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ANALYSIS & DESIGN OF CIRCULAR COMPONENTS OF WATER TREATMENT PLANT USING PRESTRESSED CONCRETE

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Abstract - *In India at least, most of the components of water treatment plant like clariflocculator, aeration tank, disinfection tank etc. are composed in RCC. Pre-stressed concrete is not economical for small structures. But this construction can be efficient for water treatment plant. The pre-stressed steel strands distribute loads uniformly around the tank circumference efficiently. In pre-stressed concrete, compressive stresses are applied to the concrete prior to loading. The entire cross section is essentially in compression under service loads, which takes advantage of concrete's considerable compressive strength but minimal tensile strength. Since concrete deforms under sustained loads (creep), pre-stressed concrete was not practical until the advent of high strength pre-stressing bars and strands. In case of RCC tanks, moisture and temperature differential may cause bend and crack of concrete walls which can be avoided by using pre-stressed concrete. The aim of study is to design the components of water treatment plants using pre-stressed concrete and compare with the components of R.C.C. water treatment plant. The components are designed for the same storage capacity for both RCC & PSC. Design of components of RCC water treatment plant is compared with the design of components of pre-stressed water treatment plant based on various important parameters. The modeling and analysis part of the water tank design will be carried out by using STAAD PRO. This study is concerned principally with recommendations for pre-stressed concrete structures for non-corrosive liquid storage.*

***Key Words*: Rigid base components of water treatment plant, Reinforced Cement Concrete Design, Pre-stressed Concrete Design, Analysis, minimum total cost, tank capacity.**

1. INTRODUCTION

India debts for 2.45% of land region and 4% of water assets of the sector however represents 16% of the sector populace. With the existing populace growth-rate (1.nine according to cent according to year), the populace is anticipated to pass the 1.five billion mark through 2050. The Planning Commission, Government of India has anticipated the water call for boom from 710 BCM (Billion Cubic Meters) in 2010 to nearly 1180 BCM in 2050 with home and commercial water intake anticipated to boom nearly 2.five times. The use of pre-pressured concrete may be very uncommon for creation of water preserving systems because it calls for professional labour, heavy machineries & eager supervision. But this creation may be most cost-efficient for water preserving systems of huge capacity. The overdue Eugene Freyssinet, a outstanding French engineer commonly seemed as the daddy of pre-pressured concrete, changed into the primary to apprehend the want to apply steels of excessive fine and power, pressured to fantastically excessive levels, so as to triumph over the unfavourable outcomes of concrete creep and shrinkage. In the early 1950s, following strategies used efficiently in Europe for some of years, numerous round pre-pressured concrete tanks have been built withinside the United States the use of post-tensioned excessive tensile-power cord tendons embedded withinside the tank partitions. The post-tensioned tendons in maximum early "tendon tanks" have been grouted with a Portland cement-water aggregate after stressing to assist shield them towards corrosion and to bond the tendons to the concrete tank partitions. Others have been unbounded- paper-wrapped person cord or strand tendons that relied on a grease coating and the cast-in-region concrete for his or her corrosion protection. Later, the usage of unbounded tendons with corrosion-inhibiting grease coatings and plastic sheaths have become extra not unusualplace. Most of the early tendon tanks built with inside the U.S. observed the not unusual place European exercise of vertically pre- stressing the tank partitions to dispose of or manage horizontal cracking. This crack manage helped save you leakage of the contents and corrosion of the pre-stressing metallic. The pre-stressing of concrete has numerous blessings in comparison to conventional bolstered concrete (RC) with out pre-stressing.

The blessings of a pre- pressured concrete member with an equal RC member are referred to below:

1) Section stays uncracked beneathneath provider loads ¬ Reduction of metallic corrosion • Increase in durability. ¬

Full phase is utilized • Higher second of inertia (better stiffness) • Less deformations (progressed serviceability). ¬ Increase in shear capacity. ¬ Suitable to be used in strain vessels, liquid preserving systems. ¬ Improved performance (resilience) beneathneath dynamic and fatigue loading.

2) High span-to-intensity ratios Larger spans viable with pre-stressing (bridges, homes with huge column- loose spaces) ¬ For the identical span, much less intensity as in comparison to RC member. • Reduction in self weight • More aesthetic attraction because of narrow sections • More most cost-efficient sections.

2. LITERATURE REVIEW

1) Comparison Of R.C.C. And Pre- confused Concrete Water Tanks By Ms. Snehal R. Metkar and Prof A. R. Mundhada

In this paper layout of styles of round water tank resting on floor is presented. These water tanks are subjected to the identical sort of ability and dimensions. As an goal feature with the homes of tank which might be tank ability, width & period etc. A laptop software has been advanced for fixing numerical examples the usage of the Indian Standard Code IS-456- 2000, IS-3370-I,II,III,IV & IS 1343-1980. This paper concluded that RCC tanks are less expensive most effective for smaller capacities as much as 10- 12 lac liters. For larger tanks, Pre-stressing is the advanced desire ensuing in a saving of overall price.

2) The Use Of Pre-stressing And Pre- casting In Concrete Water Tanks In Britain And Ireland By Michael Gould, David Cleland and Stephen Gilbert

This paper discusses the advent of pre-stressing and use of pre-casting of sections or segments at the side of pre-stressing, for the development of concrete provider water reservoir and water towers, for cause of public water deliver in Britain and Ireland. Once the usage of bolstered concrete have become great for tanks, it changed into essential to make certain that the partitions of water preserving systems had been continually watertight. In the early 1900s numerous strategies changed into hired to make certain that partitions had been watertight till it changed into found out that a very good great concrete, right layout ought to meet the necessities. This paper concluded that the usage of pre-confused concrete for creation of water tanks isn't used broadly however it is able to be low in cost for big ability of tanks.

3) ACI 373R-97: Design and Construction of Circular Pre-confused Concrete Structures with Circumferential Tendons By ACI Committee 373

This look at offers tips for the layout and creation of round pre-confused concrete systems (typically mentioned as “tanks”) post-tensioned with circumferential tendons. These skinny cylindrical shells of both cast- in-area or precast concrete are typically used for liquid and bulk garage. Vertical post-tensioning is regularly included withinside the partitions as a part of the vertical reinforcement. This look at describes modern layout and creation practices for tanks pre-confused with circumferential post-tensioned tendons located inside or at the outside floor of the wall. The tips on this file are supposed to complement the overall necessities for bolstered concrete and pre-confused concrete layout, substances and creation, given in ACI 318, ACI 301 and ACI 350R. A take a look at for water tightness ought to be finished on tanks supposed for water garage. Similar liquid tightness exams ought to be made for tanks supposed for garage of beverages aside from water. Tanks supposed for garage of dry substances want now no longer be examined for water tightness. The take a look at ought to be revamped a duration of at the least 24 hours with a complete tank. In tanks supposed for garage of potable or uncooked water, the lack of water in a 24-hour duration ought to now no longer exceed 0.05 percentage of the tank extent. If the lack of water exceeds 0.half percentage of the tank extent the tank ought to be inspected for factor reassets of leakage. If factor reassets are determined they ought to be repaired. Repairs ought to be made if the tank fails the water tightness take a look at, inclusive of the visible criteria, or is in any other case defective

4) Improvements To Seismic Design Of Circular Pre-confused Concrete Storage Tanks By J.H. Wood and M.J.N. Priestley

This paper affords an evaluation technique for estimating the reserve ability of pre-confused concrete tanks and the technique illustrated with the aid of using the evaluation of a tank of regular dimensions. Charts for estimating the impact of soil-shape interplay for the sensible variety of tank sizes and basis situations also are presented. The American Water Works Association (AWWA) codes for pre-confused concrete tanks and the New Zealand Society for Earthquake Engineering (NZSEE) recommendations for the seismic layout of garage tanks are typically hired for tank layout in North America and New Zealand respectively. The effects of the present studies have proven that there's a massive reserve of electricity in pre- confused concrete tanks above the strain situations accepted for seismic masses in maximum codes and recommendations. This reserve electricity and damping from soil-shape interplay ought to be used as the premise for specifying force-discounts in layout codes.

5) Economical Design Of Water Tanks with the aid of using Hassan Jasim Mohammed

In this paper the writer have studied the low in cost layout of concrete water Tanks with the aid of using optimization technique. He carried out the optimization approach to the structural layout of concrete square and round water tank, thinking about the overall price of the tank as an goal feature with the homes of the tank viz. tank ability, width and period

of the tank, unit weight of water and tank ground slab thickness as layout variables. From the look at he concluded that an accelerated tank ability ends in accelerated minimal overall price of the square tank however reduced minimal overall price for the round tank. The tank ground slab thickness constitutes the minimal overall price for 2 styles of tanks. The minimal price is greater touchy to modifications in tank ability and ground slab thickness of square tank however in round kind is greater touchy to extrade in all variables. Increased tank ability ends in boom in minimal overall price. Increase in water intensity in round tank ends in boom in minimal overall price.

3. METHODOLOGY

The components of water treatment plant of capacity 200 MLD are designed by using the reinforced cement concrete and prestressed concrete. The components such as Clariflocculators, Sludge thickener, Recirculation sump and pumping house etc. resting on firm ground will be designed using Reinforced concrete and prestressed concrete.

The procedure used in the study is given below:

1) The components of the water treatment plant i.e. clariflocculator, sludge thickener and recirculation sumps are designed manually considering the forces acting on it and earthquake analysis using the RCC using design codes.

2) The same components i.e. clariflocculator, sludge thickener and recirculation sump are designed using the prestressed concrete method considering different loads acting on the components including the earthquake analysis using various codes.

3) The components which are designed manually by using Reinforced concrete and prestressed concrete are modeled and analyzed in the STAAD PRO software.

4) The moments calculated by manual analysis are cross checked and validated with the moments obtained from STAAD analysis.

5) Estimation of the three components is done considering the quantity of concrete and steel required as per the design. Labour cost and machinery cost will also be included in the estimation of RCC and PSC components.

6) Cost comparison between the Reinforced concrete and prestressed concrete design is carried out based on the estimation to check whether the PSC design is economical.

7) The comparison between the Reinforced concrete and prestressed concrete is also carried out considering other parameters such as water tightness and crack formation in concrete etc.

4. RESULT & CONCLUSION

Results obtained from manual design of RCC and PSC components using IS codes and analysis with help of STAAD PRO are discussed. Comparison between RCC and PSC components is done on the basis of different parameters.

Table 1: Dimensions of components of WTP.

Component	Diameter (m)	Height (m)	F.B (m)
Clariflocculator	51	3.15	0.5
Recirculation Sump	28.3	4	0.5
Sludge thickener	21	2.5	-

Design moments obtained from the manual analysis of the components (Clariflocculator, Recirculation sump & Sludge thickener) and moments obtained from STAAD analysis of the components are compared below in the table.

Table 2: Comparison of Moments

Components	Design moments (kN-m)		
	RCC	PSC	STAAD Pro
Clariflocculator	22.22	21.83	23.14
Recirculation sump	29.22	27.90	30.12
Sludge thickener	10.91	10.91	11.98

From the calculated design moments, design of three components is done. Estimation of the components is carried out for cost comparison between RCC and PSC components. M40 grade of concrete is used for the design of components. Steel reinforcement provided are Fe500 grade TMT bars.

Overall summery of cost comparison between RCC and PSC components and percentage saving in cost is listed in the table below.

Table 3: Cost comparison between RCC and PSC components

Component	Clarifloc-culator	Recircu-lation sump	Sludge-thickener
Volume (m3)	7456.29	2830.57	865.90
RCC Cost (Rs)	9700000	3850000	1780000
PSC Cost (Rs)	8198700	3340000	1983000
Cost Saving (Rs)	1501300	510000	-203000
% Saving	15.47	13.24	-10.23

Following are the screenshots from StaadPro modeling of the structure.

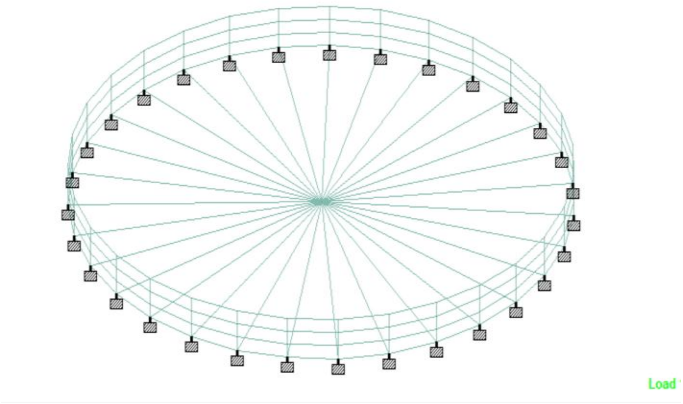

Fig -1: Geometry of Structure

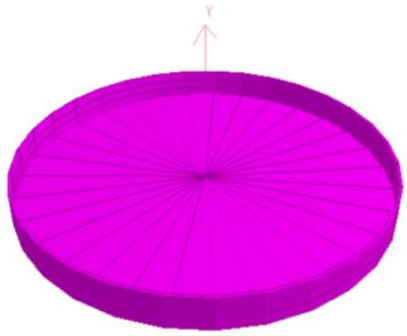

Fig -2: 3D view of structure

5. CONCLUSION

In the study, circular components of water treatment plant resting on ground are analysed and designed considering reinforced cement concrete and prestressed concrete using IS codes. STAAD PRO software is used to cross check the manual design moments. Estimation on the basis of design is carried out for both RCC and PSC components. Using MS EXCEL, spread sheets are prepared for RCC design of components, PSC design of components and estimation of the respective components. From the spread sheets design and estimation of tanks of different capacities is also carried out.

From the result of analysis and design the following conclusions are drawn:

1. Use of prestressed concrete for the construction of water retaining structures can be advantageous considering the water tightness as compared to RCC construction. As the prestressed concrete is stressed initially before application of loading, chances of cracking after application loads are very rare.

2. Prestressed concrete is more durable compared to reinforced cement concrete; therefore, PSC construction requires less maintenance than RCC construction.

3. Considering the construction cost, as seen from the results in previous chapter, for small capacity of tanks up to 1000 m3 RCC construction is economical compared to PSC construction. But as the capacity of the tank goes on increasing, PSC construction becomes economical. For larger capacity tanks PSC construction is economical than RCC construction by 17 % for M40 grade concrete and 15.75 % for M50 grade concrete on average.

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