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A Case Study on Water Tank Resting on Ground

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***Abstract*: Generally, water tank resting on ground is a container for storing water. This case study gives idea for safe and economical design with more reliable, and simple. This paper helps in understanding the philosophy for safe optimization of tank. For safe and economic design of tank this study gives various design requirements that influence the strength and support condition of the structure. This case study is being conducted on liquid retaining structure which are made with reinforced concrete and are resting on ground.**

***Keywords*: water tank, economic design, reinforcement, optimization**

1. Introduction

A. Theory

A water tank is a container for storing water. Water tanks are used to provide storage of water for use in many application, drinking water, irrigation agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses. Water tank parameters include the general design of the tank, and choice of construction materials, linings. Various materials are used for making a water tank: plastics (polyethylene, polypropylene), fiberglass, concrete, stone, steel (welded or bolted, carbon, or stainless). Earthen pots also function as water storages. Water tanks are an efficient way to help developing countries to store clean water.

Water is considered as the source living for every creation as it as a crucial element for healthy living. Safe drinking water is one of the basic elements for human to sustain a healthy life. High demand for safe and clean water is rising day by day, as one cannot live without water. Thus it becomes necessary to store the water with clean and effectively. Generally, storage reservoirs and water tanks are used to store the water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoir or tank is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage. Water or raw petroleum retaining slab and walls can be of reinforced concrete with adequate cover to the reinforcement. Water and petroleum react with concrete and hence, no special treatment is required. The need for a water tank is as old as civilization, to provide storage of water for use in many applications. Water tanks can be generally classified as circular, rectangular and conical, depending upon their quantity and location. The tanks can be made of steel or concrete. Tanks resting on ground are normally circular or rectangular in shape and are used where large quantity of water need to stored. Water tank parameters include the general design of the tank, and choice of construction materials and linings. In design of water tanks, design aspects are to be followed as per books and loads is to be applied carefully.

B. Types of Tank

Water tank can be classified in two types are as follows:

- According to placement

1) Resting on ground tanks
2) Underground tanks
3) Elevated tanks

- According to shape

1) Circular tanks
2) Rectangular tanks
3) Conical tanks
4) Intz tanks
5) Spherical tanks

- Other types of tank

1) Chemical Contact Tank
2) Ground Water Tank
3) Elevated Water Tank
4) Vertical Cylindrical Dome Top Tanks
5) A Hydro-Pneumatic Tank
6) Portable Water Tank
7) Flat Bottom Reservoir Tanks
8) Atmospheric Tank
9) High Pressure Tank
10) Thermal Storage Tank
11) Milk Tank
12) Septic Tank
13) Mobile Storage Tank

Tanks resting on ground are normally circular or rectangular in shape and are used where large quantity of water need to stored. Water tank parameters include the general design of the tank, and choice of construction materials and linings.

2. General Design Requirements

A. Design requirement of concrete (I.S.I.)

In water retaining structure a dense impermeable concrete is

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required therefore, Proportion of fine and course aggregates to cement should be such as to give high quality concrete. Concrete mix weaker than M20 is not used. The minimum quantity of cement in the concrete mix shall be not less than 30KN/m^3.

1) Permissible stresses in concrete

For resistance to cracking. For calculation to the resistance of members to cracking. The permissible stresses relating (directing and due to bending) and shear shall confirm to the values specified in Table 1. The permissible tensile stresses due to bending apply to the face of the member in contact with the liquid. In members less than 225mm. thick and in contact with liquid on one side these permissible stresses in bending apply also to the face remote from the liquid.

Table 1
Permissible stresses in concrete

Grade Of Concrete	Permissible Stress in Concrete in KN/m^2 Tension		Shear
	Direct	Bending	
M15	1.1	1.5	1.5
M20	1.2	1.7	1.7
M25	1.3	1.8	1.9
M30	1.5	2.0	2.2
M35	1.6	2.2	2.5
M40	1.7	2.4	2.7

B. Design requirement for steel

1) Permissible stresses in steel

For resisting to cracking - When steel and concrete are assumed to act together for checking the tensile stress in concrete for avoidance of crack, the tensile stress in steel will be limited by the requirement that the permissible tensile stress in the concrete is not exceed so the tensile stress in steel shall be equal to the product of modular ratio of steel and concrete, and the corresponding allowable tensile stress in concrete.

For strength calculation-In strength calculation the permissible stress shall be as follows:

Tensile stress in member in direct tension 1000 kg/cm^2.

Tensile stress in member in bending on liquid retaining face of members or face away from liquid for members less than 225mm thick 1000kh/cm^2

On face away from liquid for member 225mm or more in thickness 1250lk/cm^2

Tensile stress in shear reinforcement,

- For member less 225mm thickness 1000kg/cm^2
- For member 225mm or more in thickness 1250kg/cm^2
- Compressive stress in column subjected to direct load 1250kg/cm^2

2) Stresses due to drying shrinkage or temperature changes

1. Stresses due to drying shrinkage or temperature change may be ignored provided.
2. The permissible stresses specified above in (2) and (3) are not otherwise exceeded.
3. Adequate precautions are taken to avoid cracking of concrete during the construction period and until the reservoir is put into use.
4. Recommendation regarding joints given in article 8.3 and for suitable sliding layer beneath the reservoir are complied with, or the reservoir is to be used only for the storage of water or aqueous liquids at or near ambient temperature and the circumstances are such that the concrete will never dry out.
5. Shrinkage stresses may however be required to be calculated in special cases, when a shrinkage co-efficient of 300 X 10.6 may be assumed.
6. When the shrinkage stresses are allowed, the permissible stresses.
7. Tensile stresses to concrete (direct and bending) as given in table 1 may be increased by 33.33%.

3) Minimum reinforcement

The minimum reinforcement in wall, floors and roofs in each of two directions at right angles shall have an area of 0.3 % of the concrete section in that direction for sections up to 100mm, thickness. For section of thickness greater than 100mm, and less than 450mm the minimum reinforcement in each of the two direction shall be linearly reduced from 0.3 percent for 100mm thick section to 0.2 percent for 450mm, thick sections. For section of thickness greater than 450mm, minimum reinforcement in each of the two direction shall be kept at 0.2 percent. In concrete section of thickness 225mm or greater, two layers of reinforcement steel shall be placed one near each of the section to make up the minimum reinforcement.

In special circumstances floor slabs may be constructed with percentage of reinforcement less than specified above. In no case the percentage of reinforcement in any member be less than 0.15% of gross sectional area of the member.

4) Minimum cover reinforcement

For liquid faces of parts of members either in contact with the liquid (such as inner face or roof slab) the minimum cover to all reinforcement should be 25mm or the diameter of the main bar whichever is greater. In the presence of the sea water and soil and water of corrosive characters the cover should be increased by 12mm but this additional cover shall not be taken into account for design calculation.

For faces away from liquid and for parts of the structure neither in contact with the liquid on any face, nor enclosing the space above the liquid, the cover shall be as for ordinary concrete member.

3. Methods of analysis

Generally following three methods are used for structural design:

- Working Stress Method (WSM)
- Ultimate Load Method (ULM)
- Limit State Method (LSM)

This methods of design, considered as the method of earlier tanks, has several limitations. However, in situation where limit state method cannot be conveniently applied, working stress method can be employed as an alternative. In this method of design, the structure is not checked for serviceability perhaps with the fact that elastic limit is not crossed. Therefore, the structural design by working stress method will not have significant cracking.

Therefore, liquid retaining structures, are still preferred to be designed by working stress method as seepage of liquid is also the main criteria. Limited cracking in that structure designed by working stress method was the main reason why the IS: 3370 (1965) did not adopt the limit state design method even after adoption by IS: 456 (1978).

4. Conclusion

From this study showed that above design requirement plays vital role in the safe and economical design of various shapes of water tank resting on ground which gives idea about accurate and convenient method to optimization of tanks.

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