# DESIGN, ANALYSIS AND CONSTRUCTION OF 1500KL CAPACITY RCC OVERHEAD STORAGE TANK

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**ABSTRACT**:- According to survey, only 3% water available as fresh, out of 3% only 1% of water should to Drinkable. People in Africa & Asia have to walk an average of 6km per day to collect drinking water. Water is non-renewable source in plant earth and without water there will be no living and non-living can alive. So water storage tanks are used for store the water and supplied to public utility and industrial purpose. Tanks are important public utility and industrial structure. The design and construction methods used in reinforced concrete are influenced by the prevailing construction practices, the physical property of the material and the climatic conditions. Before taking up the design, the most suitable type of staging of tanks and correct estimation of loads including statically equilibrium of structure particularly in regards to overturning of overhanging members are made. The design is made considering the worst possible combination of loads, moments and shears arising from vertical loads and horizontal loads acting in any direction when the tank is full as well as empty. In this project by performing the analysis of high-rise tank, deflection shape due to hydrostatic pressure and stresses, etc. are analysed. Water in circular storage tanks will produce mainly hoop stresses and they can be determined by suitable design.

## I. INTRODUCTION

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. These structures are made of masonry, steel, reinforced concrete and pre stressed concrete. Out of these, masonry and steel tanks are used for smaller capacities. The cost of steel tanks is high and hence they are rarely used for water storages. Reinforced concrete tank is high and hence they are rarely used for water storages. Reinforced concrete tanks are very popular because, besides the construction and designs being simple, they are cheap, monolithic in nature and can be made leak proof. Generally no cracks are allowed to take place in any part of the structure of liquid retaining R.C.C tanks and they made water tight by using richer mix (not less than M20) of concrete. In addition sometimes water proofing materials are also used to make tanks water tight. Permeability of concrete is directly proportional to water cement ratio. Proper compaction using vibrators should be done to achieve imperviousness. Cement content ranging from 330 Kg/m3 to 530 Kg/m3is recommended in order keeping shrinkage low.

The leakage is more with higher head and it has been observed that head up to 15m does not cause leakage problem. Use of high strength deformed bars of grade 415 are recommended for the construction of liquid retaining structures .However mild steel bars are also used. Correct placing of reinforcement, use of small sized and use of deformed bars lead to differential cracks. A crack width of 0.1mm has been accepted as permissible value in liquid retaining structures. While designing liquid retaining structures recommendation of ―Code of Practice for the storage of liquids- IS3370 (Part I to IV)‖ should be considered.

**DESIGN COMPONENTS OF CIRCULAR TYPE TANK:-**

**Top Roof Dome:-**The dome at top usually 100mm to 150mm thick with reinforcement along the meridian and latitudes. The rise is usually 1/5th of the span.

**Ring Beam :-**The ring beam is necessary to resist the horizontal component of the thrust of the dome. The ring beam will be designed for hoop tension induced.

**Circular Wall :-**This has to be designed for hoop tension caused due to horizontal water pressure and to resist bending moment induced to wall by liquid load.

**Bottom Slab :-**This will be designed for total load above it. The slab will also be designed for the total load above it. The slab will also be designed as a slab spanning in both directions.

**Bottom Beams:-**The bottom beam will be designed as continuous beam to transfer the entire load above it to the columns.

**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.

**Foundation :-**As per is11682-1985, a combined footing or raft footing with or without tie beam or raft foundation should be provided for all supporting columns.

**STAGING OF TANKS:-**

The overhead tanks are generally supported on space frame staging consisting of reinforced concrete columns braced together by ring beams at top and bottom and also at a number of places along the height by braces shown. The arrangement enables effective height of columns to be taken as the distance between centers of adjacent bracings. Alternatively, the tower may be a thin walled reinforced shaft, i.e., cylindrical shell

- The design should be based on worst possible combination of loads, moments and shears arising from gravity and lateral loads in any direction when tank is full as well as empty.
- In case of lateral load due to seismic and wind action, the permissible stresses for columns of the staging are increased as per IS;456 provision. However, the increase is not allowed in the design of braces because seismic and wind loads are primary forces in them.
- In addition to the entire load of tank(gravity load), the column carry axial load, shear forces, and bending moment due to lateral forces exerted by the wind, earthquake and vibration.
- The axial force in the column due to lateral loads acting on all the part of the tanks as well as towers should be calculated by equating the moments due to all lateral forces above the level under consideration to the restraining moment offered by axial forces in column.
- The vertical spacing rigidly connected horizontally bracings should not exceed 6m.
- For staging in seismic zones where horizontal seismic coefficient exceeds 0.05, twin diagonal vertical bracings of steel of R.C.C. in additional to horizontal bracing may be provided.
- For the tower situated in seismic zones where horizontal seismic coefficient is above in 0.05, all the columns are tied together by a ring beam at the base of the tower.
- The tower foundation is so proportioned that the combined pressure on soil due to gravity load(with tank full as well as empty) and lateral pressure is within safe bearing capacity, and in the critical direction the footing does not lift to at any point.

**ANALYSIS OF WIND FORCES:-**

In addition to gravity forces the tower and the tank are subjected to wind and seismic forces depending upon the location of the tank. The wind pressure at a site is determined as per IS: 875 Part III provision. The wind force on a surface is the product of pressure per unit area and projected area normal to the direction of wind. Intze tanks offer relatively smaller resistance and a reduction factor of the order 0.7 is used to arrive at effective pressure.

**TERRAIN CATEGORY**

There are four terrain categories. Terrain in which a specific structure stands shall be assessed as being one of the following terrain categories:

- Category 1- exposed open terrain with few or no objections in which the average height of any object surrounding the structure is less than 1.5m.
- Category 2- open terrain with well scattered obstructions having heights generally between 1.5 to 10m.
- Category 3- terrain with numerous closely spaced obstructions having the size of structure up to 10m in height with or without a few isolated tall structures.
- Category 4 - terrain with numerous large high closely spaced obstructions.

Design details of reinforcing bars and spacing

| Span l in meters | Thickness of waist mm | Spacing of Reinforcement Bars | | | |
|---|---|---|---|---|---|
| | | Main Longitudinal Bars | | | Transverse Bars |
| 1.5 | 100 | 10mm | 150mm c/c | 6mm | 300mm c/c |
| 2.0 | 100 | 10mm | 130mm c/c | 6mm | 250mm c/c |
| 2.5 | 115 | 10mm | 100mm c/c | 6mm | 220mm c/c |
| 3.0 | 130 | 12mm | 140mm c/c | 10mm | 150mm c/c |

| | | | | | |
|---|---|---|---|---|---|
| 3.5 | 150 | 12mm | 120mm c/c | 10mm | 300mm c/c |
| 4.0 | 170 | 16mm | 140mm c/c | 10mm | 250mm c/c |
| 4.5 | 200 | 16mm | 120mm c/c | 10mm | 170mm c/c |
| 5.0 | 225 | 16mm | 100mm c/c | 10mm | 120mm c/c |
| 5.5 | 255 | 16mm | 90mm c/c | 10mm | 120mm c/c |
| 6.0 | 270 | 16mm | 70mm c/c | 10mm | 120mm c/c |

Fig : Showing design of the dome section

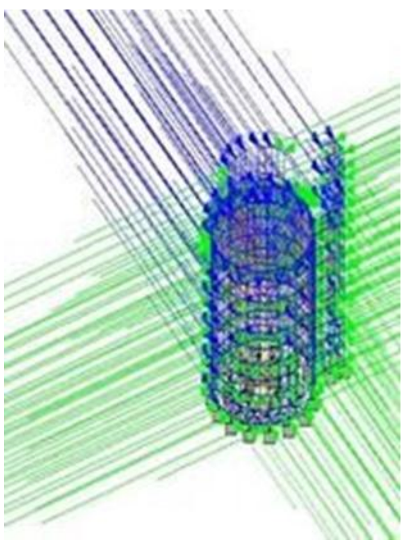

Fig : Analysis of wind force in the column

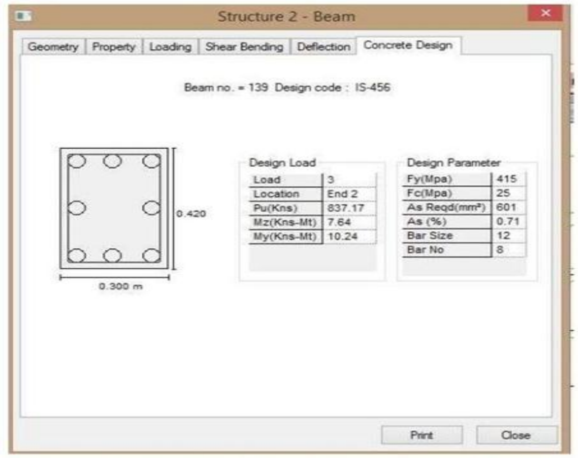


Fig : Details of column section

**DESIGN CRITERIA**:

ELSR Capacity : 1500 KL

Type : Circular

Staging : 15m

Staging type : Columns

SBC : 20t/m2

Depth of foundation : 2 m

Average G.L : 14.5 m

**MATERIALS OF CONSTRUCTION**:

The following main material has been proposed for the construction of the overhead circular water tank.

Reinforcement: HYSD /T.M.T bars of grade Fe500.

PCC: M15 Grade of concrete

Reinforced concrete: M30 (fck = 30N/mm2) for all elements

BRICK: Confirming to IS: 1077, class5.0,

Minimum compressive strength = 3.5N/mm2

**DEAD LOAD:**

The weight of all permanent construction including domes, ring beams, shafts, walls, stair case, slabs and foundation are considered. The unit weights of materials are in accordance with IS: 875-1987. The unit weight of Concrete

(RCC), Soil, Structural steel and brick masonry is taken as 25 $KN/m^3$, 18 $KN/m^3$ ,78.5 $KN/m^3$ and 19.1 $KN/m^3$.

**LIVE LOAD:**

The Live load on roof slab, walk way slab and staircase is 1.5 KN/m2, 1.5 KN/m2 and 2.0 KN/m2 respectively.

**WATER LOAD:**

Weight of water due to gross volume is calculated and applied on bottom of container unit wt. of water is 10 KN/m3

**WIND LOAD:**

As per figure -1 IS: 875(PART-3)-1978) Design wind pressure = 0.6

$Vz_2$ = 2117.01 N/m2

**EARTH QUAKE LOAD ($E_Q$):**

It is in zone-III as per IS 1893 part1 2002

Seismic coefficient $\alpha h = \beta IFo(Sa/g)$

β, coefficient of depending upon soil foundation= 1 I, factor depending upon importance of factor = 1.5

For, seismic zone factor for average acceleration spectra= 0.16 Sa/g is considered as per CI 6.3.5, (IS 1893, part-1).

RECOMMENDATIONS from Soil Testing:

Based on field and laboratory test results the following recommendations are made for the ELSR in Vijayawada, Krishna District.

- Open foundation in the form of Annular Circular Raft foundation is suitable for the ELSR.
- A total depth of foundation of 3.50 meters below the existing ground level is proposed for the raft foundation.
- The safe bearing capacity of soil at different level is given in Table 1 & 3.
- An allowed bearing capacity of 80 KN/m2 (8.0 tons/m2) is recommended at a foundation depth of 3.50 meters below the existing ground level for the Raft.
- Below the base of the foundation, sand cushion of 150 mm thick followed by bed concrete 1:4:8 mix, 150 mm thick is proposed.

Less than 300 mm for 100 blows, the N value is written as N>50. The depth of ground water table at the end of boring operation is observed .All the results obtained from the field operation is shown in the log of bore.

Fig: Showing RCC circular sidewall construction

Fig: Showing Cube sample collection at site for testing

**CONCLUSIONS**

Supplying water thorough storage tanks will reduce the drinking water problems to every individual and industrial usage. Storage of water in the form of tanks for drinking and washing purposes, swimming pools for exercise and enjoyment, and sewage sedimentation tanks are gaining increasing importance in the present day life. For small capacities we go for rectangular water tanks, while for bigger capacities we provide circular water tanks. Circular tank is a modified circular tank. Circular tank is constructed to minimize the project cost because lower dome in this construction resists the horizontal thrust.

Design of Circular water tank is a very tedious method. The whole structure is designed manually considering M30 grade concrete.

Detailed drawings have been prepared in the AutoCAD software, which is shown in necessarily. The staging has been designed with maximum safety and effects due to seismic force and wind force are also taken into account.

So, overall, this project can be implemented in the mention area, i.e., Vijayawada.

**REFERENCES**


- I.S 456:2000, —Code of Practice for Plain and Reinforced Concrete||, I.S.I., New Delhi
- I.S 875 (Part II): 1987, —Code of Practice for Imposed Load||, I.S.I., New Delhi
- I.S 875 (Part II): 1987, —Code of Practice for Wind Load|| , I.S.I., New Delhi
- I.S 1893: 1984, ||Criteria for Earthquake Resistant Design of Structures||, I.S.I., New Delhi
- I.S 3370 (Part I): 2009, —Code of Practice for Concrete Structures for Storage of Liquid||, I.S.I., New Delhi
- I.S 3370 (Part IV): 1967, —Code of Practice for Concrete Structures for Storage of Liquid||, I.S.I., New Delhi
- SP 16 (1980), —Design Aids for Reinforced Concrete to IS 456: 1978||
- 2010 17th edition of S. Ramamrutham, —Design of Reinforced concrete structures||, Dhanpat Rai publications
- 2008 edition of M.L Gambhir —Design of Reinforced concrete structures||, PHI Learning Pvt. Ltd., New Delhi.
- Theory of plates and shells by THIMOSHENKO.
- Internet data for population CENCUS details.
- SSR 2019-2020 Andhra Pradesh for Estimation of overhead tank.
- Civil engineering handbook by P.N.Kanna