International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 05 | May-2018 www.irjet.net p-ISSN: 2395-0072

THE ECONOMIC ANALYSIS & DESIGN OF R.C.C. & PRESTRESSED CONCRETE WATER TANK RESTING ON THE GROUND

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Abstract - Water tanks are used to store water and are designed as crack free structures, to eliminate any leakage. In this project design of two types of circular water tank resting on ground is planned, one is reinforced cement concrete (RCC) and another is prestressed concrete (PSC). The both water tanks are being designed and compared with all respects. These both water tanks are to be same capacity and M20 grade of concrete. As an objective of the project are economical analysis and design of both tanks resting on the ground.

Key Words: Circular Water Tank, Reinforced Cement Concrete, Water Tank, Prestressed Concrete Water Tank.

1. INTRODUCTION:

Water tank is used to storage of water for the daily requirement. The construction of concrete structure for the storage of water and other liquids imperviousness of concrete is most essential. The permeability of uniform and compacted concrete of given mix proportion is depend upon the water cement ratio. The increase in water /cement ratio then increase permeability. The decrease in water/ cement ratio the decrease permeability but very much reduced water/ cement ratio may cause compaction difficulties increase.

2. OBJECTIVE

The objectives of this project are as follows:

Analysis and design of RCC and prestressed concrete water tank.

To compare the force and stresses induced in both kind of tank.

To compare the cost of both tank.

To arrived at economical design of water tank.

3. ANALYSIS AND DESIGN OF RCC WATER TANK:

3.1 DESIGN:

The bending moment and ring tension, developed in circular water tanks due to the hydrostatic pressure depends upon the type of fixity between the tank wall and the base slab, diameter of the tank, thickness of wall and elastic constants of the material forming the walls. The circular water tank is analysis in two ways as follows:

3.1.1. Circular water tank with flexible joint between floor and wall.

3.1.2. Circular water tank with rigid joint between floor and wall.

3.1.1. Circular water tank with flexible joint between floor and wall:

When water is filled in circular tank, the hydrostatic water pressure will try to increase its diameter at any section. However this increase in the diameter all along the height of the tank will depend upon the nature of the joint at the junction B of the wall and bottom slab. If the joint at B is flexible (i.e. sliding joint), it will be free to move outward to a position B_1.The hydrostatic pressure at A is zero, and hence there will be no change in the diameter at A. The hydrostatic pressure at B will be maximum resulting in the maximum increase in diameter there, and hence maximum movement at B if the joint is flexible. Thus AB_1 will be the deflected position of wall AB. If however, the joint at B is fixed no movement is possible, and a fixing moment will be induced at B. In that case, ABC will be deflected position.

To start with, we will consider the joint to be flexible so that the outward horizontal movement corresponding to the maximum horizontal pressure is possible. Due to this, hoop tension will be induced everywhere in the wall.

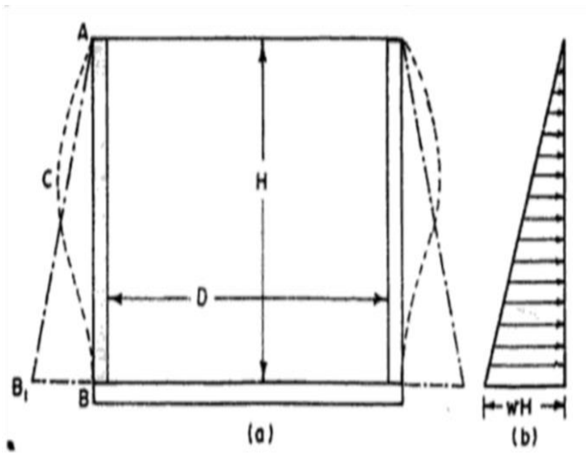


Fig. 3.1 Hydrostatic pressure Flexible base

Let D diameter of the tank ;
H = height of tank (height of water)

Maximum hoop tension at bottom, per unit height of the

$$\text{wall} = w\,H\frac{D}{2}$$

Taking permissible stress in steel in direct tension as σ_s, area of the steel per meter height at the base

$$A_{sh} = \frac{w\,HD}{2\sigma_s}$$

This area of steel may be provided at the centre of the wall if its thickness is small, or it may be provided on each face, keeping a minimum cover of 25mm if the thickness is more than 225mm. The above reinforcement is provided in the form of hoops suitably spaced, and the spacing may be increased towards the top. However, the spacing should not be more than 3 times the thickness of the wall.

Though the reinforcement has been provided to take the entire hoop tension, the concrete has not been prevented to take a part of this tension. The thickness of the wall should, therefore, be such the tensile stress developed in the composite section is within safe limit.

$$\sigma_{ct} = \frac{w\,HD/2}{1000T+(m-1)A_{sh}}\ \text{N/mm}^2$$

The value of σ_{ct} is taken as 1.2 N/mm^2 for M20 concrete.

From the above equation the thickness T can be found. Alternatively the thickness can be fixed can be fixed from the following empirical formula and the stresses may be checked from above equation

T = 30H + 50 mm
Where H = height of water retained in meter

IN addition to the main reinforcement, temperature and distribution reinforcement may be provided in the form of vertical bars @ 0.3% of the concrete section up to 100mm thickness. For section thicker than 100 mm and less than 450 mm, the minimum reinforcement may be reduced from 0.3% for 100 mm thick section to 0.2% for 450 mm thick section.

If the floor slab is resting continuously on the ground, a minimum thickness of 150 mm may be provided, with a nominal reinforcement of 0.3% in each direction. The slab should rest on a 75 mm thick layer of lean concrete (M 10 mix). The layer of tar felt to enable the floor slab to act independent of the bottom layer of lean concrete.

6. ESTIMATE FOR R.C.C. CIRCULAR WATER TANK

An estimate is a calculation of the quantities of various items of work, and the expenses likely to be incurred there on. The total of these probable expenses to be incurred on the work is known as estimated cost of the work. The estimated cost of a work is a close approximation of its actual cost.

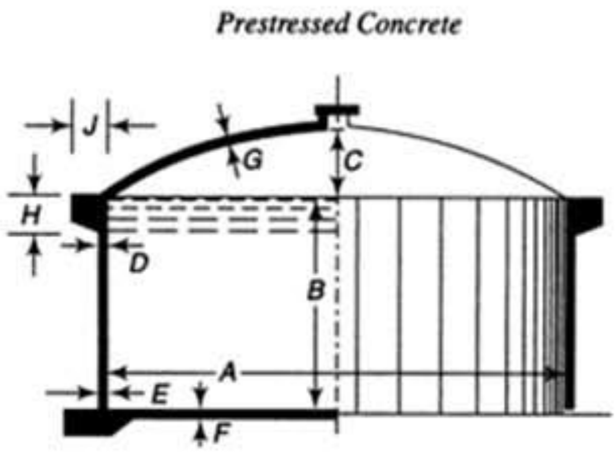


TABLE 1 DETAILED ESTIMATES FOR R.C.C. CIRCULAR WATER TANK

Item No	Description of Item	No's	L (m)	B (m)	D (m)	A m^2	QTY	Unit
1	Providing and laying nominal mix plain cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 grade stone aggregate 40mm nominal size).							
	Rigid Base	1			0.075	733.88	55.04	cum
2	RCC work in Cylindrical wall(1:1.5:3)							cum
	Wall	1		0.275	7.5		200.75	cum
	Base	1	30.568		.200	733.88	146.77	cum
						Total	347.52	cum

3	Thermo Mechanically treated bars FE 415	6068.89cum @ 100kg					606889	kg
4	Plastering in C M (1:6) for inner Cylindrical wall (12mm)				7.5		706.875	sqm
5	Plastering in C M (1:6) for outer Cylindrical wall (12mm)				7.7		739.431	sqm

6	Thick water proof cement painting for Tank portion					Total	1446.306	Sqm

TABLE 2 ABSTRACT FOR CIRCULAR WATER TANK

Item No.	Description of Item	QTY	Unit	Rate(Rs)	Amount(RS)
1	Providing and laying nominal mix plain cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40mm nominal size).	55.04	Cum	2970	163468.8
2	RCC work in Cylindrical wall(1:1.5:3)	347.52	Cum	4163	1446725.76
3	Thermo Mechanically treated bars FE 415	606889	Kg	54.50	33075450.5
4	Plastering in C M (1:6) for inner Cylindrical wall (12mm)	1446.306	sqm	91.5	132336.999
	Plastering in C M (1:6) for outer Cylindrical wall (12mm)				
5	Thick water proof cement painting for Tank portion	1446.306	sqm	41	59298.546
6	White Washing	1446.306	sqm	9.5	13739.907
				TOTAL(RS)	34891020.51

7. ANALYSIS & DESIGN OF PRESTRESSED CONCRETE WATER TANK

Prestressing is the process of wrapping the tank wall with a continuous steel strand under high tension to keep the tank walls in constant compression even when the tank is filled with water.

Shapes of Prestressed Concrete Tanks

A. Circular cylindrical tank.
B. Conical tank.
C. Water tower with conical tank.
D. Water tower of doubly curved shell.

ECONOMIC DIMENTIONAL PROPORTION OF CIRCULAR TANK

Prestressed Concrete tanks built all over the world are circular shape, and based on experience it is found that the cost of the circular cylindrical prestressed concrete tank it is influenced by the ratio of the diameter to height. Table (3) and Fig (7.1) shows the economical dimensions of the various structural components of circular tanks for capacities varying from 378 to 37800 m^3These provisions are based on the experience of Pre load Engineering

Company, New York, who have constructed a large number of tanks in U.S.A.[18]. The economic proportion of diameter to height of circular cylindrical tanks was found to be 4:1. The dimensions of wall thickness given in the table refers to the condition that the wall of the walls of the tank are not continuous with the base slab, but they are free to slide, being supported on a neoprene pad.

8. Estimate For Prestressed Concrete Circular Water Tank

An estimate is a calculation of the quantities of various items of work and the expenses likely to be incurred there on. The total of these probable expenses to be incurred on the work is known as estimated cost of the work. The estimated cost of a work is a close approximation of its actual cost.

Table 4 DETAILED ESTIMATES FOR PRESTRESSED CONCRETE CIRCULAR WATER TANK

Item No.	Description of Item	No's	L (m)	B (m)	D (m)	A m^2	QTY	Unit
1	Providing and laying nominal mix plain cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 grade stone aggregate 40mm nominal size).							
	Rigid Base	1			0.075	733.01	54.976	cum
2	Providing and laying pre- stressed cement concrete of M20 grade in superstructure including form work but excluding reinforcement complete as per drawing specification		185074.74cum @ 100kg				18507474	kg
3	Plastering in C M (1:6) for inner Cylindrical wall (12mm)				7.5		706.85	sqm
4	Plastering in C M (1:6) for outer Cylindrical wall (12mm)				7.7		739	sqm
						Total	1445.85	Sqm
5	Thick water proof cement painting for Tank portion						1445.85	sqm

Table 5 ABSTRACT FOR PRESTRESSED CONCRETE CIRCULAR WATER TANK

Item No.	Description of Item	QTY	Unit	Rate(Rs)	Amount(RS)
1	Providing and laying nominal mix plain cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 40mm nominal size).	54.976	Cum	2970	163278.72
2	Providing and laying pre- stressed cement concrete of M20 grade in superstructure including form work but excluding reinforcement complete as per drawing specification	5600	kg	6130	34328000
3	Plastering in C M (1:6) for inner Cylindrical wall (12mm)	1445.85	sqm	91.5	132295.275
	Plastering in C M (1:6) for outer Cylindrical wall (12mm)				
4	Thick water proof cement painting for Tank portion	1445.85	sqm	41	59279.85
5	White Washing	1445.85	sqm	9.5	13735.575
				TOTAL(RS)	34696589.42

Comparison between Design data of R.C.C. and P.C. Circular Water Tank

Design data of R.C.C. and P.C. Circular Water Tank are compared with number of components are as tabulate below:

S. NO.	Components	Reinforced cement concrete	Prestressed concrete
1.	Capacity	5277 m^3	5277 m^3
2.	Grade of concrete	M20	M20
3.	Diameter	30 m	30 m
4.	Height of storage water	7.5 m	7.5 m
5.	Thickness of tank wall	284 mm	150 mm
6.	Thickness of base	200 mm	200 mm
7.	Thickness of lean concrete covered with a layer of tar felt	75 mm	75 mm
8.	Maximum ring tension or hoop tension	750000 N at 2.5 m height	720 N/mm at 7.5 m height
9.	Maximum B.M	78125 N-m/m at 2.5 m height	42500N-mm/mm at 7.5 m height

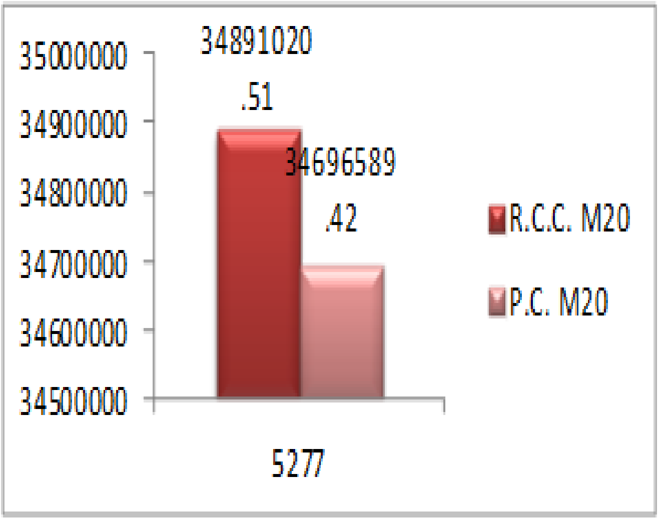
Cost comparison of both type of water tank

Both type of water tank with same grade of concrete and capacity cost of water tank are different are as follows:

M20 Grade of concrete	Capacity of water tank m^3	Cost of water tank
Reinforced cement concrete	5277	34891021
Prestressed concrete	5277	34696589

Cost observation with the help of graph

Both type of water tank with same grade of concrete and capacity cost of water tank are different are observed by bar chart.



CONCLUSION:

Water tanks are constructed for the drinking and washing purpose, swimming pools for exercise and enjoyment and sewage sedimentation tanks are gaining increasing importance in the present day life. Water tank is design for future aspects. For small capacities we go for rectangular water tanks while for bigger capacities we provide circular water tanks.

Prestressed concrete is very important to understand for upcoming engineers. It is basically a high strength concrete with high tensile steel wires tensioned prior to application of loads. Concrete can be pre compressed to such a level that when the structure is loaded, there is practically no net tension developed in structure. It is basically used in case of long span or no-crack structures(Water Tanks) or repeated/fatigue loaded structure(Rail tracks).

Water tanks are analyzed, designed and estimated for the same capacity then seen that thickness of r.c.c. circular water tank is more than pre stressed concrete circular water tank and other design data's are different. The cost of r.c.c. circular water tank is more than prestressed concrete circular tank. By these results pre stressed concrete circular water tank is economic for the construction purpose.

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