A Comparative Study in The Analysis and Design of Intz Type Water Tank Using Staad.Pro and Manual Design Approches

Seema Afroz[1], E. Lali[2], Udaya Kumar[3], Vijay Kumar B[4], Prof. Vishwa B T[5]
[1,2,3,4] *B.E 4th year students, Department of Civil Engineering, Navodaya Institute of Technology, Raichur, Karnataka, India*
[5] *Asst. Professor (Guide), Department of Civil Engineering, Navodaya Institute of Technology, Raichur, Karnataka, India*

***Abstract*—Water is necessary for all living beings to live. In locations where water is scarce, water provision is critical. Water is stored in tanks and later supplied based on demand. These water tanks are built to fulfill the needs of public. These tanks are constructed in number of shapes, sizes and various heights. Water storage is essential for meeting municipal, industrial and emergency demands. This project focuses on the comparative analysis and design of a RCC Intz-type elevated water tank using manual calculations and STAAD.Pro software by applying the Working Stress Method to ensure safety, reliability and compliance with IS codes. Manual design is time-consuming compared to the efficient, precise and faster process offered by STAAD.Pro. Key structural components including beams, columns, bracings, cylindrical walls and conical sections are analyzed under various loads such as dead load, live load and hydrostatic pressure with both methods confirming safety against shear, bending and deflection. STAAD.Pro optimizes structural elements, reduces material usage, facilitates the modeling of complex geometries and load combinations. It also makes the design process more economical especially in terms of steel reinforcement without compromising structural integrity. Overall STAAD.Pro significantly enhances the accuracy, efficiency and reliability of RCC Intz-type water tank design establishing itself as a preferred tool for modern structural engineering applications.**

***Index Terms*—STAAD.Pro software, RCC Intz-type tank, Analyzing, Designing, Working Stress Method, Hydrostatic pressure.**

I. INTRODUCTION

Water storage is a fundamental necessity for municipal, industrial and emergency applications, ensuring a continuous and controlled supply in regions with varying demand patterns. Elevated water tanks play a crucial role in maintaining water pressure for efficient distribution. Among different types, the Intz-type elevated water tank is widely used due to its structural stability, efficient load transfer and economical design.

An Intz-type water tank consists of a cylindrical body with a conical base and dome roof, supported by columns and braces. This unique shape allows it to withstand hydrostatic pressure, reduce material usage and enhance durability. The foundation, girder beams and braces further contribute to its stability against wind and seismic forces.

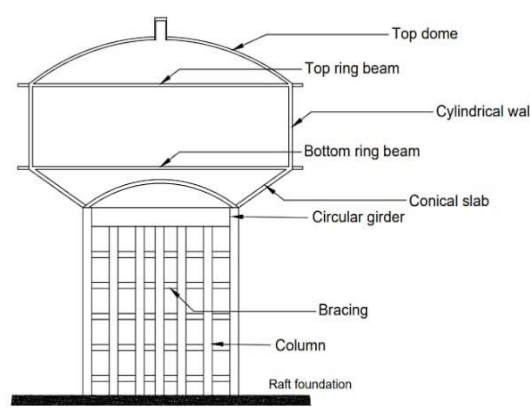

Fig 1.1: Components of an Intz-Type Water Tank

Traditionally, the design of water tanks has been carried out using manual calculations based on IS codes. However, advancements in structural analysis software, such as STAAD.Pro, have enabled automated, precise and optimized designs, significantly reducing time and effort. While manual design remains essential for understanding structural behavior and fundamental principles, software-based methods offer greater accuracy, efficiency and material optimization.

This study presents a comparative analysis of an Intz-type elevated water tank designed using both manual calculations and STAAD.Pro. The objective is to evaluate the accuracy, efficiency and cost-effectiveness of each method while ensuring compliance with IS codes and structural safety requirements. The results aim to highlight the most effective approach for designing economical and structurally sound water tanks.

1.1. Classifications

Classification based on under three heads:

1) Tanks resting on ground
2) Elevated tanks supported on staging
3) Underground Tanks.

Classification based on shapes:

1) Circular Tanks.
2) Rectangular Tanks.
3) Spherical Tanks.
4) Intz Tanks.
5) Circular tanks with conical bottom

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II. LITERATURE REVIEW

2.1 Mainak Ghosal et al: Designed an elevated circular water tank using STAAD.Pro V8i with the Limit State Design methodology, analyzing dead, hydrostatic and wind loads per IS 456:2000. A 3D model was developed, validating stresses and deflections under low seismic conditions (Zone II) to ensure sufficient storage capacity for growing populations.

2.2 Er. Venkata Raju Badanapuri et al: Analyzed an 800m³ Intz-type tank using STAAD.Pro, considering M30 concrete, Fe-415 steel, and IS:3370-1965, IS:456-2000 standards. Seismic analysis for Zones III and IV was conducted per IS 1893-2002, evaluating structural stability, shear forces and axial loads while optimizing material usage.

2.3 Prakash Mahdewa et al: Compared manual and STAAD.Pro-based designs for a 150,000L circular RCC water tank using Limit State Method (LSM). The software-based approach proved more efficient, reducing material consumption and improving seismic and wind load performance.

2.4 Roshan Kumar Pakhale et al: Designed an elevated Intz tank using STAAD.Pro, focusing on municipal demand, seismic resistance, and structural efficiency. The study emphasized the importance of wind and seismic forces in disaster-prone areas, validating results with manual calculations.

2.5 Sharanabasappa Karur et al: Compared manual and software-based designs for a 200,000L elevated circular tank. STAAD.Pro analysis required less steel and was 10% more time-efficient, ensuring optimal design for future water demands.

III. OBJECTIVES

1. To evaluate the tank's ability to withstand various loads (dead and live or hydrostatic load).
2. To analyse stresses and deflections under different loading conditions.
3. To check compliance with design codes, standards, and regulations
4. To optimize tank size and shape or balance storage capacity and space constraints.
5. To compare the results obtained from STAAD.Pro with manual method.

IV. METHODOLOGY

To achieve the objectives of the study that is to analyze and design water tank using STADD PRO method, which meets the basic requirements such as safety, durability, it has been proposed to follow the following methodology.

4.1 The study is done in two phases

1) Planning
2) Designing

4.1.1 Planning

4.1.1.1 Sources of Water Supply

The various sources of water can be classified into two categories –

Surface sources, such as:

1) Ponds and lakes.
2) Streams and rivers.
3) Storage reservoirs.
4) Oceans, generally not used for water supplies, at present.

Sub-surface sources or underground sources:
1) Springs.
2) Infiltration wells and
3) Wells and Tube-wells.

4.1.1.2 Water Quantity Estimation
1) The quantity of water required for municipal uses for which the water supply scheme has to be designed requires following data:
2) Water consumption rate (Per Capita Demand in liters per day per head) Population to observed.
3) Quantity = per demand x Population

4.1.1.3 Water Consumption Rate
It is very difficult to precisely assess the quantity of water demanded by the public, since there are many variable factors affecting water consumption. various types of water demand, which a city may have to fulfill.

4.1.1.4 Factors affecting per capita demand:
Size of the city: Per capita demand for big cities is generally large as compared to that for smaller towns as big cities have skewered houses.
1) Presence of industries.
2) Climatic conditions.
3) Habits of economic status.
4) Quality of water: If water is aesthetically people and their
5) Medically safe, the consumption will increase as people will not resort to private wells, etc.
6) Pressure in the distribution system.
7) Efficiency of water works administration: Leaks in water mains and services; and UN authorized use of water can be kept to a minimum by surveys.
8) Cost of water.
Policy of metering and charging method: Water tax is charged in two different ways: On the basis of meter reading and on the basis of certain fixed monthly rate.

4.1.1.5 Fluctuations in Rate of Demand:
Average Daily per Capita Demand =Quantity Required in 12 Months/(365xPopulation) If this average demand is supplying data the times, it will not be sufficient to meet the fluctuations.
- Seasonal variation: The demand peaks during summer, Fire, breakouts are generally more in summer, increasing demand So, there is seasonal variation.
- Daily variation: depends on the activity. People draw out more water on Sundays and Festival days, thus increasing demand on these days.
- Hourly variations: are very important as they have a wide range. During active household working hours i.e. from six to ten in the morning and four to eight in the evening, the bulk of the daily requirement is taken. During other hours the requirement is negligible. Moreover, if a fire breaks out, a huge quantity of water is required to be supplied during short duration, necessitating the need for a maximum rate of hourly supply.

So, an adequate quantity of water must be available to meet the peak demand. To meet all the fluctuations, the supply pipes, service reservoirs and distribution pipes must be properly proportioned. The water is supplied by pumping directly and the pumps and distribution system must be designed to meet the peak demand. The effect of monthly variation influences the design of storage reservoirs and the hourly variations influences the design of pumps and service reservoirs. As the population decreases, the fluctuation rate increases.
Maximum daily demand = 1.8 x average daily demand Maximum hourly demand of maximum day i.e. Peak demand
=1.5 x average hourly demand
=1.5 x Maximum daily demand/24
=1.5 x (1.8 x average daily demand)/24
=2.7 x average daily demand/24
=2.7 x annual average hourly demand

4.1.1.6 Design Periods & Population Forecast
This quantity should be worked out with due provision for the estimated requirements of the future. The future period for which a provision is made in the water supply scheme is known as the design period. Design period is estimated based on the following:

- Use fulfils of the component, considering obsolescence, wear, tear, etc.
- Expandability aspect.
- Anticipated rate of growth of population, including industrial, commercial developments & migrationimmigration.
- Available sources.
- Performance of the system during initial period.

4.1.1.7 Population Forecasting Methods

The various methods adopted for estimating future populations are given below. The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discretion and intelligence of the designer.

1) Incremental Increase Method
2) Decreasing Rate of Growth Method
3) Simple Graphical Method
4) Comparative Graphical Method
5) Ratio Method
6) Logistic Curve Method
7) Arithmetic Increase Method
8) Geometric Increase Method.

"Population forecasting according to census of bijanagera village population data"

Using the Arithmetic Increase Method:

Step – 1: Projected population increase in 20 years

The formula is

$$p_n = p_0 + n \times x$$

- $p_0 = 4500$ (Present population in 2024)
- n = 2 decades (20 years)
- x = 500 (population increase per decades)

$$p_{2044} = p_{2024} + n \times x = 4500 + 2 \times 500 = 5500$$

Increase in population in 20 years

5500 - 4500 = 1000

Step 2: Total Water Requirement per Day

Each person requires 135 liters/day.

For: p_{2044} = 5500

Water requirement per day = 5500 × 135 = 7,42,500 liters/day (0.743 million liters/day).

Step 3: Adding Extra Capacity

To account for additional growth or future requirements, and provisions for animal use and farming purposes, we add 0.257million liters to the base capacity:

Total tank capacity = 0.743 million liters + 0.257 million liters

Total tank capacity = 1.0 million liters (1,000,000 liters)

∴ Water tank capacity needed: 1,000,000 liters.

4.1.1.8 Pipeline Distribution Network

Pipeline distribution networks are aimed at design of suitable routes for piping. It is very important for proper water pressure, capital cost and operation and maintenance cost. Different types of networks are adopted looking to the pressure requirement, operation and maintenance strategy adopted, cost parameter and overall length of distribution system

- Dead end distribution system
- Grid Iron System
- Ring System
- Radial System

4.1.2 Designing

4.1.2.1 Staging Portion

1) Columns & Braces

 Columns - These are to be designed for the total load transferred to them. The columns will be braced at intervals and have to be designed for wind pressure and seismic loads whichever govern.

 Braces-The braces are the members connecting the columns at intermediate height of columns. It is provided in slender columns to increase the column's load carrying capacity.

2) Foundation - As per IS: 11682-1985, a combined footing or raft footing with or without tie beam or raft foundation should be provided for all supporting columns

4.2 Flow Chart of Methodology

1. Literature Review.
2. Study About Conditions of Water Tank.
3. Data Collection.
4. Analysis & Design of Water Tank by Manually.
5. Analysis & Design of Water Tank by STAAD.Pro Software.
6. Comparative Statement & Model Output
7. Results & Discussions.

4.3 Data Collection

- We conducted a survey in the village of Bijanagera, Raichur District, and found that the existing water tank is non-functional and under repair.
- The village has a population of approximately 4,500 with an average daily water requirement of 135 liters per person.
- Considering that the population could double in the coming decades, the village requires a water supply of around 10,00,000 liters to meet current and future demands.
- To address this need and accommodate population growth, we propose designing a new water tank.

Photograph of Existing Water Tank

4.4 Analysis & Design of Water Tank by Manually

For larger capacity of overhead tanks, flat bottom circular tanks become uneconomical, since thickness of slab required increase considerably. In such cases intz tanks are more economical.

4.4.1 Design Principles of Various Elements

Membrane theory is the easiest method for the analysis of various structural elements. However since all joints are rigid continuity analysis of joints is required which involves expressions of defection and rotations of circular beams and shells.

(i) Design of top dome: Its rise may be kept 1/7th of diameter of cylindrical wall and usually 75 mm thickness is sufficient. However, if environmental conditions require more thickness, one a can think of providing even 100 mm thickness.

(ii) Design of top ring beam (A-A): In case of larger tanks, it is economical to support circular base slab with a ring beam.

(iii) Cylindrical wall: It is designed for hoop tension and is provided with 0.3% reinforcement in vertical direction.

(iv) Bottom ring beam (beam B-B): Total weight of roof, top ring beam and side wall be V per metre rum.

(v) Conical dome: This is subjected to meridional thrust as well as hoop tension.

(vi) Bottom spherical dome: It is designed for meridional and circumferential forces due to weight of water and self weight

(vii) Bottom ring girder: The ring girder is to be designed for this superimposed load. The various elements of Intz tank may be designed for the membrane forces.

4.4.2 Manual design

1. Dimensions

- Capacity of tank = 10,00,000 liters = 1000m$^{3.}$
- Diameter of cylindrical portion **(**D) =14 m
- Rise of top dome, $(h_1 = \frac{1}{7}\text{D}) = 2$ m
- Height of cylindrical tank, $(h_2 = 0.4\text{D}) = 5.6$ m
- Height of conical dome, $(h_3 = 0.2\text{D}) = 2.8$ m
- Rise of bottom spherical dome, $(h_4 = \frac{1}{7}\text{D}) =$ 2 m
- Diameter of bottom circular girder, $(\text{D}_1 = 0.6\text{D}) = 8.4$ m

4.5 ANALYSIS AND DESIGN OF WATER TANK BY STAAD.Pro

Analysing and designing a water tank in STAAD.Pro involves multiple steps, from setting up the structural model to performing load analysis and design according to applicable codes. Below is a general outline of the process for designing a water tank.

4.5.1 PROCEDURE FOR ANALYSIS AND DESIGNING OF INTZ TYPE WATER TANK BY STAAD.Pro

- Step 1: Create a New Project: Open STAAD.Pro, select "Analytical Model," and set the unit system. Name the project and choose a working directory.
- Step 2: Define Geometry: Navigate to Geometry > Run Structure Wizard, select Models > Tank, and choose the Intz Tank template. Input tank dimensions, including dome, cylindrical wall, and ring beam properties, along with staging details (columns, braces).
- Step 3: Assign Material Properties: Define materials as per IS 456 (M30 concrete, Fe500 steel). Assign thickness for plate elements and cross-section properties for beams and columns.
- Step 4: Apply Supports: Assign fixed supports to staging columns. Modify as needed for pile-supported tanks.
- Step 5: Apply Loads: Define dead loads (self-weight), hydrostatic pressure, live loads, and wind loads per IS 875 (Part 3). Create relevant load combinations such as 1.5(DL + LL) and 1.2(DL + WL + EQX).

- Step 6: Perform Analysis: Run structural analysis to check reactions, deflections, and stresses. Ensure compliance with permissible limits.
- Step 7: Design Components: Use RCC design tools in STAAD.Pro for cylindrical walls, domes, ring beams, columns, and braces. Ensure structural stability under axial, bending, and lateral forces.
- Step 8: Validate and Optimize: Review results, verify stresses and deflections, and optimize material usage for cost efficiency.
- Step 9: Documentation: Generate a report with input data, load cases, design details, and foundation reactions for further structural detailing.
- This systematic approach ensures efficient modeling, analysis, and design of an Intz-type water tank.

4.5.2 DATA USING FOR MODELING, ANALYZING AND DESIGNING OF INTZ TYPE WATER TANK IN STAAD.Pro

Assuming Data:

- Capacity of water tank 10,00,000 Liters
- Staging height of water tank 9 m
- Diameter of Cylindrical wall (D) 14.00 m and Height 5.6 m
- Diameter of bottom girder 8.4 m
- Rise of Top dom 2.00 m
- Rise of Conical dom 2.8 m
- Thickness of Conical dom 0.3 m
- Thickness of Top dom 0.075 m
- Thickness of Bottom dom 0.25 m
- Thickness of Cylindrical wall 0.275 m
- Girder Ring beam 0.6 x 1.2 m
- Top Ring beam 0.4 x 0.3 m
- Bottom Ring beam 1.2 x 0.6 m
- Circular column size 0.650 m
- Bracing size 0.55 x 0.55 m.

4.5.3 Geometry of water tank

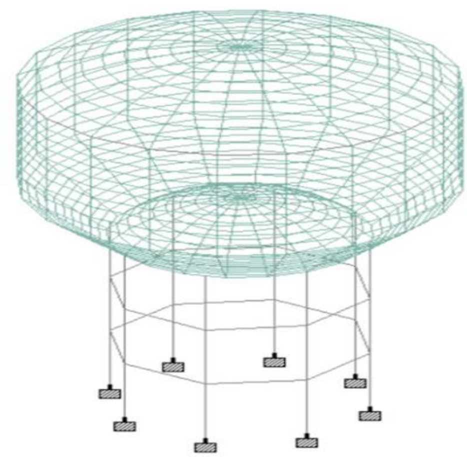

Fig 4.5.3.1: Wired water tank with supports

4.5.4 Assigning of material properties

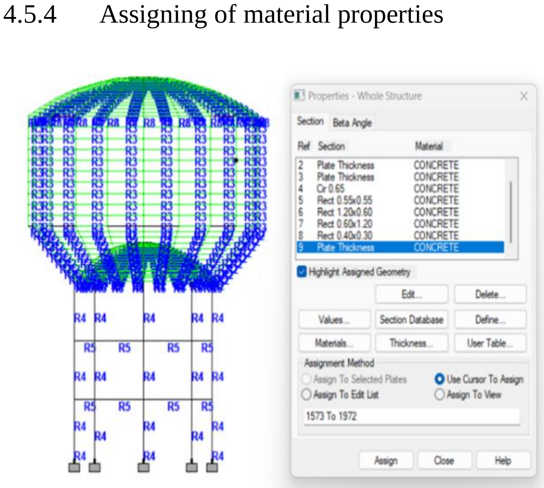

Fig 4.5.4.1: Assigning material properties

4.5.5 Design of column

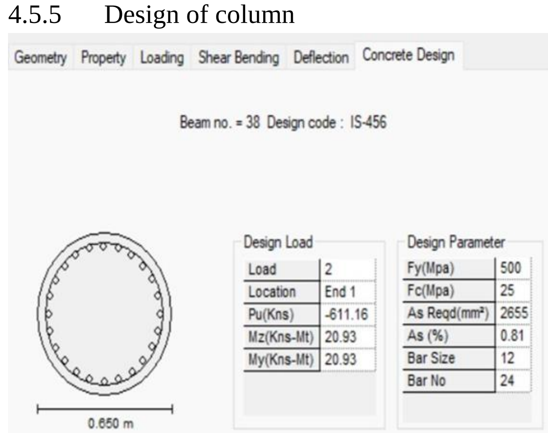

Fig 4.5.5.1: Design of column

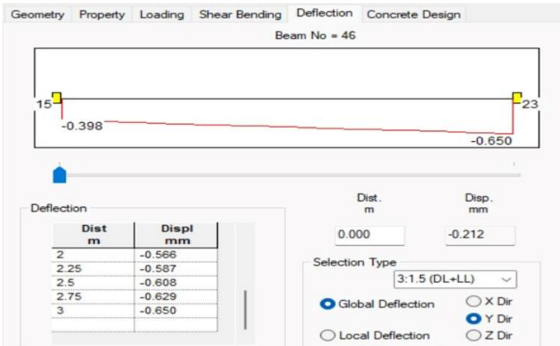

Fig 4.5.5.2: Deflection of column

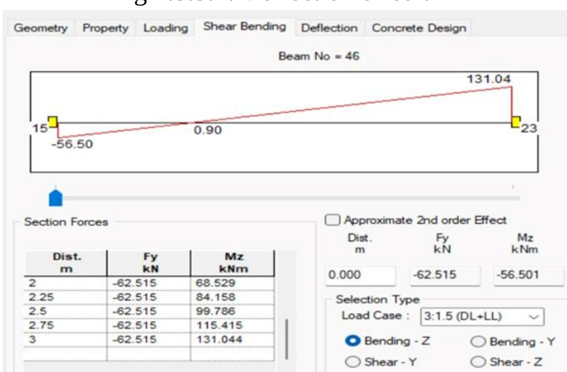

Fig 4.5.5.3: Shear bending of column

4.5.6 Design of beam

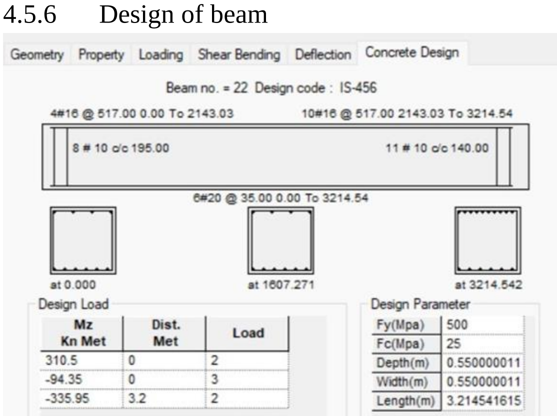

Fig 4.5.6.1: design of beam

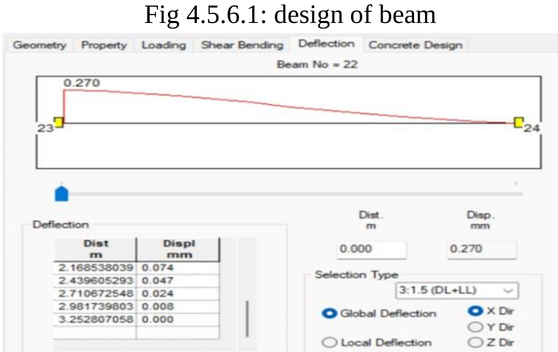

Fig 4.5.6.2: Deflection of beam

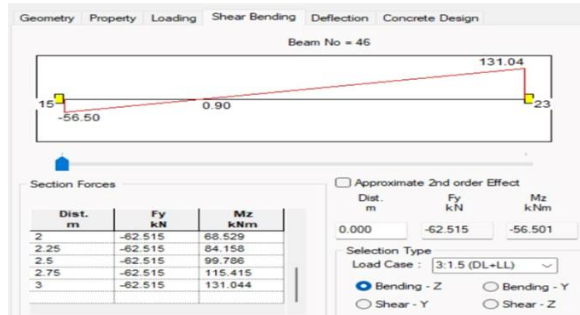

Fig 4.5.6.3: Shear bending of beam

4.5.7 Stresses on water tank

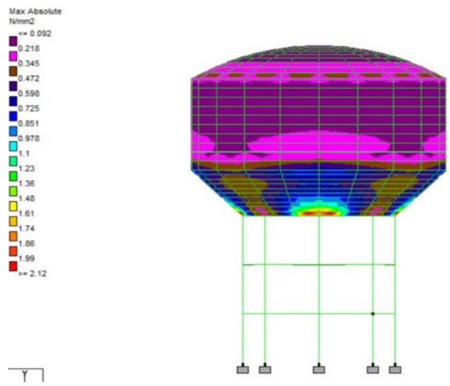

Fig 4.5.7.1: Max stresses on water tank

4.5.8 Bending moment and shear displacement

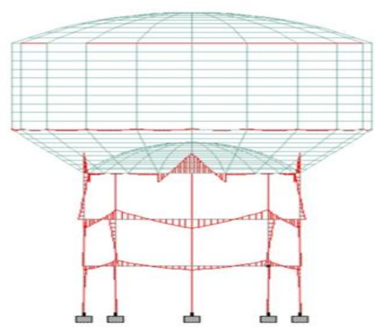

Fig 4.5.8.1: Bending moment

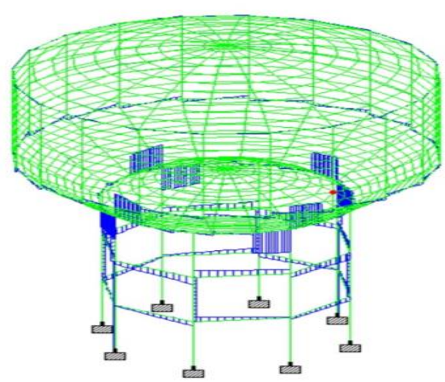

Fig 4.5.8.2: Shear displacement

4.5.9 3D - MODEL OF INTZ TYPE WATER TANK

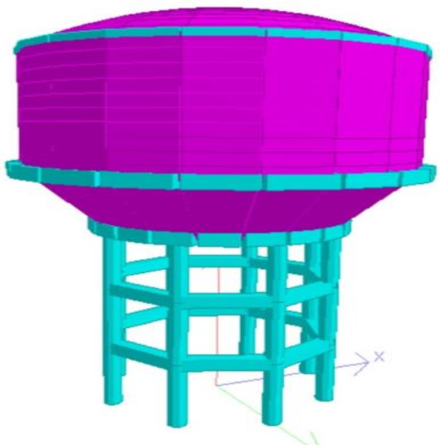

Fig 4.5.9.1: 3D model of intz type water tank

4.6 FOOTING DESIGN BY STAAD.Pro FOUDATION

4.6.1: Geometry of Footing

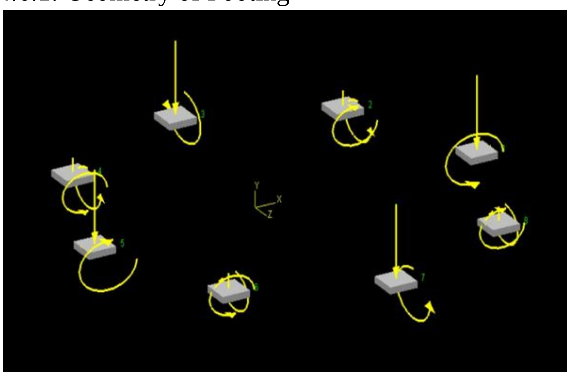

Fig 4.6.1.1: Geometry of footings

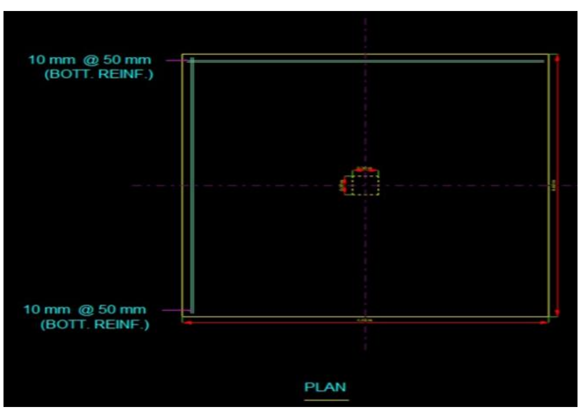

Fig 4.6.1.2: Footing Plan

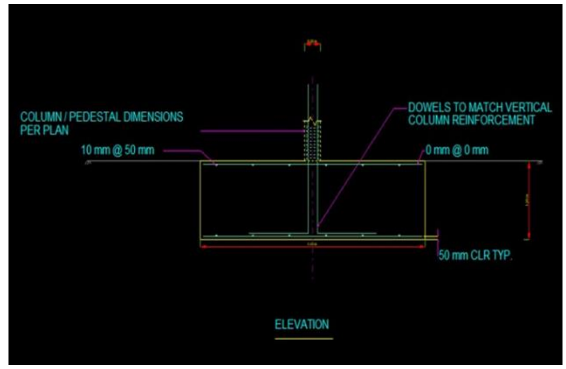

Fig 4.6.1.3: Footing elevation

MARK	SIZE	Column Nos.
Fl1	4.400 X 4.400 X 1.200	2
Fl2	1.750 X 1.750 X 0.450	3
Fl3	4.400 X 4.400 X 1.200	4
Fl4	1.750 X 1.750 X 0.450	5
Fl5	4.400 X 4.400 X 1.200	6
Fl6	1.750 X 1.750 X 0.450	7
Fl7	4.400 X 4.400 X 1.200	8
Fl8	1.750 X 1.750 X 0.450	9

Fig 4.6.1.4: GA drawing details

V. RESULTS AND DISCUSSIONS

5.1 Manual Design Results

1. Top Dome: 8 mm dia. bars @ 200 mm c/c (radial & circumferential).
2. Top Ring Beam (A-A): 6 bars of 16 mm dia., nominal shear reinforcement: 6 bars @ 300 mm c/c.
3. Cylindrical Wall: 8 mm dia. bars @ 140 mm c/c on each face.
4. Bottom Ring Beam (B-B): 20 bars of 20 mm dia., 12 mm stirrups @ 150 mm c/c.
5. Conical Dome: 12 mm dia. bars @ 100 mm c/c (both faces).
6. Bottom Spherical Dome: 8 mm dia. bars @ 150 mm c/c (meridional & circumferential).
7. Bottom Ring Girder: 8 bars of 20 mm dia., 4 bars of 20 mm dia. at mid-span, 12 mm stirrups @ 110 mm c/c.

5.2 STAAD.Pro Design Results

1. Top Dome: 10 mm dia. bars @ 260 mm c/c.
2. Top Ring Beam: 5 bars of 16 mm dia., nominal shear reinforcement of 6 mm.
3. Conical Dome: 10-12 mm dia. bars @ 150 mm c/c (meridional).

4. Cylindrical Wall: 10 mm dia. bars @ 150 mm c/c (both faces).
5. Bottom Ring Beam: 18 bars of 20 mm dia., 12 mm stirrups @ 170 mm c/c.
6. Bottom Spherical Dome: 10 mm dia. bars @ 180 mm c/c.
7. Girder Ring Beam: 6 bars of 24 mm dia. at supports, 4 bars of 20 mm dia. at mid-span, 12 mm stirrups @ 100 mm c/c.
8. Circular Columns: 24 bars of 12 mm dia. @ 300 mm c/c.
9. Bracings: 6 bars of 20 mm dia. @ 300 mm c/c, 4 bars of 20 mm dia. at mid-span, 10 mm stirrups @ 180 mm c/c.

5.3 Foundation Design (STAAD.Foundation)

- Footing Dimensions: 4.4 m × 4.4 m × 1.2 m.
- Stability: Sliding FOS = 92.239, Overturning FOS = 172.099.
- Moments: Max Mu = 2995.33 kNm (≤ Mumax = 19140.41 kNm).
- Shear: One-way & two-way shear: Safe (Tv < Tc).
- Reinforcement: Ø10 @ 50 mm o.c., Ast = 6336 mm^2.

The comparison shows that STAAD.Pro is more efficient and accurate than manual design for water tanks. Manual methods, though reliable, tend to overdesign due to conservative assumptions. STAAD.Pro optimizes reinforcement by accurately analyzing loads and forces, ensuring an economical and precise design. It also provides detailed results for components like circular columns and bracings, making it better suited for complex analyses.

VI. CONCLUSIONS

For the design of RCC Intz type water tank by manual and STAAD.Pro approach, Working Stress Method is adopted. The following conclusions are drawn based on results.

- Manual design method requires more time and tedious compared to STAAD Pro design.
- Amount of steel provided for the whole structure is adequate and economical for software design compared to manual design.
- Proposed sizes of structural elements can be used for the erection of water tank.
- The design of beams, columns, bracings, cylindrical and conical wall are safe in shear bending, deflection and other aspects.

In summary, using STAAD.Pro for design of RCC Intz type water tank enhances the accuracy, efficiency and reliability of the entire process. It ensures the tank is safe, cost effective and compliant with standards, providing a robust and durable structure.

VII. SCOPE FOR FUTURE WORK

1. Dynamic Analysis: Evaluates seismic performance, ensuring stability, safety, and minimal displacement.
2. High-Strength Materials: Enhances load capacity, reduces weight, and optimizes cost.
3. Wind Load Analysis: Assesses stability, pressure distribution, and resistance to overturning in high-wind zones.
4. Alternative Shapes: Explores cost-effective designs with improved structural efficiency.
5. Non-Linear Analysis: Examines extreme load behavior for realistic response assessment.
6. 6.Sustainable Materials: Reduces environmental impact while enhancing durability.
7. Advanced FEA: Provides precise stress and deformation analysis for better structural stability.
8. Durability & Maintenance: Ensures longer service life with minimal repairs.
9. Comparative Analysis: Validates design accuracy using ETABS or SAP2000.
10. BIM Integration: Improves visualization, coordination, and project management efficiency.

REFERENCES

[1] Mainak Ghosal,"Water Tank Analysis Using STAAD.Pro", International Transaction on Engineering & Science, Volume 1, Issue 2, January 2019, pp 7-15.

[2] Er.Venkata Raju Badanapuri,"Analysis and Design of Elevated Intez Water Tank based on Normal Frame Staging Subjected to Seismic Loading by Using STAAD.Pro Software", International Journal of Science and Research

(IJSR), Volume 10, Issue 3, ISSN: 2319-7064, March 2021, pp 720-731.

[3] Prakash Mahdewa & Kirti Sahu Tirpude,"Design of Circular Water Tank by using STAAD.Pro Software", International Journal of Science and Research (IJSR), Volume 10, Issue 12, ISSN: 2319-7064, December 2021, pp 305-310.

[4] Roshan Kumar Pakhale, Dr. Rajeev Singh Parihar & Dr. Abhay Kumar Jha, "Analysis & Design of Intz Water Tank by Using Staad. Pro", International Journal of Trend in Scientific Research and Development (IJTSRD), Volume 6, Issue 3, ISSN:2456-6470, March-April 2022, pp 691-698.

[5] Sharanabasappa Karur & Vishwanath Hiremath, "Comparitive Study on The Design of Elevated Circular Tank using STAAD.Pro V8i Software and Manual Design", International Journal of Creative Research Thoughts (IJCRT), Volume 10, Issue 8, ISSN:2320-2882, 8 August 2022, pp 538-556.

[6] IS: 875 - 1987, "Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Part 1: Dead Loads-Unit Weights of Building Materials and Stored Materials", Second Revision, Bureau of Indian Standards, New Delhi-110002.

[7] IS: 875 - 1987, "Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Part 2: Imposed Loads", Second Revision, Bureau of Indian Standards, New Delhi-110002.

[8] IS: 875 - 1987, "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 3: Wind Loads", Second Revision, Bureau of Indian Standards, New Delhi-110002.

[9] S.S. Bhavikatti, "Advance R.C.C Design", Second Edition, New Age International Publishers, 2008.