International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 07 | July 2024 www.irjet.net p-ISSN: 2395-0072

Design Requirements of Water Tank and Permissible Stresses.

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Abstract - *The water tank is a container designed to store water and supply it for various purposes. It comes in different shapes and sizes and is made of different kinds of materials. A water tank is typically comprised of various components and the use of different types of materials for construction. The dimensions of water tanks depend on the capacity of tanks. In the case of elevated water tanks, the height of the staging of the tank also depends on how much height water is to be pumped with the self-watering head of the tank. The water tank could be classified as per the shape, size, situations, location, and material to be used for construction. Due to the hydrostatic water pressure induced in the water tank, it will try to increase in diameter at any section. However, it will depend upon the nature of the joint at the junction of the wall and bottom slab. Concrete's imperviousness is critical for building structures made of it to store liquids, such as water.*

In the design of liquid-retaining structures, the avoidance of cracking due to tensile strength is essential. In any case, no crack should be induced on the water face of the water tank. It is essential to select a richness of mix compatible with available aggregates, whose particle shape and grading have an important bearing on workability, which must be suited to the means of compaction selected. The quantity of cement should not be less than 350 kg/m3 of concrete and also be less than 530 kg/m3 of concrete to keep shrinkage low. It is usual to use a rich mix of M-30 grade concrete in most water tanks. Concrete must be designed to prevent cracking on its water face. Crack risk can also be reduced by removing obstacles to the structure's ability to expand or contract freely.

Key Words*: *Conventional concrete, water tank, steel reinforcement, strength calculation.

1.INTRODUCTION:

A water tank is a water storage reinforcement concrete structure used to store water and supplied for different purposes, such as residential, industrial, and commercial. Water tanks are typically constructed by using construction materials such as concrete, sand, cement, and steel reinforcement. The Intze type and cylindrical overhead water tanks are cylindrical structures typically constructed. The curved dome-shaped roof is adopted to help distribute the load of the stored water evenly across the tank wall. This design minimizes stress concentration points, making the tank more structurally stable. The Intze type water tank is well known for their efficient use of space. The cylindrical shape of the water tank also allows for maximum storage capacity, and it is ideal for urban environments where space is limited. The curved roof design eliminates the need for internal supports, further optimizing the storage space.

In the construction of water tanks, locally available materials are generally used. The locally available materials, like coarse aggregates, fine aggregate, cement, and reinforcement bar, help to reduce construction costs. The durability and low maintenance requirements give long-term cost savings. The Intze type and other types of tanks are used to fulfill the requirement of water supplied for residential, commercial, and industrial purposes. The water and other liquid storage concrete structures and the rich mix sound concrete should be used. The design of the liquid-retaining structure should be free from cracks, fishers, and bulging. For the elevated water tank, the wind force and earth quake forces are most dangerous.

The water tank should be designed as an as an earthquake-resistant tank. At the time of design, the wind forces should be considered along with vertical downward loads. The various types of water tanks are built in different parts of the country. The water tanks may be circular, rectangular, or square in shape. The typical shape of tank is being designed as an Intze tank, and it is widely used all over the country and abroad. As per their situation, it may be underground, on the ground, or overhead. Generally, two kinds of water tanks, reinforced concrete and pressed steel water tanks, are built. Now a days, mostly cylindrical and Intze types of overhead reinforcement are being constructed.

The imperviousness of concrete is very important for the construction of concrete structures for storage of water and other liquids. The mix proportion of concrete gives good permeability and uniform ability and also thoroughly compacted components. It is essential to select a rich mix of concrete with available materials. The quantity of cement should not be less than 350 kg/m^3 of concrete and also be less than 530 kg/m^3 of concrete to keep shrinkage low. Usually rich mix M-30 grade concrete is used in most of the water tanks. In the construction, the cracking should be avoided by reducing the restraints on the free expansion or contraction of the structures.

2. PERMISSIBLE STRESSES IN PLAN CONCRETE STRUCTURES:

By permitting stress in plain concrete up to the acceptable limits for tension in bending given in IS 456-2000, the plain concrete members of reinforced concrete liquid structures

can be built against structural failure. This will automatically take care of the failure due to cracking. However, nominal reinforcement in accordance with the requirements of IS 456-2000 shall be provided for plain concrete structural members. The small liquid containers generally resting on the ground are made with plain concrete. The permissible stresses of concrete and steel reinforcement should be properly in corporate to avoid any kinds of failures. The recommendations and provisions given in the Indian standard code of practice IS 456:2000 is to be followed for other things like size of members, thicknesses of cover of steel reinforcement, and spacing of steel reinforcement.

2.1 Resistance to Cracking:

Indian standard code IS 456-2000 does not specify the permissible in concrete for resistance to cracking. But its previous version, IS 456-1964, includes the allowed stresses in shear, bending tension, and direct tension. The member's face that is in contact with the liquid is subject to the allowable tensile stresses resulting from bending. In members with thickness is less than 225 mm and in contact with the liquid on the side, these permissible stresses in bending apply also to the face remote from the liquid. The permissible values are given in the table 2.1.

Table 2.1 Permissible concrete stresses to resistance of cracking

Grade of Concrete	Permissible Stresses		Shear Q/bjd
	Direct Tension	Tension due to bending	
	N/mm²	N/mm²	N/mm²
M 15	1.1	1.5	1.5
M 20	1.2	1.7	1.7
M 25	1.3	1.8	1.9
M 30	1.5	2.0	2.2
M 35	1.6	2.2	2.5
M 40	1.7	2.4	2.7

2.2 Strength Calculations:

In strength calculations, the usually permissible stresses in accordance with IS 456:2000 are used for the design of water or liquid containers. Where the calculated shear stresses in concrete above exceed the permissible value, reinforcement acting in conjunction with diagonal compression in concrete shall be provided to take the whole of the shear. The compressive strength and tensile stresses calculated should be according to the provisions of Indian Standard Code of Practice IS 456:2000.

3. PERMISSIBLE STRESSES IN STEEL REINFORCEMENT:

3.1 Resistance to Cracking:

The assumption that steel and concrete would work together to monitor the tensile stresses in the concrete to prevent cracking will restrict the tensile stresses in steel by requiring that the permitted tensile stress in the concrete is not exceeded so that tensile stresses in steel shall be equal to the product of the modular ratio of the steel and concrete, as well as the appropriate permissible tensile stress in the latter. If the tensile stress in concrete is greater than permissible values, then the tensile stress in steel reinforcement will be increased with the permissible value.

3.2 Strength Calculations:

The Indian standard code of practice IS: 456 2000 fourth revision is available, but at the same time the corresponding codes IS: 3370 1965 (Parts I, II, II, and IV) are still in use. However, the fourth reprint of IS 3370 1965 (Part II) in 1982 and amendment regarding the permissible stresses in steel reinforcement. The revised values of permissible stresses are given in Table 3.2 and converted into SI units using the approximation 10 Kg/cm² to 1 N/mm².

Table 3.2 Permissible stresses in reinforcement for strength calculations

Type of stress in steel reinforcement	Permissible Stresses in N/mm²	
	Plain round mild steel bars conforming to grade 1 of IS: 482 (Part I) 1966	High yield strength deformed bars (HYSD) conforming to IS: 1789 – 1966 or IS: 1139-1966
1.Tensile stress in members under direct tension σs	115	150
2.Tensile stress in members due to bending σst		
(a). On liquid retaining face of members	115	150
(b) On face away from liquid for members less than 225 mm	115	115
(c) On face away from liquid for members 225 mm or more in thickness	125	190
3. Tensile stress in shear reinforcement σsv	115	150
(a) For members less than 225 mm thickness	125	175
(c) For members 225 mm or more in thickness	125	175
1.Compressive stress in columns subject to direct load σsc		

3.3 Stress due to drying shrinkage or temperature change

Stress due to drying shrinkage or temperature change may be ignored provided that the permissible stresses specified for concrete and steel are not exceeded. Adequate precautions are taken to avoid cracking of concrete during the construction period and until the reservoir is put into use. When the shrinkage stresses are allowed, the permissible stresses and tensile stresses in concrete directly and bending both may be increased Sby 33 and 1/3 percent. Where reservoirs are protected with an internal permeable lining, consideration should be given to the possibility of concrete eventually drying out. Unless it is established on the basis of tests or experiences that the lining has adequate crack-bringing properties, allowance for the increased effect of drying shrinkage should be made in the design.

4. STEEL REINFORCEMENT:

4.1 Minimum Reinforcement:

The minimum reinforcement in the walls, floors, and roofs in each of the two directions at right angles shall have an area of 0.3 percent of the concrete section in that direction for sections up to 100 mm thickness. For sections of thickness greater than 100 mm and less than 450 mm, the minimum reinforcement in each of the two directions shall be linearly reduced from 0.3 percent from the 100 mm thick section to 0.2 percent. In no case will the percentages of reinforcement in any member be less than 0.15 percent of the concrete section.

4.2 Minimum Cover to Reinforcement:

For liquid faces of part of members either in contact with the liquid or enclosing the space above the liquid, minimum cover to all reinforcement should be 25 mm or the primary bars' diameter, whichever is larger. In the presence of sea water, soil, and water of corrosive character, the cover should be increased by a minimum 12 mm, but this additional cover shall not be less taken into account for design calculations. For faces away from the liquid and for parts of the structure neither in contact with the liquid on any face nor enclosing the face above the liquid, the cover should be the same as provided for other reinforced concrete sections.

5. CONCLUSIONS:

- The water tank is designed for storage of water to be used for different purposes by humans. Stored water used in the different types of water tanks and used for residential, commercial, and industrial purposes should be leakage-seepage proof so that water losses could be minimized.
- A water tank is typically comprised of various types of components and constructed by using different types of materials. The shape and size of water tanks depend on the population of that area for which the tank is to be designed. The height of the staging of the water tank depends on the storey height of the building of the area for which the water tank is constructed. The water tank could be classified as per the shape, size, situations, location, and material to be used for construction.
- When the water is in the containers, the outward forces are induced as per the height of the tank. In the water tank outward, high water pressures are induced, and the components like the tank wall and bottom dome should be strictly water tight. That is why the recommendation and provision of the Indian Standard Code of Practice IS 456:200 and IS 3370:1965 were followed. The circular water tanks are most effective against such kinds of forces and stresses.

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