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Parametric Study on Conical Shape Tank

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Abstract

In this paper parametric study of conical tank is investigated with original approach considering the (IS-3370) draft code. The main focus for studying this topic is mainly to identify the major parameter affecting the storage of conical tank. The Conical tank shape is optimized based on different parameters example for diameter, slope, and length of slop. The basic parameter like capacity of conical tank, height of water tank from ground are tacking constant here. A excel model and mathematical model is develop, and the model result were validates with available data from the books "advanced reinforced concrete design" by Krishna Raju. The studies of different parameters are observing by the result of force, moment, stress etc. and suggest the best optimum shape of the cinical tank. The hydrodynamic and dynamic effects were not considered in the analysis.
Keyword- Conical tank, Optimization, Parametric study

I. INTRODUCTION

There is number of storage tanks have been built around the world. A developing country like India consists a large number of urban and rural areas. The elevated water tanks are the public utility structures and it is considered as important city services in villages and major cities. Due to urbanization, the need of water is continuously increasing day by day. For providing better water distribution network use of elevated storage tanks becomes necessary. The most common types of elevated water tanks are

1) The intze type tank
2) The circular tank
3) The conical shaped tank.

A circular tank with a horizontal or flat floor slab is only economical for smaller storage capacity of up to 200,000 liters and diameters in the range of 500 to 800 cm. The depth of the storage is generally between 3 to 4 m. The side walls are designed for circumferential hoop tension and bending moment since the walls are fixed to the floor slab at the junction. The design forces are determined using coefficients recommended in IS: 3370 (part IV).

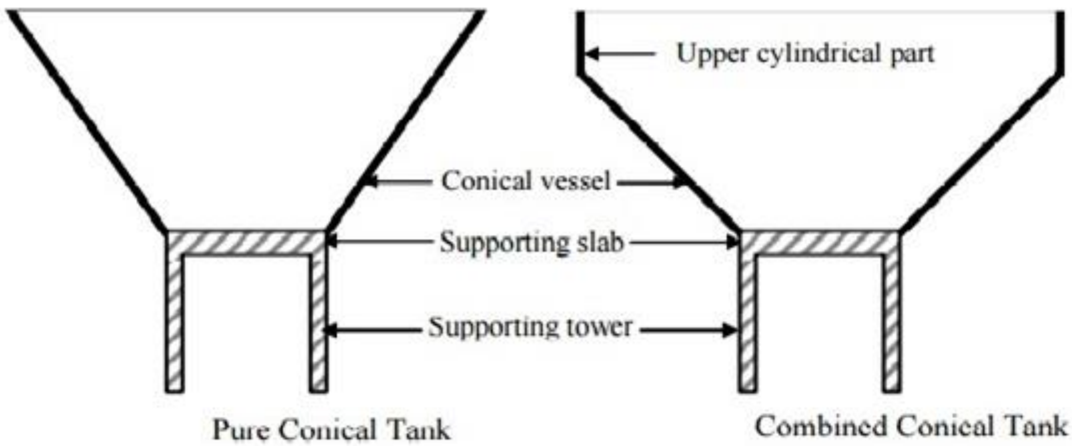

Fig. 1: conical Shape tank

In case of large diameter elevated circular tanks, thicker floor slabs are required resulting in uneconomical domes. For Providing Greater Liquid Retaining Capacity for Equal Base Radios of a cylindrical Counterpart elevated conical tanks are considered as one of the most popular construction. In such cases, conical tank and bottom spherical domes provides an economical solution. As all of we know that measure of good civil engineering structure is economy in its design. Design of conical tank involves proportioning and structural design, in which proportioning part mainly depends upon geometric aspects. Optimum cost design of such a structure needs several trial design. In present study, an optimum cost design of conical tank considering geometric and structural design aspects. The cost of the conical tank has been considered as the objective function and the geometric parameters have been considered as constraints.

A. Shape Optimization of RC Flexural Members

1) By D. P. Rath, A. S. Ahlawat, and A.Ramaswamy [1]
He suggested that the objective function is the total cost, of material, fabrication, and placement costs. Material and formwork cost of concrete is directly depended to the volume of concrete. The shape optimization of reinforced concrete flexural members a natural velocity field method has been demonstrated here. The objective function is the total cost, of material, fabrication, and placement costs. Material and formwork cost of concrete is directly depended to the volume of concrete. Consider two different diameters of bars to provide the same area of steel.

2) Simplified procedure for design of liquid-storage combined conical tanks by Amr M. I. Sweedan a, Ashraf A. El Damatty [2]
He conclude that maximum overall stresses developed in the tank walls the stresses magnification due to the localized bending effect resulting from the support restraints and geometric imperfections.

3) Application of optimization method to the design of storage tanks was done by Mohammed [3].
They found out the total cost of the tank (rectangular and circular), considering the cost as an objective function with the properties of the tank that were tank capacity, width and length of tank in rectangular, depth of water, unit weight of water and slab thickness of tank floor, as design variables.

B. General Requirement
Leakage is one of the major issues faced while constructing liquid storage tanks. While designing such tanks the following general requirements must be satisfied
1) Concrete should be impervious. To achieve the desired imperviousness, cement concrete grade greater than M20 is recommended for water retaining structures.
2) The structure is designed in such a manner so that the Concrete member remains free from cracks. During calculations for tension. It is assumed that concrete is capable of resisting limited tensile stresses to guard against cracking. So that working stress method is desirable.
3) Joint tillers, joint sealing compounds, and water bars shall conform to the requirements of relevant Indian Standards. Other jointing materials such as polyurethane and silicone based sealants may also be used provided there are satisfactory data on their suitability.

II. SPREAD SHEET DESCRIPTION

Analysis, Design and cost estimation of elevated water tanks is a time consuming task, which requires more efforts and expertise. Many times it is required to know the total cost of an elevated tank of known capacity and geometry before its design. Quick estimation of cost is a challenging for the less experienced design engineers.

To make automated design of elevated conical type tank for any height, any volume based on working stress method spread sheet was developed and validate using book of "Advanced Reinforced Concrete Design by N.Krishna Raju" and "structural Design-II R.C.C. by Dr.R.P.Rethaliya". A number of inputs are required to designing the conical type tank. Following is a list of the major input parameters used while computing the results.
1) Capacity of the tank, m^3
2) Height of supporting tower, m
3) Number of columns
4) Diameter of the tank, m
5) Height of conical dome, m
6) Base diameter of the tank, m
7) Grade of concrete and steel, N/mm^2
8) Wind pressure intensity, 1.5 kN/m^2

The outputs helped us to analysis the tank design and perform the parametric study. The following outputs have been studied:
1) Angle of conical dome
2) Stresses at ring beam
3) Base shear & base moment
4) Volume of concrete
5) Weight of steel reinforcement
6) Cost of concrete
7) Cost of steel
8) Total material cost of the tank

III. PARAMETRIC STUDY

Design with the working stress method, a conical type tank already consists of steel reinforcement in excess. The top dome, conical dome, bottom spherical dome, bottom circular beam, columns, bracings and other members are thicker and wider hence they are an uneconomical in design.so we have performed a parametric study for finding the condition of the optimum shape of conical tank with minimum material cost by studying the effect of alteration of member length, height and Diameter. While performing the study, the capacity of the tank was kept Constant at 600 m^3. The material cost of the tank consists of the cost of concrete and cost of steel.

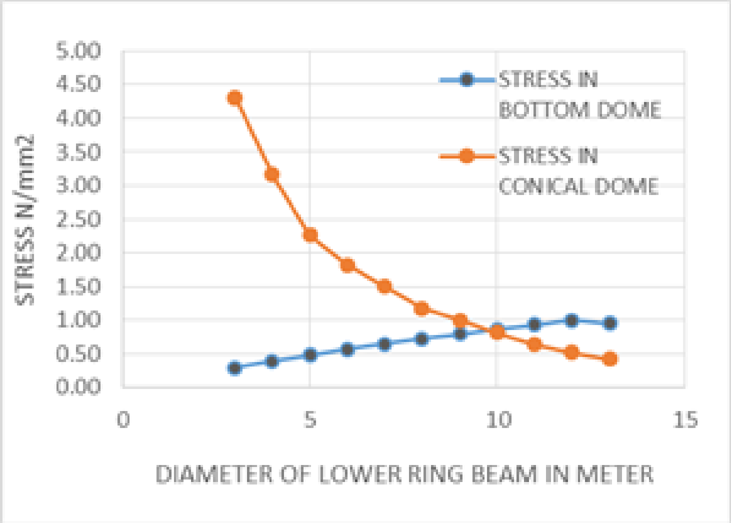

Fig. 2: Effect of diameter of ring beam on bottom dome and conical dome

It was observe that the stress in bottom dome increase with the increase in diameter of lower ring beam and at same time stress in conical dome decreases with the increases with the diameter of lowering ring beam

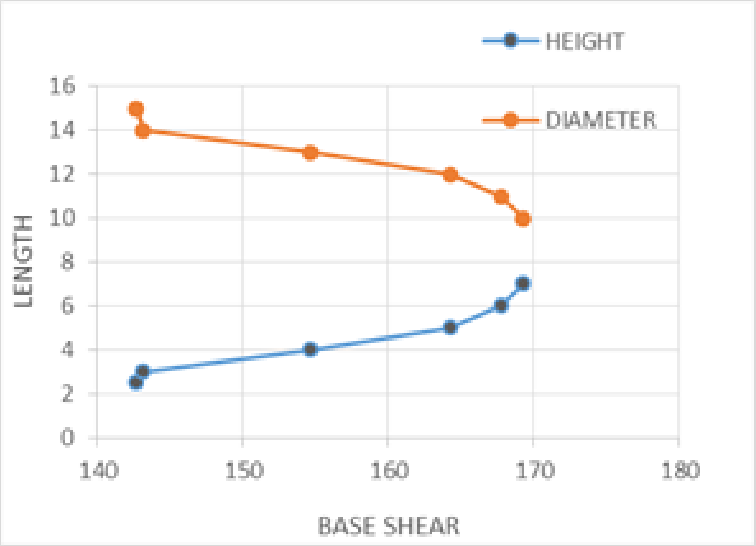

Fig. 3: Effect of side wall height and diameter on the base shear

In Fig.3 It was observe that the base shear is increasing with the increasing in height of side wall and decries in diameter. The lower ring beam from the corresponding value of stress is lies between 0.5 to 0.7 times the diameters of side wall. And height of side wall is lies between 0.6 to 0.7 times the diameters of side wall.

The study was done for the three different numbers of circular columns of same diameter. 6nos, 8nos and 10 numbers and it was found that the most economical angle of conical dome lies between 40 to 50 degrees with the horizontal. The economical angle was not affected by changing the number of columns.

IV. CONCLUSIONS

In the present study, an automated analysis and design of a conical type tank was done using working stress method. Parametric study to optimization is performed to find a condition for minimum material cost of the tank with balance load transfer. The results obtained from the geometric optimization of following conclusions were drawn:

- The spread sheet developed makes it easier to estimate the material cost of the tank. The parametric study on geometric optimization of the position, orientation and geometry of the various structural members can be used to achieve an economic design of the tank.
- The diameter and height of side wall of the cylindrical portion of the tank adversely affects the material cost of the conical type tank.
- The lower ring beam from the corresponding value of stress is lies between 0.5 to 0.7 times the diameters of side wall. And height of side wall is lies between 0.6 to 0.7 times the diameters of side wall.
- The most economical angle of conical dome lies between 40 to 50 degrees with the horizontal. The economical angle was not affected by changing the number of columns.

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