# DESIGN OF OVERHEAD RCC RECTANGULAR WATER TANK BY USING WORKING STRESS METHOD

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**ABSTRACT**- *Water tanks are the storage containers for storing water. Elevated water tanks are constructed in order to provide required head so that the water will flow under the influence of gravity the construction practice of water tanks is as old as civilized man. The water tanks project have a great priority as it serves drinking water for huge population from major metropolitan cities to the small population living in towns and villages.*

**Keywords**: Optimization of Steel, Economic design, Water Tank

## 1. INTRODUCTION

Water tanks are storage containers of water; these tanks are usually storing water for human consumption. The need for water tanks is old as civilized man. Water tanks provide for the storage of drinking water potable, irrigation, agriculture, fire suppression, agricultural farming and live stoke, chemical manufacturing, food preparation and many other applications.

The leakage is more with higher liquid head and it has been observed that water head up to 15 m does not cause leakage problem. Use of high strength deformed bars of grade Fe415 are recommended for the construction of liquid retaining structures. Crack width of 0.1mm has been accepted as permissible value in liquid retaining structures. Fractured strength of concrete is computed using the formula

□cat= 0.27 □fck for direct tension and □cbt= 0.37 □fck for bending tensile strength.

Allowable stresses in reinforcing steel are □st= 115 MPa for Mild steel and □st= 150 MPa for HYSD bars

In order to minimize cracking due to shrinkage and temperature, minimum reinforcement is recommended as:
i) For thickness □ 100 mm = 0.3 %
ii) For thickness □ 450 mm = 0.2%
iii) For thickness between 100 mm to 450 mm = varies linearly from 0.3% to 0.2%

For concrete thickness □ 225 mm, two layers of reinforcement be placed, one near water face and other away from water face. In case of concrete cross section where the tension occurs on fibers away from the water face, then permissible stresses for steel to be used are same as in the analysis of other sections, ie., □st=140 MPa for Mild steel and □st=230 MPa for HYSD bars.

## 2. Elevated Water Tank

"A Water Storage structure which is constructed above the ground" Overhead water tanks of various shapes can be used as service reservoirs, as a balancing tank in water supply schemes and for replenishing the tanks for various purposes. Reinforced concrete water towers have distinct advantages as they are not affected by climatic changes, are leak proof, provide greater rigidity and are adoptable for all shapes.

1) Components of a water tower or tank elevated or overhead Water tank consist of:

a) Tank portion with

- Roof and roof beams (if any)
- Sidewalls
- Floor or bottom slab
- Floor beams, including circular girder
- Cylindrical portion

b) Staging portion, consisting of:

- Columns
- Bracings and
- Foundations

2) Types of Overhead Water Tanks: This may be:

- Circular tanks
- Rectangular tanks
- Intze tanks
- Circular tank with conical bottom
- Spherical tanks.

3) Types of staging:

There are two types of support staging on which top part is stand:
- Hollow circular shaft
- Brace column staging

## 2. DESIGN ASPECTS OF THE OVER HEAD TANK

Number of over head tanks urban water systems should have at least one elevated tank for each of the areas. Two tanks (or a tank with two compartments) are desirable to improve reliability and pump control during times when one tank is out of service for inspection, cleaning, painting, or other maintenance. The height of an elevated tank determines the maximum water pressure available in the part of the distribution system connected to the tank. The town is divided into number of zones with independent storage tanks to facilitate effective and equitable water distribution.

### 2.1 Location of the over head tanks

The location of the over head tanks is of importance for regulating the pressure in importance for regulating the pressure in the water distribution system. The storage tank is generally located at the highest point and as far as possible at the centre of the distribution area. The topography of a water distribution area is an important consideration in system design and type of storage facilities to be incorporated into a water supply system. In some cases, ground level storage systems can be sited at higher elevations (on hills), allowing for gravity supply to all or portions of a distribution area or pressure zone. Storage tanks at higher elevation can also take advantage of topographic features to reduce height requirements of EOHT and provide wider pressure zone coverage.

### 2.2 Elevation of the over head tank

In order to maintain the minimum residual pressure in the distribution system, the elevation of the L.W.L of the storage reservoir should be fixed consistent with the provision of economic sizes of pipes in the distribution network. The LWL of the over tank is fixed considering the following aspects.

1. The minimum residual pressure to be maintained in the distribution system,
2. The G.L at the farthest point in the distribution system and its distance from the service reservoir,
3. The G.L at the highest elevation in the distribution system other than the location of the over head tank; and
4. The approximate loss of head due to friction over the distance to the farthest point from the over head tank.

The LWL of the over head tank should be greatest of the following:
1. G.L at the farthest point plus minimum residual pressure to be maintained plus the frictional loss in the pipeline between over head tank and the farthest point; or
2. G.L at the highest elevation in the distribution zone plus minimum residual pressure
3. plus the frictional loss in the pipeline between over head tank and the location of the highest elevation.

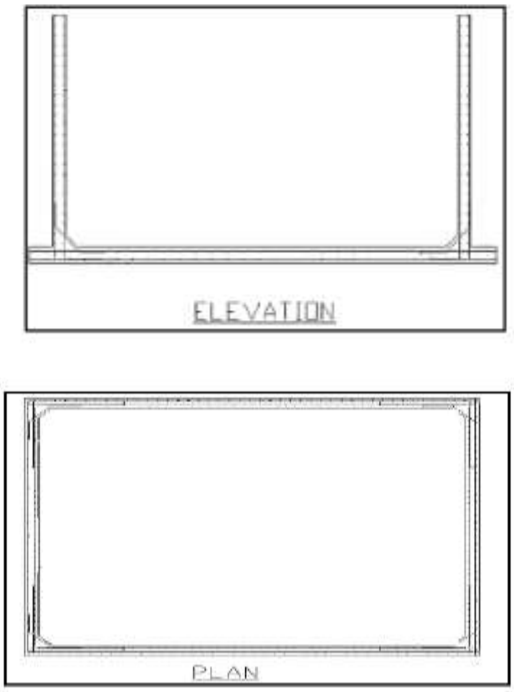


Fig. 2.1: Rectangular Water Tank resting on ground shows reinforcement detailing ideas

3 Rectangular tank with fixed base resting on ground :
Rectangular tanks are used when the storage capacity is small and circular tanks prove uneconomical for small capacity. Rectangular tanks should be preferably square in planfrom point of view of economy. It is also desirable that longer side should not be greater than twice the smaller side.
Moments are caused in two directions of the wall ie., both in horizontal as well as invertical direction. Exact analysis is difficult and such tanks are designed by approximate methods. When the length of the wall is more in comparison to its height, the moments will be mainly in the vertical direction, ie., the panel bends as vertical cantilever. When the height is large in comparison to its length, the moments will be in the horizontal
direction and panel bends as a thin slab supported on edges. For intermediate condition bending takes place both in horizontal and vertical direction.

In addition to the moments, the walls are also subjected to direct pull exerted by water pressure on some portion of walls. The walls are designed both for direct tension and bending moment.

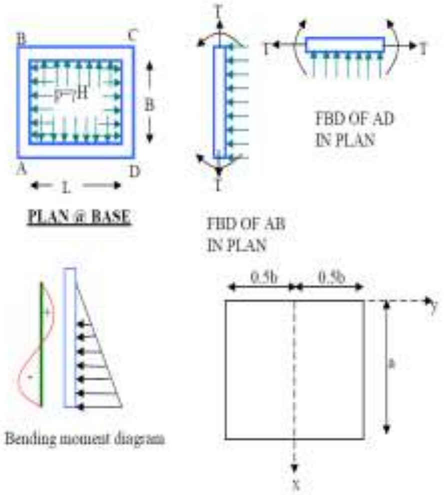


Fig. 3.1: Pressure, BM diagram (with FBD) acting on Rectangular Water Tank

**3.1 coefficient for max Bending moments in horizontal and vertical direction.**

Maximum vertical moment = Mx⍰wa3 ( for x/a = 1, y=0)
Maximum horizontal moment =My⍰wa3 (for x/a = 0, y=b/2)
Tension in short wall is computed as Ts=pL/2
Tension in long wall TL=pB/2
Horizontal steel is provided for net bending moment and direct tensile force

$$A_{st}=A_{st1}+A_{st2};\quad A_{st1}=\frac{M'}{\sigma_{st}\, jd}$$

M'=Maximum horizontal bending moment – T x; x= d-D/2

$$A_{st2}=T/\sigma_{st}$$


**4. Working Stress method:**

In this method the concrete and steel are assumed to be elastic. At the worst combination of working loads, the stresses in materials are not exceeded beyond permissible stresses. The permissible stresses are found by using suitable factors of safety to material strengths. The modular ratio 'm' of composite material ie., RCC is defined as the ratio of modulus of elasticity of steel to modulus of elasticity of concrete. But the code stipulate the value of 'm as

$$m=\frac{280}{3\sigma_{bc}}$$

where ⍰bc is the permissible stress in concrete in bending compression. To develop equation for moment of resistance of singly reinforced beams, the linear strain and stress diagram are shown in Fig. 3.2

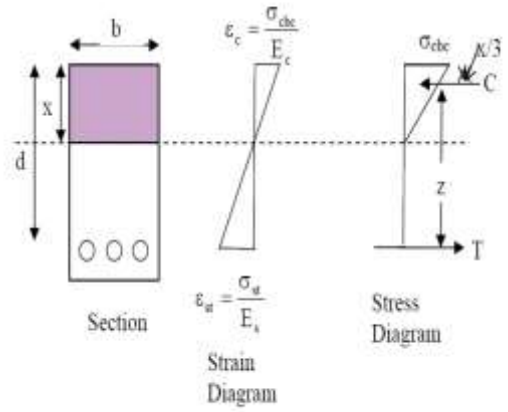


Fig. 3.2 Singly Reinforced Section

The neutral axis depth is obtained from strain diagram as

$$\frac{x}{d-x}=\frac{\sigma_{cbc}/E_c}{\sigma_{st}/E_s}=\frac{m\sigma_{cbc}}{\sigma_{st}}\ \text{solving for x; } x=\left[\frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}}\right]d=kd$$

where, $k=\left[\frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}}\right]$, k is known as neutral axis constant

The lever arm z=d-x/3 = d-(kd/3)= d(1-k/3) = jd, where, j=1-k/3; j is known as lever arm constant

$C=\frac{1}{2}\sigma_{cbc}bx;\ T=\sigma_{st}A_{st}$

Moment of resistance M=C z=T z

Consider, $M=C\ z=(\frac{1}{2}\sigma_{cbc}bx)jd=(\frac{1}{2}\sigma_{cbc}bkd)jd=(\frac{1}{2}\sigma_{cbc}kj)bd^2=Q_{bal}bd^2$

Where, $Q_{bal}$ is known as moment of resistance factor for balanced section.

Now consider $M=T\,z=\sigma_{st}A_{st}jd$;

$\therefore A_{st}=\frac{M}{\sigma_{st}jd}$; Let $p_t$ be the percentage of steel expressed as

$$p_{bal}=\frac{100A_{st}}{bd}=100\frac{M}{\sigma_{st}jd}\frac{1}{bd}=\frac{50k\sigma_{cbc}}{\sigma_{st}}$$

Table 4.1 Design Constants

| Concrete Grade | Steel Grade | $\sigma_{cbc}$ | $\sigma_{st}$ | k | j | $Q_{bal}$ | $P_{bal}$ |
|---|---|---|---|---|---|---|---|
| M20 | Fe250 | 7 | 140 | 0.4 | 0.87 | 1.21 | 1.00 |
| | Fe415 | 7 | 230 | 0.29 | 0.9 | 0.91 | 0.44 |
| M25 | Fe250 | 8.5 | 140 | 0.4 | 0.87 | 1.48 | 0.68 |
| | Fe415 | 8.5 | 230 | 0.29 | 0.9 | 1.1 | 0.533 |

**5. Conclusion**

Water tanks are considered to be expensive, but they are constructed to reach present and future population.

They are considered to highly economical and safely store the portable water. Water can be distributed to number of houses, Industries and public places by means of a network of a distribution system. Thus water tanks are considered to be supporting systems and useful for the society. Rectangular tanks are used when the storage capacity is small and circular tanks prove uneconomical for small capacity. Rectangular tanks should be preferably square in plan from point of view of economy. It is also desirable that longer side should not be greater than twice the smaller side.

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