"Comparative Study of Rectangular Elevated Watertank on varying Staging Heights Along with and Without Bracing"

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CHAPTER 1
INTRODUCTION

General Overview

An elevated water tank is a big water storage container designed to keep water at a specific height in order to maintain pressure in the water distribution system. Water tanks are used to store water for a variety of purposes, including drinking water, irrigation, agriculture, fire suppression, agricultural farming for both plants and animals, chemical manufacture, food preparation, and a variety of others. Tanks for water are an effective approach to assist impoverished countries.

Water is delivered from elevated storage tanks through a big distribution system or through stand pipes near the source. When ground storage tanks can't be created due to a lack of natural elevation and standpipes are fed by a motorised pump, elevated storage tanks are used.

Plastics (polyethylene, polypropylene), fibre glass, concrete, stone, and steel are among the materials used to construct water tanks (bolted or welded, carbon or stainless). Earthen pots can also be used to store water.

Types of Water Tank:

Based on placement of water tank-

- Resting on ground
- Underground
- Elevated

Based on shape of tank-

- Circular
- Rectangular
- Intze
- Spherical

LITERATURE SURVEY

Literature Papers

"shaik. subhani, t. sai latha, naga babu", "*Design & analysis of intze type water tank*", International Journal of Advance Scientific Research & Engineering Trends June2021

Wind and seismic forces acting on an Intze type water tank for Indian settings are investigated in this study. More than 60% of India is prone to earthquakes, according to the seismic code IS 1893(Part-1). IS 3370, IS 456, IS 800, IS 875, and IS 1893 were used to conduct the investigation. For the Agiripalli Town in Krishna District, Andhra Pradesh, an Intze type water tank with a capacity of 10 lakh litres was developed. STAAD will be subjected to various loads, including dead loads, live loads, and wind loads. Pro model and manual design at proper spot according to loading codes STAAD provided all of the results stadd. Pro will be compared to manual design results.

"Priyanka M. Mankar; H.R. Nikhade", "Analysis of Circular Elevated Service Reservoir Using STAAD Pro by Considering the Effect of Continuity" Elsevier 02/07/2021

The main goal of this study is to see how important continuity analysis is in practical applications and how to use Staad pro software to analyse an elevated circular water tank. The continuity effect is used to inspect the bottom joint of a water tank. The base slab, wall, bottom rings beam, gallery, column, and base beam all meet at this point. Water causes self-weight and hydrostatic pressure in the water tank. The continuity effect increases stress, hoop tension, and BM, so it's important to think about it when constructing the tank. The results acquired with the STAAD.Pro software are almost identical to those obtained manually. This revealed that STAAD.Pro is appropriate for water tank design and analysis.

"Mainak Ghosal", "Water Tank Analysis Using STAAD PRO", International Transaction on Engineering & Science, January 2019

When there is a problem, every design emerges. To solve the current difficulties, a design is built. People in areas where water is scarce do not have enough flow, speed, or discharge, particularly those who live on the higher levels of multi-story buildings. As a result, individuals are deprived of water due to an insufficient supply to meet their daily needs. As a first step in solving this challenge, a water storage facility known as an Overhead Water Reservoir should be developed using STAAD principles. The current work uses STAAD to analyse and construct an elevated circular water tank. Pro V8i. The design includes manual load estimates and STAAD analysis of the entire structure. Pro

"Dhritiman Mondal", "*Comparative study on various shapes of RCC underground & rest on ground water reservoir",* International Journal of Innovative Research & Studies April 2018

This research compares subterranean and above-ground R.C.C. water tanks of various shapes (circular and rectangular) with a capacity of 500000 lit. or 130000 gallon (US). The work entails the design and costing of circular and rectangular R.C.C. subterranean water tanks that rest on the ground. The fact that there are multiple construction styles to choose from can often be confusing. The best method is to choose the sort of building that best suits the circumstances and structure. The goal of this study is to create high capacity R.C.C water tanks in a variety of forms and compare the results. STAAD PRO software is used to analyse both water tanks. The idea is to reach a definite conclusion regarding the superiority of the two techniques over one another for specified capacity

"Chirag N. Patel & Mehul S. Kishori", "*Analytical and Software Based Comparative Analysis of on Ground Circular Water Tank*" International Journal of Civil Engineering (IJCE), Apr - May 2016;

This research compares and contrasts analytical and software-based methodologies for analysing an on-ground concrete circular water tank. Analytical methods are based on IS 3370 and the PCA (Portland Cement Association), and are compared to the results of FE analysis using the Staad Pro programme. The purpose of this research is to observe actual tank behaviour under static loading conditions, with a focus on IS: 3370. In the examined analytical approach, hoop tension and bending moment are similar, but software-based approach has a significant benefit due to finite element modelling. It also indicates that engineers can use a software-based method to complete the actual tasks of structural modelling and analysis in engineering with greater flexibility and efficiency to achieve economy.

"Chetan Jagtap, Siddharth Pastariya", "Seismic analysis on cylindrical ground supported water tank by varying their aspect ratio", OAIJSE, October 2020

This process results in parts that are thicker and more extensively reinforced. The amended code IS 3370: 2009 adopted the usage of the limit state approach of design, as well as a provision for checking the crack width. This research is being carried out to establish the best cost-effective height to diameter (H/D) ratio to be used in the design of overhead water tanks with a given capacity with various heights and diameters. Six circular 500 kL water tanks with top and bottom dome patterns were designed in STAAD by adjusting the H/D ratio from 0.15 to 1.05 to optimise the results and check the accuracy of the design. After assuring the safety of all the structures, further analysis is done to calculate the costeffectiveness of the structures by comparing the approximate total cost of materials. It was found that the aspect ratio (H/D) of 0.60 led to the most efficient design

"Vaseem Akhtar, Shaik Rehman, S Zubeeruddin", "*Design And Analysis Of Elevated Water Tank By Using Staad Pro*" International Journal of Research, Volume 08 Issue 03 March 2021

This project explains the theory behind the design of liquid retaining structures in a concise manner. Water tanks are the containers used to store water. Elevated water tanks are built to give the necessary head to allow water to flow under gravity's influence. The practise of building water tanks dates back to the dawn of civilization. The water tanks project is a high priority since it provides drinking water to a large population ranging from major metropolitan cities to rural towns and villages.

"C. Pavithraa , J. Yogeshwaran", "Seismic Evaluation of a RC Elevated Water Tank" International Journal of Control Theory and Applications, Number 12, 2017
A RC raised rectangular tank with a volume of 900m3 is subjected to seismic stresses in this study, and the tank's behaviour is assessed using dynamic analysis. This research encompasses hydrodynamic pressure generation, varied fluid levels in the tank, and the tank's reactivity to diverse levels of filling conditions. Findings: Analytical work was done on an elevated fluid storage tank for various soil conditions utilising STAAD Pro and response spectra as per IS 1893 (Part II): 2002.

"Aman Jain, Armanjai Ratia, Hari Kishan Dewangan", "Design of Cylindrical Overhead Water Tank by STAAD Pro Software" International Journal of Innovations in Engineering and Science, Vol 5, No.3, 2020
The goal of the ESR study is to develop and analyse a safe ESR that minimises damage to the structure and its structural components, even in the event of a natural hazard such as an earthquake. In 2009, the Indian standard for the design of liquid retaining structures was amended. The limits state design method was included in this revised edition. The limit state design method was not used for water retaining structures because liquid retaining structures must be crack-free. However, this edition of the Indian standard uses the limit state method to address two issues. It does two things: first, it minimises steel stresses so that concrete is not overstressed, and second, it restricts cracking breadth. This project explains the design theory in detail of liquid retaining structure.

"Mohammad Quais Khan, Mr. Babar Hussain", "*Analysis and Design of Intze water tank as Per IS: 3370 & IS: 456 -2000 using STAAD Pro Software*", IJARIIE 2019
Water tanks are critical public and industrial structures. The prevalent construction practises, the physical characteristic of the material, and the climatic circumstances all impact reinforced concrete design and construction processes. IS 3370, IS 800:2002, IS 875, and IS 1893 are all used to conduct the analysis. The dome designed the tank. Supporting the dome is a ring beam. Walls that are cylindrical, At the intersection of the cylindrical and conical walls, there is a ring beam. slab, conical The tank's floor, The girder ring, Columns, Bracings on the tower The IS 3370-Part III foundations will be built utilising a 2-Dimensional STAAD model for a tank with a capacity of 3,00,000 litres. There will be different loads such as dead loads, live loads, wind loads, and Earthquake loads will be applied on STAAD model at appropriate location as per codes used for Loading. These elevated water tanks are especially vulnerable to horizontal forces such as wind and earthquakes.

Objectives

1) The main objective of this project is to study analysis and design of Elevated Reservoirs using Staad pro. Connect

2) To perform Seismic analysis for Rectangular Elevated water tank with and without bracing at different staging height.

3) To analyze the structure for carrying the various load like dead load, live load, wind load and seismic load.

4) To compare various parameters Such as Displacement, Moment, Base Shear, Axial Forces etc.

5) To find the most efficient Water Tank shape.

Need of research

- Elevated water tanks are commonly used for storing water in public water distribution system and it should be competent of keeping the expected performance during and after earthquake.

- It has large mass concentrated at the top of slender supporting structure and hence extremely vulnerable against horizontal forces due to earthquake.

- Elevated water tank is a structure which is constructed at a sufficient height to cover a large area for the supply of water

- The performance of elevated water tanks during earthquakes is of much interest to engineers, not only because of the importance of these tanks in controlling fires, but also because the simple structure of an elevated tank is relatively easy to analyze and, hence, the study of tanks can be important.

Methodology

PHASE-I

- To Decide Aim, Objective and Need of Work
- To Review Various Literatures, Codes and Journals
- To decide the flow of work i,e Methodology

PHASE-II

- Detail Study of all possible Structural
- Effect of Earthquake and Its parameter
- Types of loading and Methods of Analysis
- Fixing All general Structural Data and Case Considerations of Models
- Results and Comparison

PHASE –III

- Analyzing all the selected model patterns
- Drafting of Comparative result Statements
- Discussing all obtained Results
- Conclusions on results obtained after analysis and Discussion

PHASE IV

- Results and Comparison

ELEVATED WATER TANK

The water tank is used to store water in order to meet daily needs. Water tanks come in a variety of capacities, depending on the amount of water consumed. Different types of water tanks exist, based on their design, location relative to ground level, and other factors. Water tanks can be on-ground tanks, elevated tanks, or underground tanks in general. The behaviour of the water tank has been studied for a variety of factors, including changes in staging height, tank design, seismic intensities, wind loads, and bracing pattern.

PARAMETERS OF WATER TANK

In this dissertation, three types of raised water tanks are investigated: representative 30m height tanks with various bracing patterns are shown in lists, and parameters such as height and form are evaluated for the study.

DESIGN PARAMETRS

- INPUT PARAMETERS
- M30 CONCRTE GRADE
- FE415 STEEL GRADE
- STAGING HT 10M and 15M
- SLAB THICK 150MM
- BEAM 250X350MM
- COL 350X350MM
- BRACING 230x230MM

LOAD CASES

- DEAD LOAD - 3.5KN/M
- LIVE LOAD – 2 KN/M
- EARTHQUAKE LOAD X DIRE

- EARTHQUAKE LOAD Y DIRE
- WIND LOAD X DIR
- WIND LOAD Y DIR

IS Codes

1. IS 456-2000
2. IS 1893 - 2002/2005
3. IS 875 – Part III 1987
4. IS 3370 - Part IV 1967

TYPES OF LOADS

DEAD LOAD

The dead load is the structure's weight plus any permanent loads attached to it. The dead load is assumed at first and verified once the design is completed.

HYDROSTATIC LOAD

It is the pressure exerted by a fluid at equilibrium due to gravity at a given place inside the fluid. Because of the rising weight of fluid exerting downward force from above, hydrostatic pressure rises in proportion to depth measured from the surface.

WIND LOAD

Wind load on elevated water tanks is normally uplift force perpendicular to the water tank, unless the water tank is excessively high, due to the suction effect of the wind blowing over the cross arms. As a result, wind loads on water tanks normally act in the opposite direction of gravity loads, and their magnitude can be greater than gravity loads, creating force reversal in water tanks. The intensity is calculated according to IS 875 (part 3): 1987.

SEISMIC LOAD

If a water tank is built in an earthquake-prone area, the earthquake or seismic forces must be taken into account while designing the building; earthquakes create vertical and horizontal forces in the structure that are proportionate to the structure's weight. Water tank structures must take into account both horizontal and vertical components. The earthquake loads are considered in this project using equivalent static analysis and response spectrum as defined by IS 1893 (part 1): 2002. Response spectra are generated according to IS 1893-2002. The kind of soil, type of construction, dynamic behaviour of the structure, and proper seismic zone are all factors to consider.

RESULT & DISCUSSION

Loads Considered On Elevated Water Tank :

Any miscalculation in the load assessment will result in an incorrect elevated tank design. Depending on the water tank design specifications, several sorts of loads must be precisely estimated. The wind has an important influence in load calculations. Correct wind evaluation leads to proper load assessment and reliable elevated water tank construction design.

The following load cases are considered in this thesis.

- Dead load is the self-weight of structure of the elevated water tank and bracings.
- Hydrostatic load is calculated as per dimensions of tank.
- Wind load on the elevated water tank is taken for normal load condition as per IS802 (part 1: sec 1)-1995 and IS 875(part3)-1987.
- Earthquake load on the elevated water tank is considered as per IS 1893(part1):2002**.**

Loading Combinations Considered

When more than one load type acts on a structure, it is called a load combination. In order to ensure the structural safety under various maximum predicted loading situations, building codes often prescribe a number of load combinations as well as load factors (weightings) for each load type.This thesis considers various load combinations.

This study takes into account four different load combinations:

- Self-weight + hydrostatic load + earthquake load
- Self-weight + hydrostatic load + wind load

- Self-weight + earthquake load
- Self-weight + wind load

Terminology for Earthquake Engineering

- **Design Horizontal Acceleration Coefficient (Ah):** This is a horizontal acceleration coefficient to be applied in structure design..

- **Importance Factor (I):** It is a factor used to calculate the design seismic force based on the structure's functional usage, which is defined by the risk of failure, the structure's post-earthquake functional necessity, historic value, or economic significance.

- **Reduction Factor (R):** It is the factor by which the design lateral force is lowered from the actual base shear force that would be created if the structure remained elastic during its response to the Design Basis Earthquake (DBE) shaking.

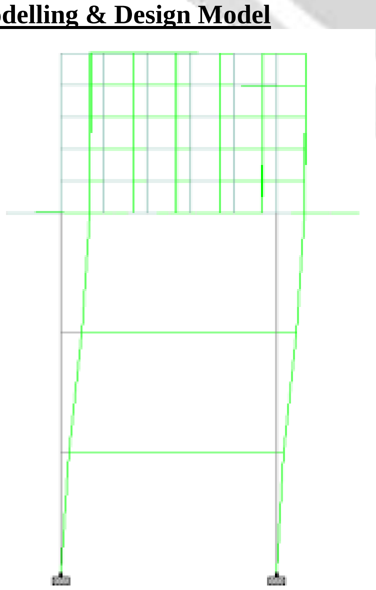
- **Structural Response Factors (Sa /g):** It is a factor that describes the acceleration response spectrum of a structure subjected to earthquake ground vibrations and is dependent on the structure's natural period of vibration and damping.

- **Zone Factor (Z):** It is a factor used to determine the design spectrum based on the maximum seismic risk in the zone where the structure is located, as measured by the Maximum Considered Earthquake (MCE). This standard's basic zone factors offer a realistic estimate of effective peak ground acceleration.

<u>**Assumptions**</u>-

- Z = Zone factor is for the Maximum Considered Earthquake (MCE) and service life of structure in a zone. The factor 2 in the denominator of Z is used to reduce the Maximum Considered Earthquake (MCE) zone factor to the factor for Design Basis Earthquake (DBE).
- I = Importance factor, depending upon the functional use of the structures, characterized by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance.
- R = Response reduction factor, depending on the perceived seismic damage performance of the structure, characterized by ductile or brittle deformations. However, the ratio (I/R)shall not be greater than 1.0.
- Sa/g = Average response acceleration coefficient, in case design spectrum is specifically prepared for a structure at a project site; the same may be used for design at the discretionof the project authorities. For rock and soil sites and based on appropriate natural periods and damping of the structure

<u>**Modelling & Design Model**</u>



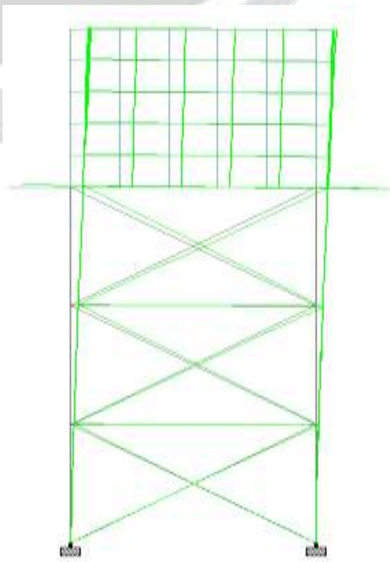


Figure5.3: Without Bracing 10M,

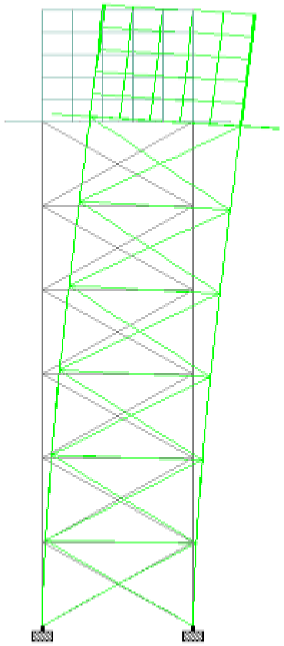


Figure5.2: With Bracing 10M

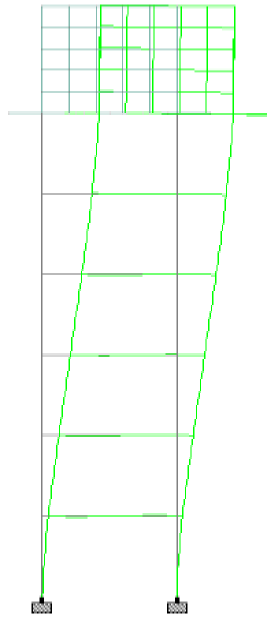


Figure5.4: With Bracing 20M,

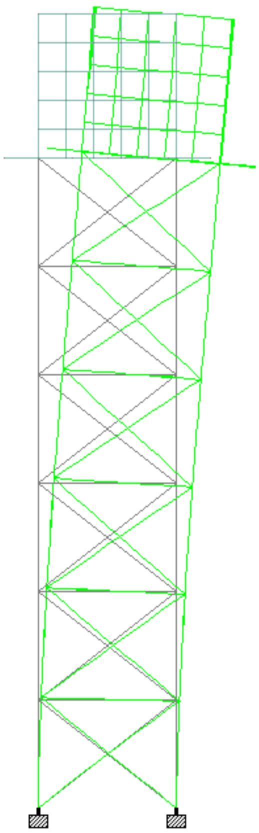
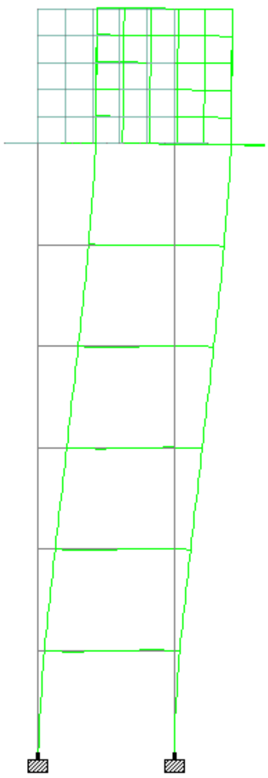
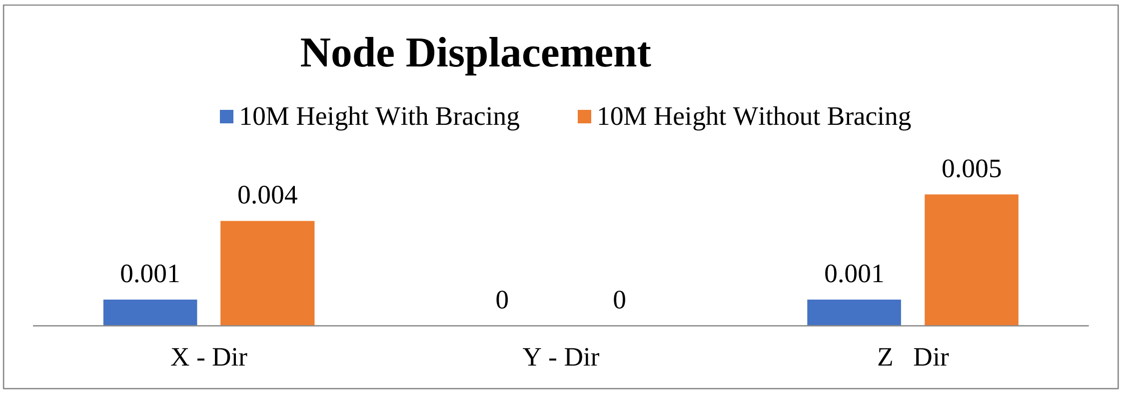


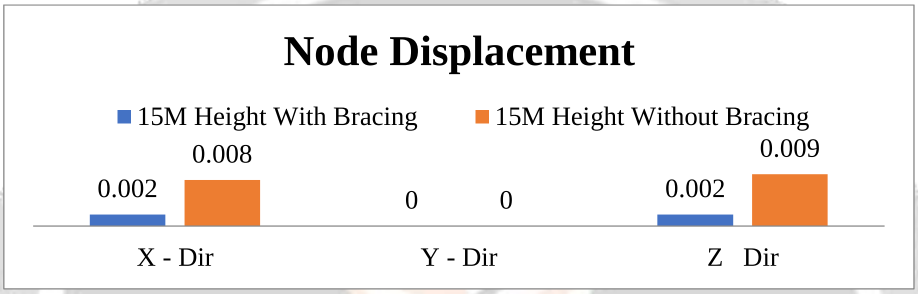
Figure5.5: Without Bracing 20M



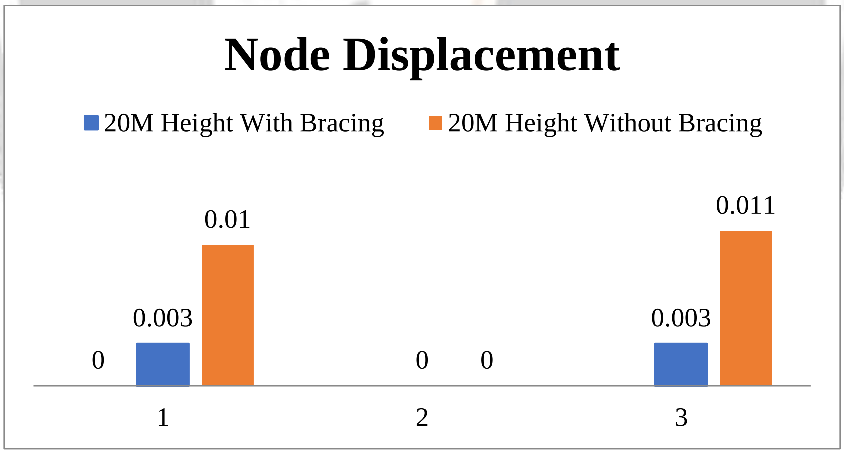
With Bracing 20M, Without Bracing 20M



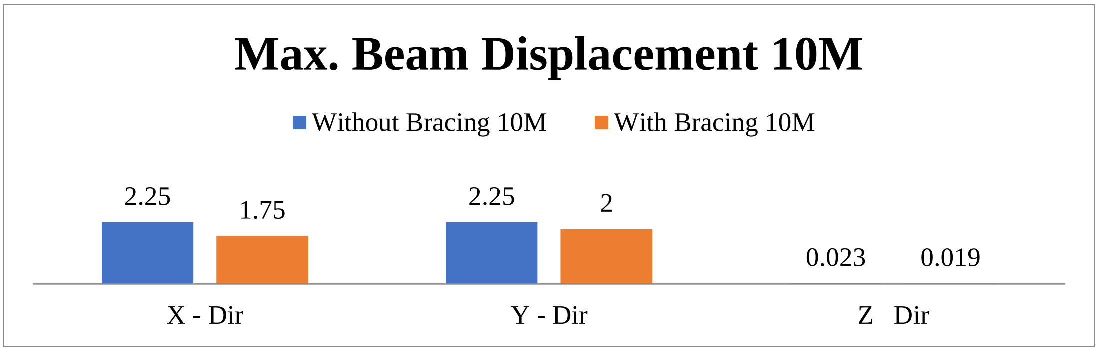
Comparison between Node Displacement of 10M with & without bracing



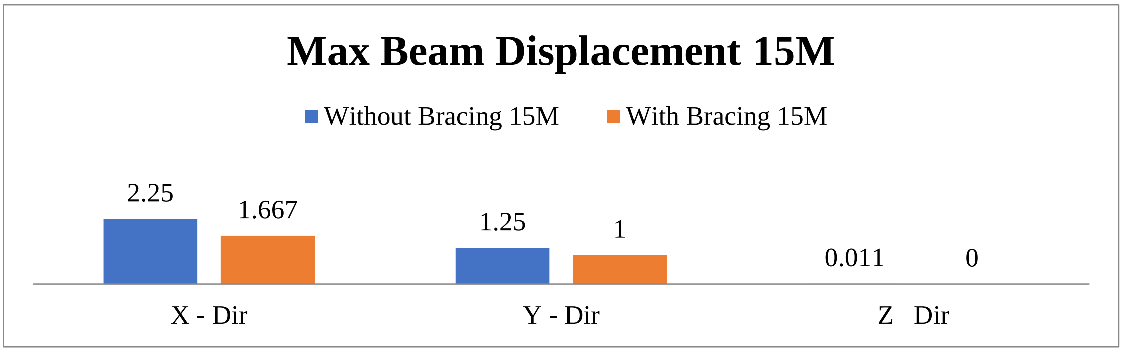
Comparison between Node Displacement of 15M with & without bracing



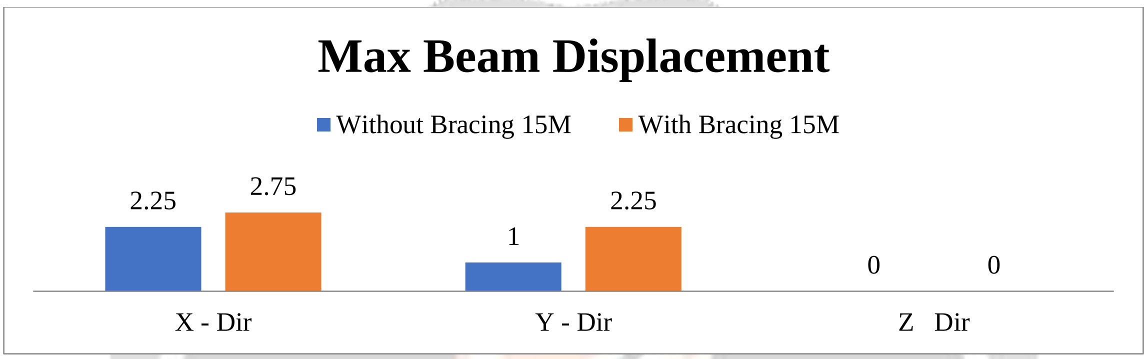
Comparison between Node Displacement of 20M with & without bracing



Comparison between Max Beam Displacement of 10M with & without bracing

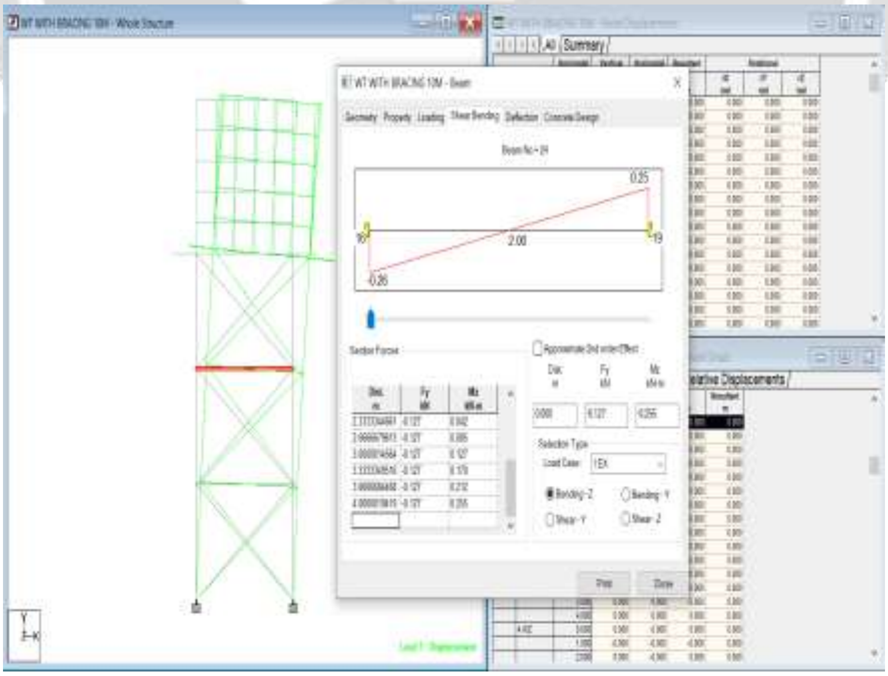


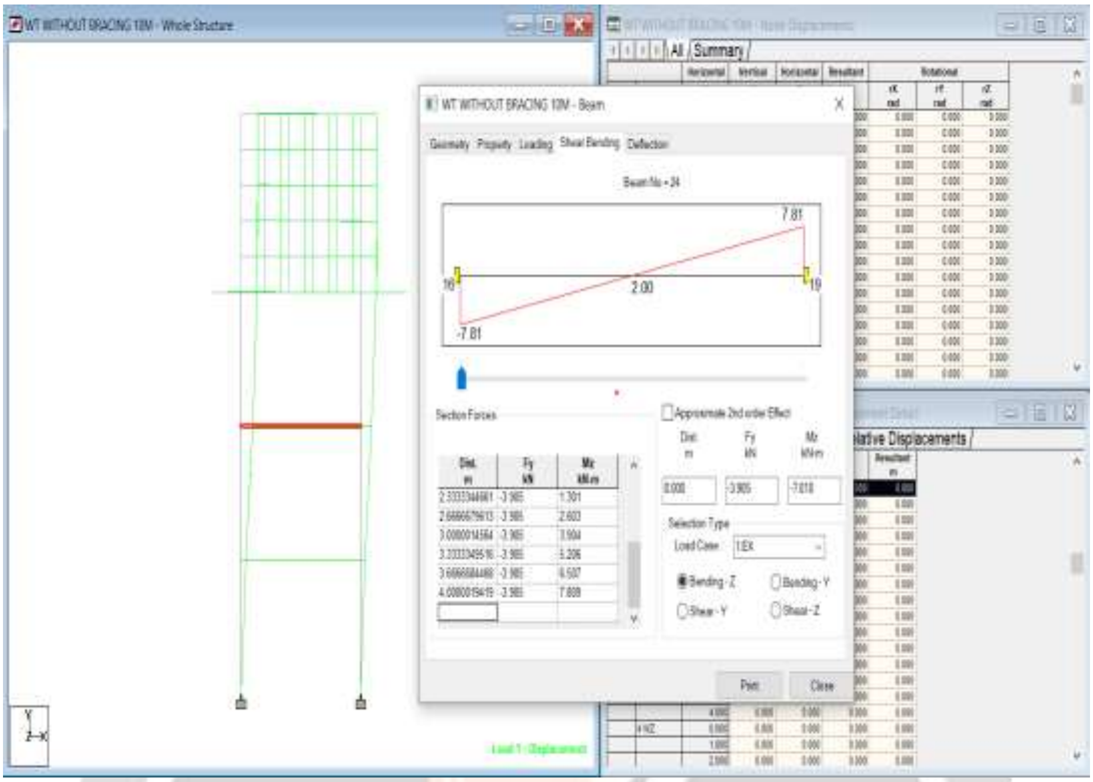
Comparison between Max Beam Displacement of 15M with & without bracing



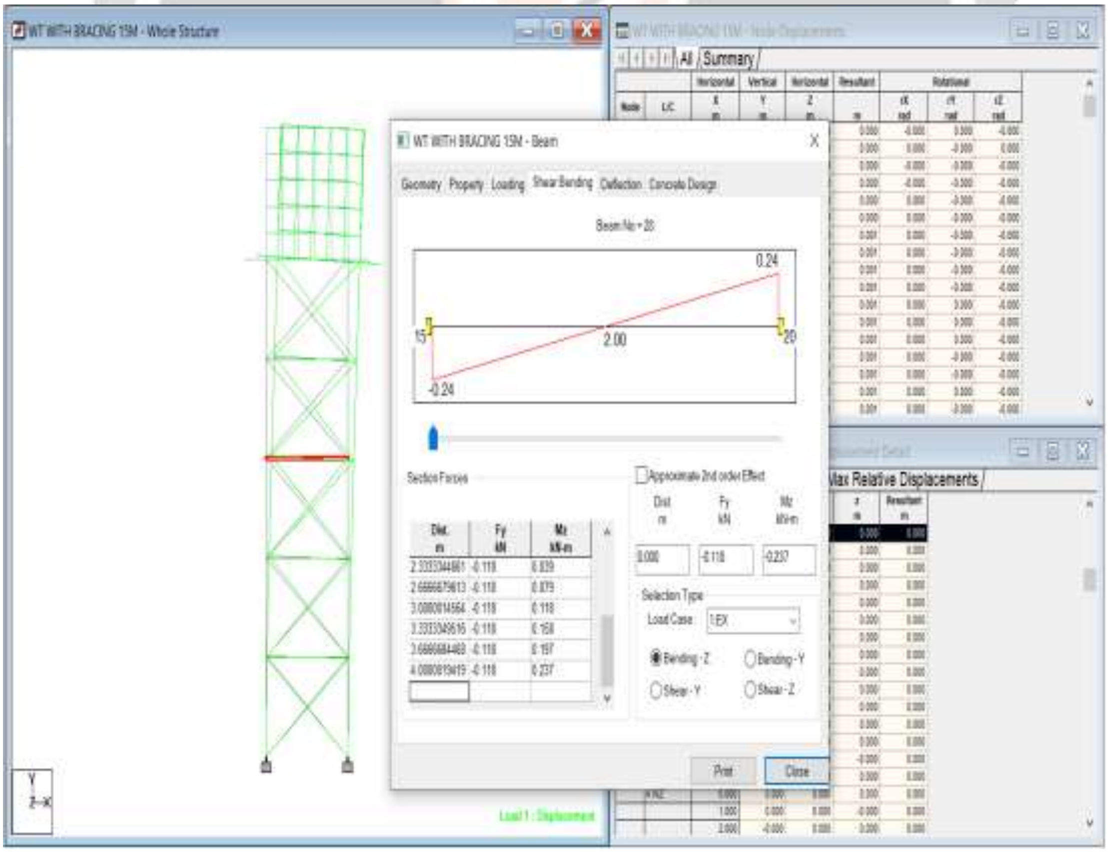
Comparison between Max Beam Displacement of 10M with & without bracing

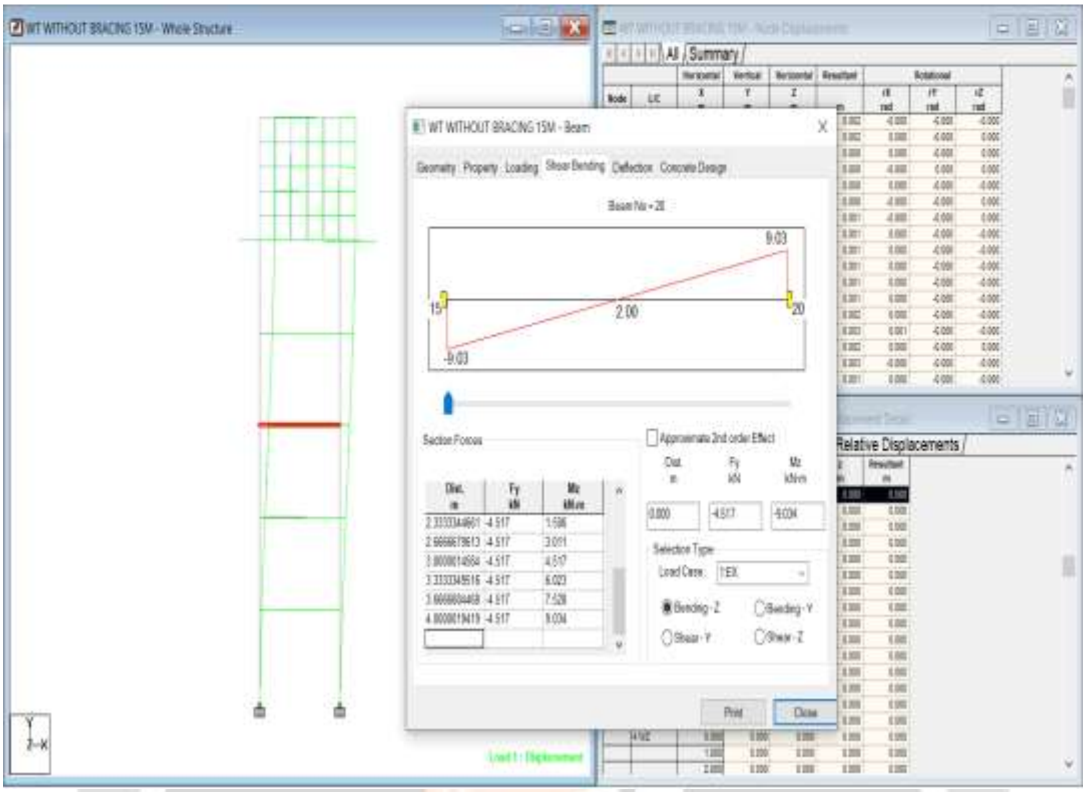
Shear Bending At 10M, 15M, 20M





Shear Bending At 10M





Shear Bending At 15M

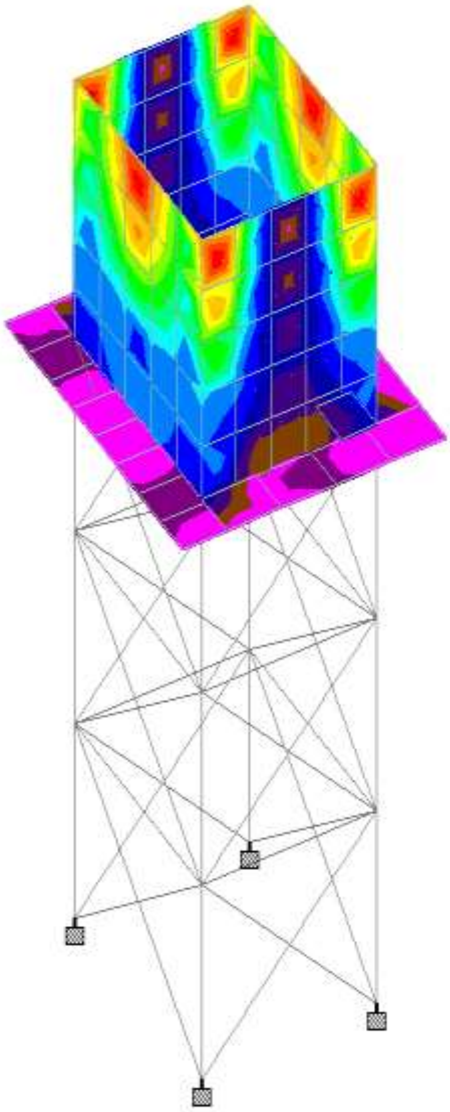
Maximum moments along x-direction and z direction for the Rectangular Tank on different staging heights

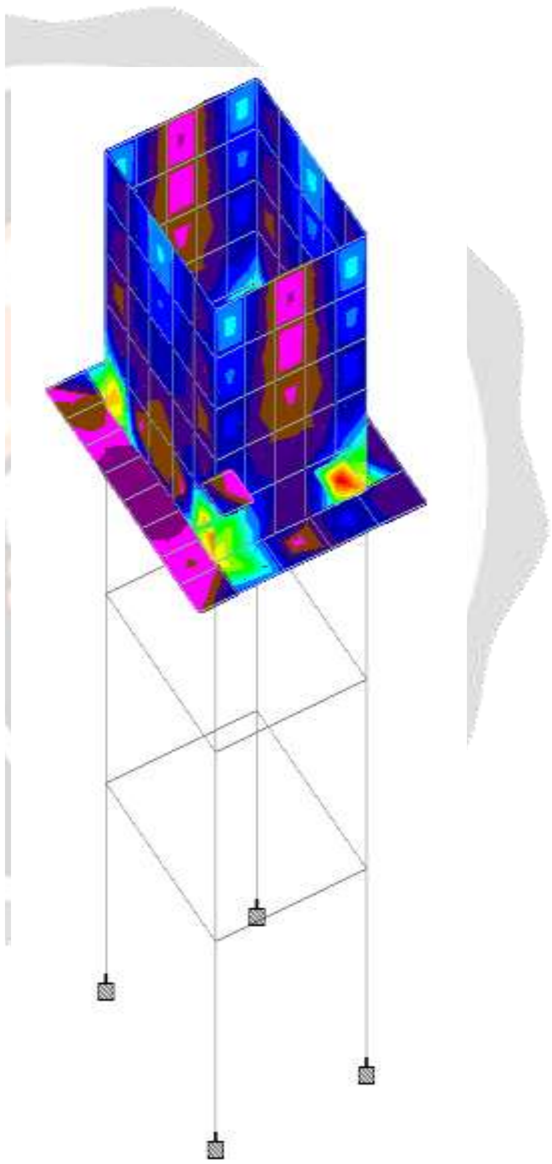
	Max Moment At 10M		**Max Moment At 15M**		**Max Moment At 20M**	
	With Bracing	**Without Bracing**	**With Bracing**	**Without Bracing**	**With Bracing**	**Without Bracing**
Mx	**2.13**	**13.476**	**1.525**	**13.402**	**1.137**	**13.399**
My	**0.058**	**0.009**	**0.108**	**0.001**	**0.055**	**0**
Mz	**1.769**	**12.427**	**1.363**	**12.275**	**1.245**	**12.27**

Max. Base Shear in X & Z Direction

Base Shear KN						
	At 10M		At 15M		At 20M	
	With Bracing	Without Bracing	With Bracing	Without Bracing	With Bracing	Without Bracing
X – Direction	29.742	6.011	32.891	5.817	29.515	5.796
Z - Direction	22.845	6.462	27.735	6.283	22.55	6.263

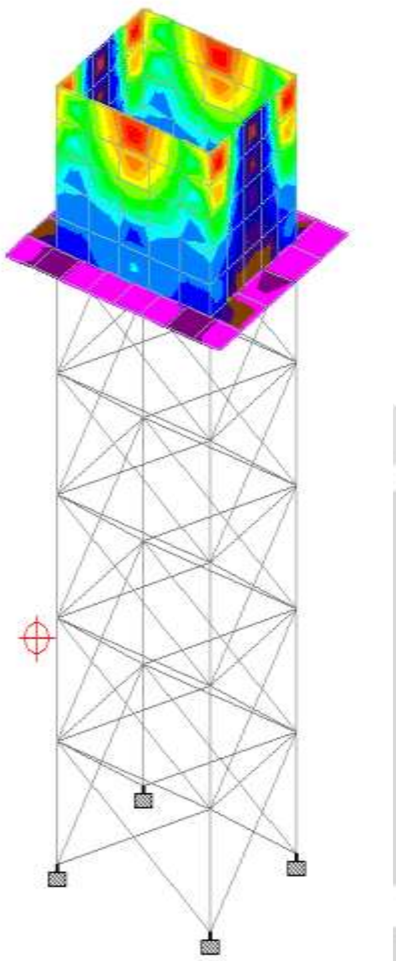
Stresses on Plate with Bracing 10M

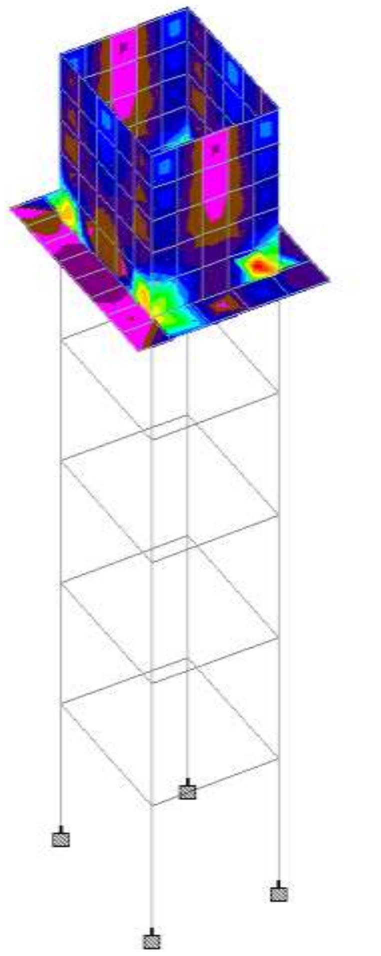




Max. Stress on Plate with Bracing 10M, **Max. Stress on Plate without Bracing 10M**

Stresses on Plate with Bracing 15M





Max. Stress on Plate With Bracing 15M **Max. Stress on Plate Without Bracing 15M**

CONCLUSION

- The maximum moments for rectangular elevated services reservoirs with and without bracing are the increasing along x-direction and z-direction.
- The value of moments goes on increasing as the staging height for the tanks goes on increasing for the same tank capacity.
- Parametric study is carried out by using patterns of bracings in staging of an elevated water tank. From result the base shear value, reduces for bracing pattern in staging. This is apparent because of the reduction of overall stiffness of the structure.
- Cross bracing pattern gives the minimum value of displacement, but from the construction point of view and economy of overall construction, the diagonal bracing pattern can be suggested.

REFERENCES

[1]. Kulvendra patel, Wind and Seismic Analysis of Elevated Water tank using Staad Pro, International Research Journal of Engineering and Technology, e-ISSN: 2395-0056, Volume: 05 Issue: 10 | october-2018.

[2]. Bharat Bhushan Jindal, Dhirendra Singhal, Comparative Study of Design of Water Tank with Reference to IS 3370, Research gate, Conference paper: March 2012.

[3]. N. Krishna Raju, Advanced Reinforced Concrete Design (IS 456-2000), 2nd Edition 2005, CBS Publishers and Distributors Pvt Ltd.

[4]. Gaikwad Madhurar V, Prof. Mangulkar Madhuri N , Comparison between Static and Dynamic Analysis of Elevated Water Tank, International Journal of Scientific & Engineering Research, ISSN 2229-5518, Volume 4, Issue 6, June-2013.

[5]. Prof. Patel Nikunjr, Prof. Jugal Mistry Analysis of Circular Water Tank Stresses Under Hydrostatic Loading by Using Stadd Pro Software, Indian Journal of Research, ISSN - 2250-1991, Volume : 5 | Issue : 9 | September 2016

[6]. Hariteja N., Yogesh Kaushik, Rohit Varma M., Sachin Sharma and Sameer Pathania, Seismic Assessment of Elevated Circular Water Tank, International Journal of Engineering Technology Science and Research, ISSN 2394 – 3386 Volume 3, Issue 5 May 2016.

[7]. IS 3370:1967, IS 3370:2009 Indian Standard concrete structures for storage of liquids. 10. IS 456:2000 Indian standard plain and reinforced concrete

[8]. **Bojja.Devadanam, M K MV Ratnam, Dr.U RangaRaju**- "Effect of Staging Height on the Seismic Performance of RC Elevated WaterTank" vol 4, issue 1, January 2015.

[9]. **Hemishkumar Patel, Prof. Jayeshkumar Pitroda, Dr.K. B.Parikh**-"Analysis of Circular And Rectangular Overhead Water Tank".

[10]. **Prof. Patel Nikunjr, Prof. Jugal Mistry**- "Analysis of Circular Water Tank Stresses under Hydrostatic Loading by Using Stadd Pro Software", vol 5, issue 9, September 2016.

[11]. **Mor Vyankatesh K, More Varsha T**- "Comparative Study on Dynamic Analysis of Elevated Water Tank Frame Staging and Concrete Shaft Supported", volume 14, issue 1 version 1 January 2017.

[12]. **Mayank Gopal Manwani, Deepa P. Telang** – "Review on Seismic Analysis of Elevated Water Tank with Variations of H/D Ratio andContainer Shape", volume 6, issue 5, may 2017