Reliability Analysis of Elevated Circular Water Tank using STAAD Pro

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ABSTRACT: One of the basic elements for survival of life is water, which is only 3% of freshwater available on earth for drinking purpose. Water tank is one of the storage structures used for supplying water based on per capita demand of particular area. There are many types of water tanks based on their shape, location and materials. In this paper, we have mainly focussed on "Elevated Circular Water Tanks" which are most economical when compared to Underground water tanks, rectangular water tanks, etc. We have performed reliability analysis and design of the water tank by using limit state method using Staad pro v8i software by following the Indian Codal Provisions. Some of the loads like Dead load due to self-weight of the structure, Live loads due to hydrostatic load in x & z direction, Plate loads on bottom slab of water tank, Wind loads in x & z direction, Seismic loads based on zone 2 are considered during analysis of model in Staad Pro v8i.

KEYWORDS: Elevated water tank, Reliability analysis, Structural design, Plate loads, Indian Codal Provisions, load combinations, Limit state design method, Staad Pro v8i.

1. INTRODUCTION

Water is vital element for survival of plants, animals, human beings. It is the responsibility of every individual to store the freshwater which is only 3% left on earth. Water storage tanks are one of the structures which serve a community of people/ society. They are classified into three main categories as;

a. Based on Location of water tank – Underground water storage tanks, Water storage tanks resting on ground, Elevated water storage tanks.
b. Based on Shape of water tank – Circular, Rectangular, Square, Intze, Conical.
c. Based on manufacturing materials – Reinforced cement concrete, Plastic, Steel, Precast concrete, Masonry water tank.

Out of all the types, Elevated water storage tanks use the natural force of gravity to pump water based on per capita demand throughout its lifetime by creating pressure at the ground level.

Hence, they are most economical sections than compared to underground water tanks and tanks resting on the ground, etc. These tanks are most commonly used for large-scale communities for storing portable water based on consumption rate. These tanks are designed by various shapes, sizes of beams & columns and materials to provide best economical model with greater durability and stability of the structure.

Reliability analysis of a structure is the probabilistic consistency measure of the structural safety and durability. It gives the idea about total resistance of the structure towards failure based on applied load combinations. It helps to determine the total errors in the model by examining all elements individually.

Indian Standard Codal Provisions used for the design of elevated water storage tanks are;

- IS 3370:2009: (PART 2) – Code of practice for reinforced concrete structures for storage of liquids.
- IS 456:2000 – Code of practice for plain and reinforced concrete structures.
- IS 875-3: (1987) – Code of practice for basic design loads.
- IS 1893-1:2002 – Code of practice for earthquake resistant structures design.

The basic components of elevated circular water tank are as follows;

a. Columns
b. Beams
c. Bracings
d. Top and Bottom Dome structure
e. Bottom slab
f. Cylindrical walls
g. Top and Bottom ring beam

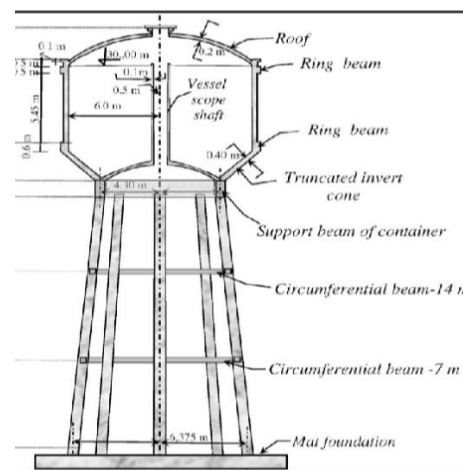**Fig:1-** Elevated Circular Water Storage tank

Fig:2- Line diagram of Water tank

LITERATURE REVIEW

1. **Design and Analysis of underground water tank by using Staad Pro** - By Komal K Wagh1, Akshay K Ghuge2, Deepak N Gaidhane3, Gajendra R Gandhe4- Volume: 08 Issue: 04 | Apr 2021 IRJET

- The project was aimed on the analysis and design of underground water tank. In this paper, we had discussed about the design of underground water tank of rectangular shape are Designed and analysed using Staad pro.

2. **Design, Analysis and Comparison of Underground Rectangular water tank by using STAAD Provi8 software –** By 1 Issar Kapadia, 2Purav Patel, 3NileshDholiya, 4Nikunj Patel- Volume 2: Issue- January 2017 IJSDR

- The paper includes the study of UG Rectangular tank that how the shape deflected and what are the actions will be produced when tank empty or full by using STAAD Pro software that discussed.

3. **ANALYSIS AND DESIGN OF ELEVATED RCC WATER TANK –** By-KARANVIR SINGH RANA and KUNDAN KUMAR – Volume-May-2015

- Rectangular water tanks are economical for smaller capacities. However, cylindrical or Intze tanks might be more economical and a viable choice in case of larger capacities.

4. **Design and Analysis of Elevated Water Tank –** By- Tejaswini, Mamatha Volume: 07 Issue: 08 | Aug 2020 IRJET
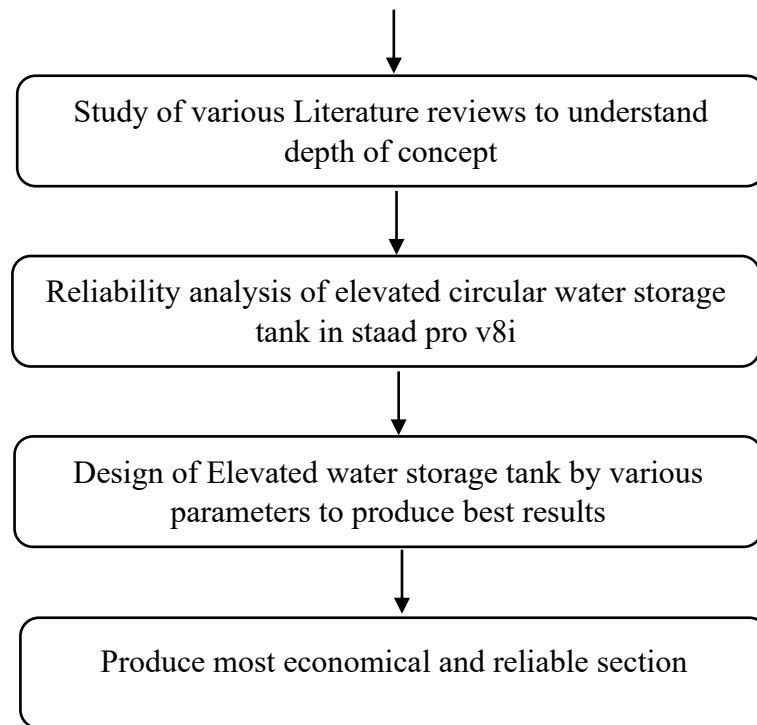
- In this method the structure is first designed under limit state of collapse, then checked under serviceability. IS3370:2009 adopts limit state design.

Highlights

- ➢ To understand the basic concept and working principle behind water tanks.
- ➢ To design most economical, durable water tank by Limit State Method.
- ➢ To study of various codal provisions for design of water storage structures.
- ➢ To perform Reliability analysis on elevated circular water storage tank by using Staad pro v8i software.
- ➢ To design the elevated water storage tank by limit state method to produce most economical structure with greater lifetime.

METHODOLOGY

> Understanding basic principle behind working of elevated water storage tank

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                    ┌─────────────────────────────────────┐
                    │ Study of various Literature reviews  │
                    │ to understand depth of concept       │
                    └─────────────────────────────────────┘
                                      │
                                      ▼
                    ┌─────────────────────────────────────┐
                    │ Reliability analysis of elevated     │
                    │ circular water storage tank in       │
                    │ staad pro v8i                        │
                    └─────────────────────────────────────┘
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                    ┌─────────────────────────────────────┐
                    │ Design of Elevated water storage     │
                    │ tank by various parameters to        │
                    │ produce best results                 │
                    └─────────────────────────────────────┘
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                    ┌─────────────────────────────────────┐
                    │ Produce most economical and          │
                    │ reliable section                     │
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Fig:3- Flow chart of methodology

MODEL DESCRIPTION

The model considered in the paper is "Elevated Circular water storage tank" of maximum capacity of 3.5 litres with the following parameters;

Table:1- Description of the Model

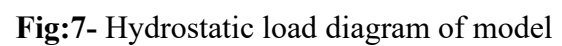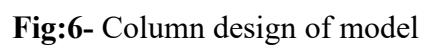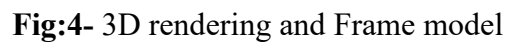| Particulars	Dimensions	Particulars	Dimensions
Thickness of wall	150mm	Plate thickness	150mm
Diameter of tank	10m	Column size	650mm*500mm
Height of tank	5m	Beam size	500mm*500mm
No. of Columns	8	Bracing size	500mm*500mm
Slab thickness	180mm	Zone	0.16
Top dome rise	5.013	Response factor	3
Dome thickness	0.15	Important factor	1
Wind type	Type 1	Damping ratio	0.05
Top ring beam size	500mm*500mm	Free board	500mm

Design Steps for Analysis and Design of Elevated Circular water Storage tank

The following given below are the steps to be followed to perform analysis and design of elevated circular water storage tank in Staad Pro v8i pro software;

    i.   Open Staad pro v8i software → Enter name and Select file location path →

    ii.   Select units → Click on Add Beam → Enter

iii. Click on Geometry → Run Structural Wizard → Select Frame models → Select Reverse Cylindrical model → Enter dimensions of the model → Paste the prototype model in staad pro v8i software

iv. Select View → Select Snap node beam → Click on Geometry → Run Structural wizard → Select Frame models → Click on circular beam → Move prototype model → Enter y axis length in staad pro v8i

v. Add 4 node plate to one bay → Select plate by clicking on 3d circular plate

vi. Enter no. of steps → Select top circular plate by placing section in front view

vii. Generating Surface meshing → Select all nodes

viii. Produce Surface/Plate models by run structural wizard → Move prototype model → Display node to node distance → Move entities

ix. Go to General → Select Properties → Define section

x. Assign plate element thickness → Assign Beams and Columns → Assign by missing attributes → By Missing property to selected all members

xi. Go to Supports → Select fixed support → Assign to selected nodes

xii. Go to Loads & Definitions → Add load cases → Select primary load and assign Dead Load with self-weight factor as 1.

xiii. Add live load as hydrostatic load with min. intensity of 40 kn/m^2 and plate/element load on thickness of plate/slab

xiv. Add Seismic loads as per Codal Provisions IS 1898-2002/2005 part 4 as per intensity zone 2 of Visakhapatnam area

xv. Add wind loads as per type 1wind load with wind load intensity ranging from 1.25 to 1.61 kn/m^2 intensity from height 0m to 34.29m respectively

xvi. Assign all the load definitions to the structure by assign to view

xvii. Click on analysis & print → Add data → Perform run analysis

xviii. Go to Post processing mode → Click on design of model → Select Indian Codes as IS 456:2000

xix. Define parameters → Add Characteristic Strength of concrete → Add Ultimate tensile strength of Steel

xx. Add parameters → Add Plate thickness → Add Concrete Take off

xxi. Assign to View the parameters → Click on Analysis & print → Add data → Perform run analysis

xxii. View output file → Go to Post processing mode for 3d rendering view, Shear force diagram, bending moment diagram, deflection diagram, etc.
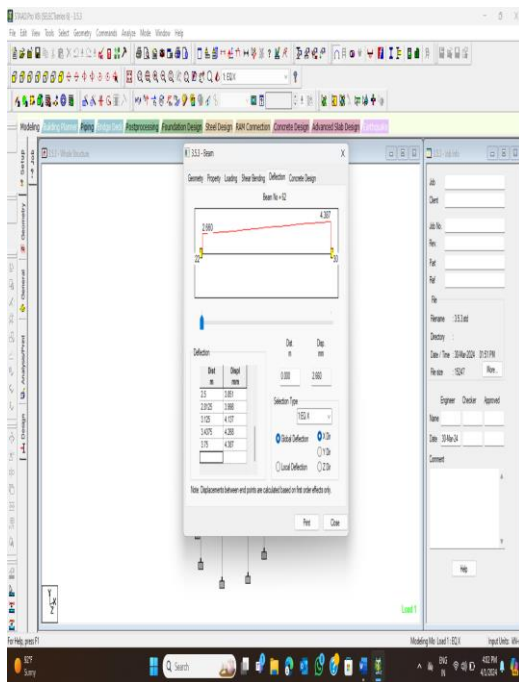
Results

Fig:4- 3D rendering and Frame model

Fig:5- Beam Design of model

Fig:6- Column design of model

Fig:7- Hydrostatic load diagram of model
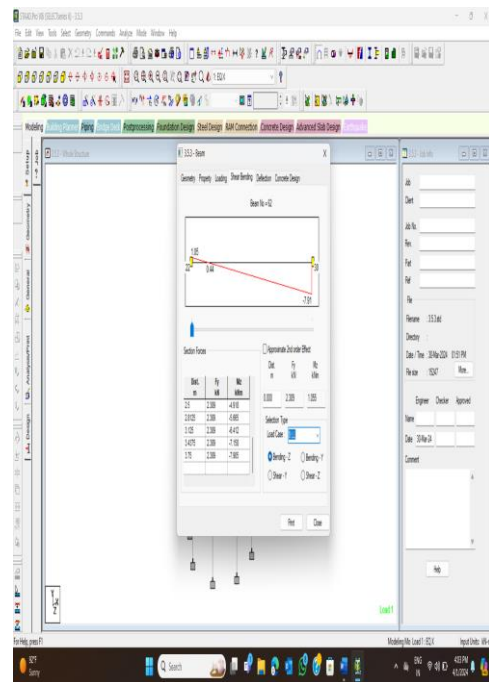
Fig:8- Column design of model

Fig:9- Hydrostatic load diagram of model

Conclusions

1. In comparison to underground water storage tanks, Elevated water storage tanks are most economical since they do not require pumps to supply the water.
2. Rectangular tanks are simple in design but cylindrical tanks are difficult to design.
3. Circular water storage tanks are more reliable than compared to other shapes in terms of capacity of the water tank.
4. Elevated Circular water tanks are most suitable for greater capacities and to supply water to large society or community.
5. We have successfully performed reliability analysis of elevated circular water storage tank in staad pro v8i with maximum capacity of 3,50,000 litres.
6. We have achieved the design of elevated circular water storage tanks as per limit state design by Indian codal provisions.
7. Most Economical and Reliable elevated circular water storage tank is produced.

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2) https://r.search.yahoo.com/_ylt=AwrPrLaT_QJmd88Sw2K7HAx.;_ylu=Y29sbwNzZz MEcG9zAzEEdnRpZAMEc2VjA3Ny/RV=2/RE=1711500820/RO=10/RU=https%3a %2f%2flaw.resource.org%2fpub%2fin%2fbis%2fS03%2fis.3370.1.2009.pdf/RK=2/R S=PnKN1m2Agi6KcQqPSDoPMOQjs4w- IS 3370-1:2009 – Code of Practice for Concrete Structures for storage of liquids
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