. Also, due to shortage of electricity, it is not possible to supply water through pumps at peak hours. In such situations overhead water tanks become an indispensable part of life.

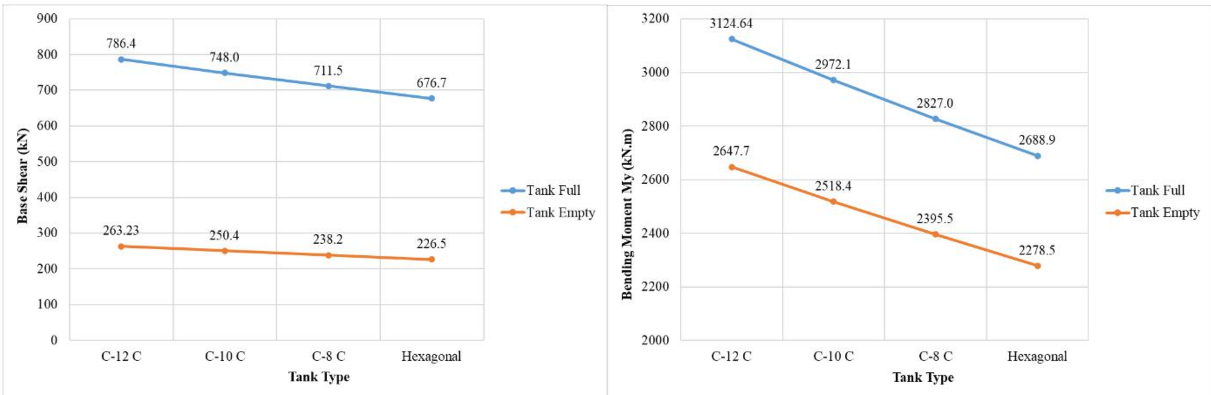

Figure 3. Variation of base shear and bending moment at Y-direction while tank is full and empty condition with respect to the different tank type

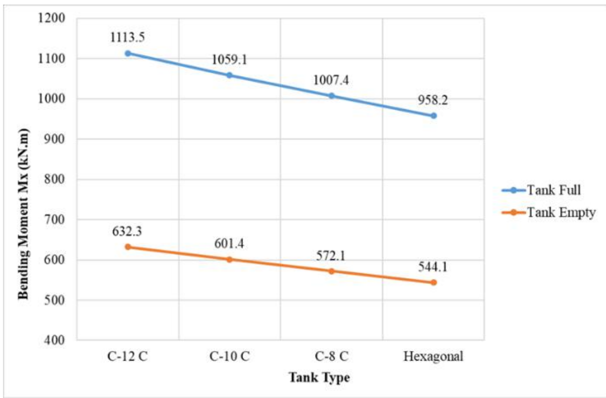

Figure 4. Variation of bending moment at X-direction with respect to the different tank type

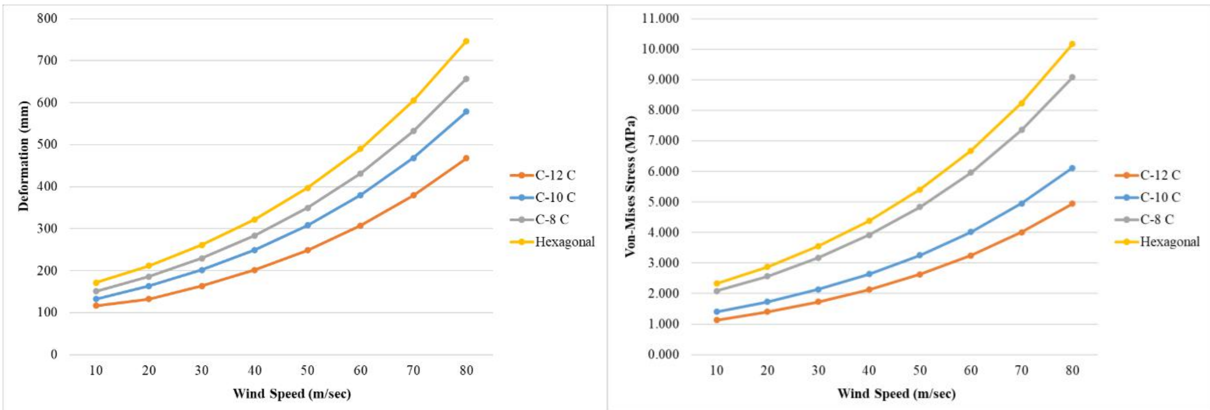

Figure 5. Variation of total deformation and von-mises stress with effect of different wind speed on different types of tanks

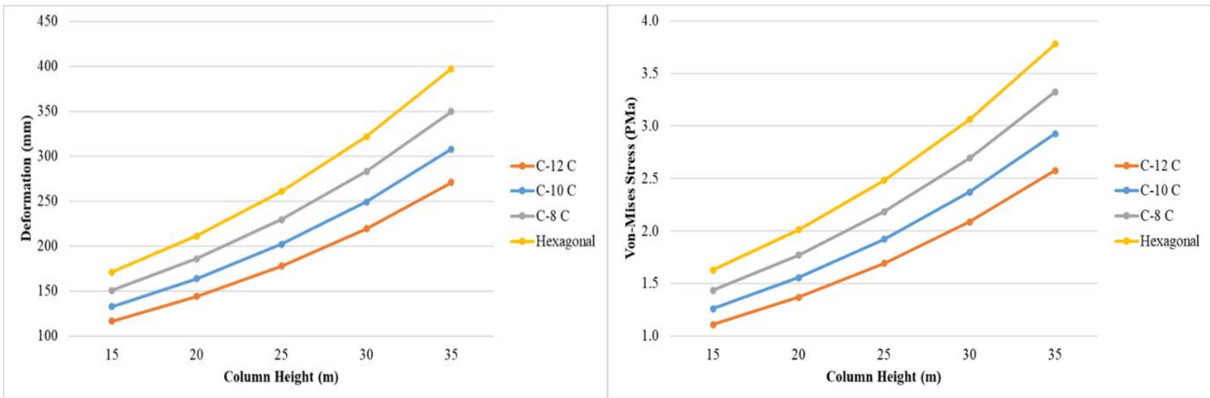

Figure 6. Variation of total deformation and von-mises stress with effect of different column height on different types of tanks

4. Conclusion and Future Scope

In this present work performed the dynamic analysis and obtained various results viz. base shear, deformation, von-mises stress, tresca stress, bending moment at X and Y direction for different types of tanks i.e., circular with 12 columns (C-12 C), circular with 10 columns (C-10 C), circular with 8 columns (C-8 C) and hexagonal tank. The present work also performs the analysis with various height of column, wind speed.

From the analysis it has been observed that the base shear is less in C-10C, C-8C and hexagonal tank type as compared to the C-12C type tank, that means C-12C tank is gives more stiffness as compared to other.
While increasing the wind speed, it has been observed that the total deformation, maximum von-mises stress, maximum tresca stress, bending moments has been increasing with 12 columns (C-12 C) to hexagonal tank. But the minimum value of total deformation, maximum von-mises stress, maximum tresca stress, bending moments found in the circular with 12 columns (C-12 C) and maximum at hexagonal tank.

Also, while increasing the height of tank column, it has been observed that the total deformation, maximum von-mises stress, maximum tresca stress, bending moments has been increasing with 12 columns (C-12 C) to hexagonal tank. But the minimum value of total deformation, maximum von-mises stress, maximum tresca stress, bending moments found in the circular with 12 columns (C-12 C) and maximum at hexagonal tank.

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