Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 8, No. 3, August : 2023

"DESIGN AND ANALYSIS OF CIRCULAR WATER TANK AND INTZE TANK AND CHECK FOR CRACK WIDTH"

Ms. Rahul Salecha Mtech Scholar, Department of Civil Engineering rahulsalecha619@gmail.com
Mr. Pukhraj Sahu Assistant Professor & Department of Civil Engineering Government Engineering College, Jagdalpur (C.G.) pukhrajsahu@gmail.com
Mr. Pravek Sahu Assistant Professor & Department of Civil Engineering Government Engineering College, Jagdalpur (C.G.) spravek619@gmail.com

ABSTRACT:
Water tank plays a crucial role in storing and supplying water for various applications. The design of water tanks requires careful considerations of structural integrity and durability. IS 3370 covers the design and construction of reinforced concrete structures, including water tanks. This thesis investigates the design and assesses crack width as per new provision IS 3370:2021 to ensure long term performance and safety for Design of Intze water tank and Circular water tank with rigid base and Flexible base. The design of the Reinforced Concrete (RC) water tank has been carried out using the working stress method as per IS 3370 (Part- II):1965 in earlier time, which led to heavily reinforced and thicker concrete sections. IS 3370 (Part II) was revised in 2009, in line of Euro codes. As per revised IS 3370 (Part II) While following limit state method for design of RC liquid retaining structures, crack width needs to be less than 0.2 mm. Through control of cracking leakage of water and other durability problems can be avoided. For effective design procedure, the parameters affecting the crack width in RC water tank need to be understood. Pure tension cracks are more harmful to the serviceability of the structures that must be treated carefully. The present study aims to understand various parameters affecting crack width calculations for design of RC circular water tanks. Such relationships will be very useful to structural engineers for selecting the appropriate geometry and reinforcement details for the RC circular water tank that would ultimately help to keep the crack width under permissible limit.

Keywords: -
Intze water tank, Circular Water tank, Crack width, Permissible limit.

1. INTRODUCTION:

Water is a basic human needs for daily life sufficient water distribution depends on design of a water tank in certain area. A water tank is an essential component of a building water supply system. It serves as a reservoir for storing water that can be used for domestic or commercial purposes, including drinking, cooking, cleaning and fire fighting. When designing water tank, several factors need to be taken into consideration. These factors include the purpose of the tank, the amount of water it need to hold, the space available for the tank, the material of the tank and location of the tank. The purpose of the tank will determine the amount of water it need to hold. For example, a residential water tank will typically hold less water than a commercial or industrial tank. The space available for the tank will also influence its size and shape. A smaller space may require a vertical tank, while a larger space may allow for a horizontal or spherical tank. Water supply is a life line facility that must remain functional even if disaster occurred.

Fig – 1 – water tank

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 8, No. 3, August : 2023

2. LITERATURE REVIEW:

I.R. Saudagar, A.N. Shaikh [OCT 2019]:

The present study concerned with the performance of two types of elevated water tank with varying slopes by Response Spectrum Analysis on varying slopes. It is carried out by considering various parameters like water storage capacity and staging height which are constant, various types of staging arrangement and variation in the ground slope. By intercombining each of these parameters ten models of tank were created. All tank models have their locality in earthquake zone III. Dynamic response of elevated water tanks is hard to define, as the behavior of tank is unpredictable. All tank models are analyzed by Etabs software to study the effect of time periods, maximum displacement, base shear and base moment

Anjana M. V, Lakshmi Bliga [SEP 2021]:

Elevated circular water tanks in this project were manually designed utilising the limit state design method while referencing the standards IS 3370: 2009(Part I–IV), IS 456–2000, and ETABS. the amount of steel that the water tank needs in terms of area. Comparing software design to manual design, less steel is needed for the entire construction. In total, 9948 mm2 of steel are needed for manual design and 9334 mm2 for software design. Software design reduces the need for steel in the entire structure by 10% when compared to manual design. While using ETABS software to design a building takes less time and is more efficient than using a manual process. It is reported that there has been a little decrease in at the project.

Sapan Chawla, Sagar Jamle and Kundan Meshram [FEB 2020]:

The power assessment of the store or tanks is about the comparable free of the substance thought of the thing. All tanks are arranged as split free structures to discard any spillage. In this project, it concluded that the total vertical load on column is same but the bending moment keeps on increasing with increase in breeze speeds. Intensity of breeze pressure with total horizontal keeps on increase on increasing with increase in breeze speeds respectively. Column moment as base keeps on increasing with increase in breeze speed. Due to increase in breeze speeds, permissible stresses and moment on raft slab keeps on increasing. Area of steel required in Raft slab marked maximum on 55m/sec speed.

Tejaswini R, Mamatha A [AUG 2020]:

The recent edition for the design concerning towards liquid retaining structure have been revised. The revised edition incorporated limit state design method. In this method the structure is first designed under limit state of collapse, and then checked under serviceability. IS 3370:2009 adopts limit sate design. The elevated rectangular RC water tank designed under limit state design method and analysis carried out for the empty tank, full tank condition using linear static analysis and linear dynamic analysis using ETABS software. From the results it concludes that base shear and base moment for empty tank condition is more compare to full tank condition. Because of water tank is empty hence no water pressure from inside, only earthquake forces are acting from outer side only. Hence more base shear and base moment in empty tank condition.

3. OBJECTIVE OF THE PROJECT:

(i) To Compare the different aspects of Intze water tank and circular water tank with flexible base and rigid base.

(ii) To analysis for crack width for Intze water tank and circular water tank with flexible and rigid base and comparing their result.

4. DESGIN METHODS:

Three method of design are there:

(i) Working Stress Method

(ii) Limit State Method

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 8, No. 3, August : 2023

(iii) Ultimate Load Method

However, Ultimate load method has become obsolete these days. We have used working stress method and limit state method in this thesis.

5. METHODOLOGY:

These thesis compares water tanks of different configuration viz. Inze tank and Circular water tanks with different base conditions namely Rigid and Flexible with the help of IS codes 3370:2009 and checks their crack width as per IS 3370:2021. Comparison is made on the factors that one of the parameters for each of the criteria must be kept constant to provide a basis for comparison, Crack width checks are made with the assumption that concrete is weak in tension and takes none of it. So an equivalent section is made with proper stress and strain diagram and a perfectly defined neutral axis is stated, where flexure is predominant but some tension exists at the section, the depth of neutral axis should be adjusted.General basis of design is made in line with the IS 456:2000, water tanks designed below are designed for exposure class severe and cracks are checked and kept in line to satisfy the serviceability criteria of the limit state method of design adopted in the latest Indian Standard code 3370 -2021 part 2.

Fig-2 Flow Chart

Result Tabulation of Intze Tank

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 8, No. 3, August : 2023

S.No.	Components	Forces& Stresses	Steel required
1	Top Dome	Meridonial Force(T_1)= 22.22 KN/m Hoop Force (T_2)=9.78KN/m	8mm φ @ 200mm c/c Ast=2400 mm^2
2	Top Ring Beam	Horizontal component of T_1,W= 17.77 KN/m	12 φ @ 130mm c/c,Ast=869 mm^2 8φ – Legged vertical stirrups @ 225mm c/c Asv=100 mm^2
3	Cylindrical wall	Due to water inside, T=300 KN/m	12mmφ @180 mm c/c, Ast=2307 mm^2,8mmφ distribution steel @180 mm c/c,Ast =279 mm^2
4	Bottom Ring Beam	Due to superstructure and internal water pressure, H=75.45 KN/m	12 no. of 20mmφ,Ast=3769 mm^2
5	Conical Dome	Meridonial Force (T_3) =385 KN Hoop Tension (H_t)=499.26KN	16 mmφ@100 mm c/c, Ast =2011 mm^2, 10mm φ distribution steel @120 mm c/c, Ast=654 mm^2
6	Spherical Dome	Meridonial Force(T_4) =212.30KN/m	10mmφ@130mm c/c,Ast=604 mm^2
7	Bottom Circular Beam	Hoop Compression=452.96KN	18φ-6 nos,Ast=3694mm^2, *12φ- 4-Legged Vertical stirrups @ 150mm c/c, Asv=452* mm^2

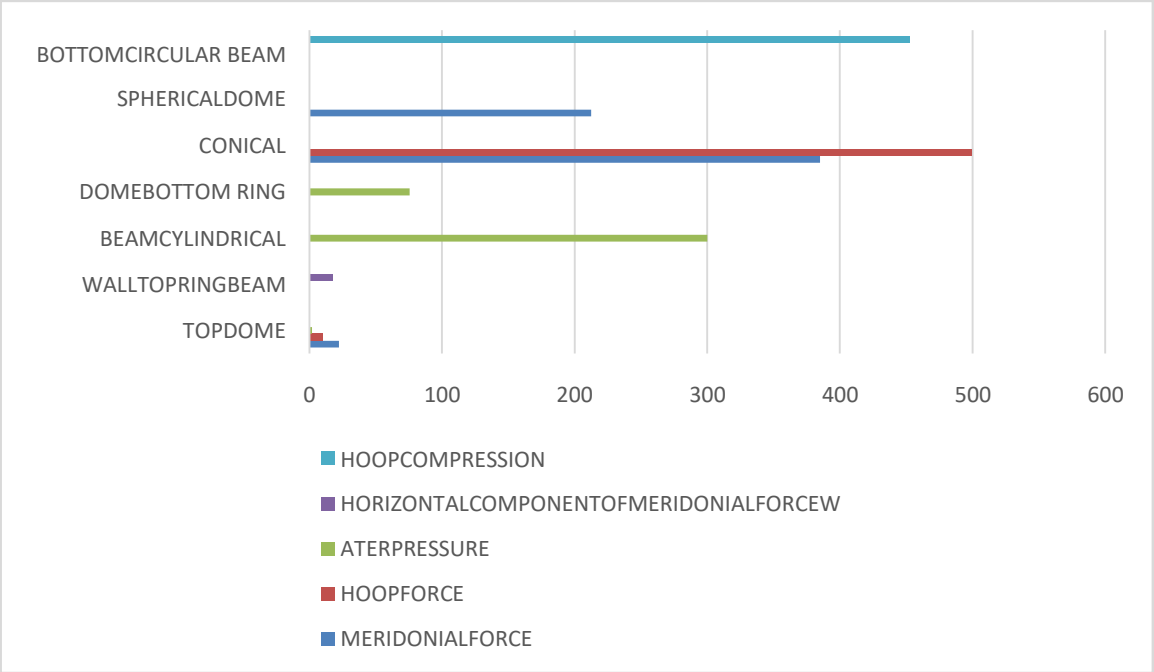

Fig-3 - Force on each component

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 8, No. 3, August : 2023

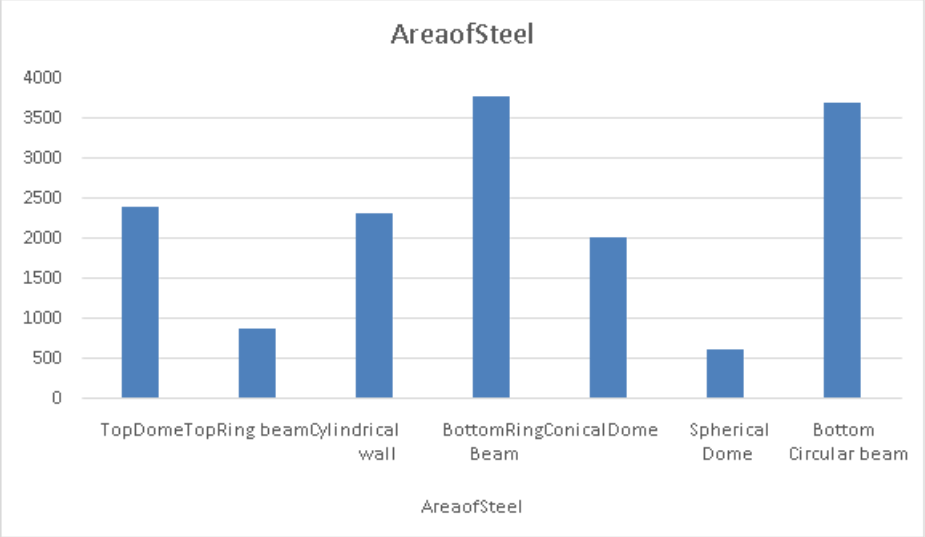

Fig-4-Area of steel for each component of Intze tank

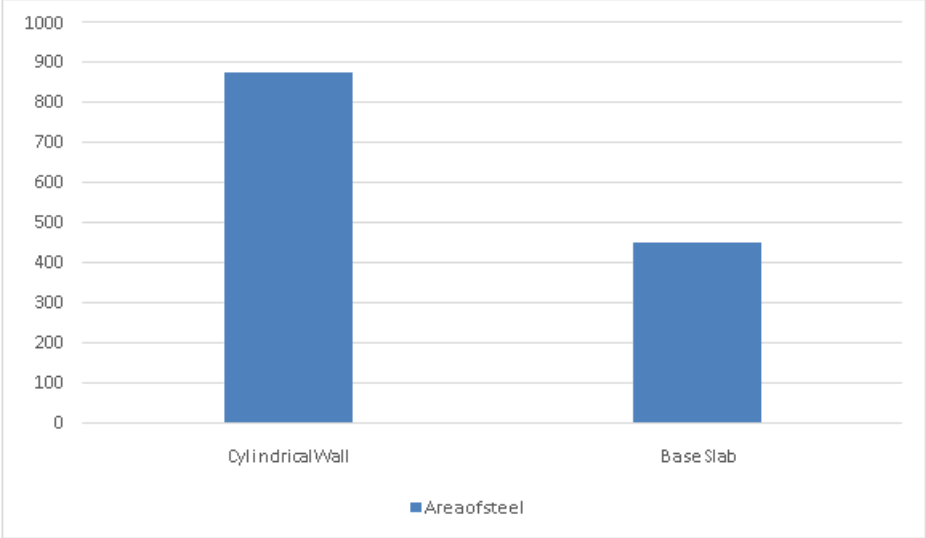

Fig-5 Area of steel required on each component of circular water tank with rigid base

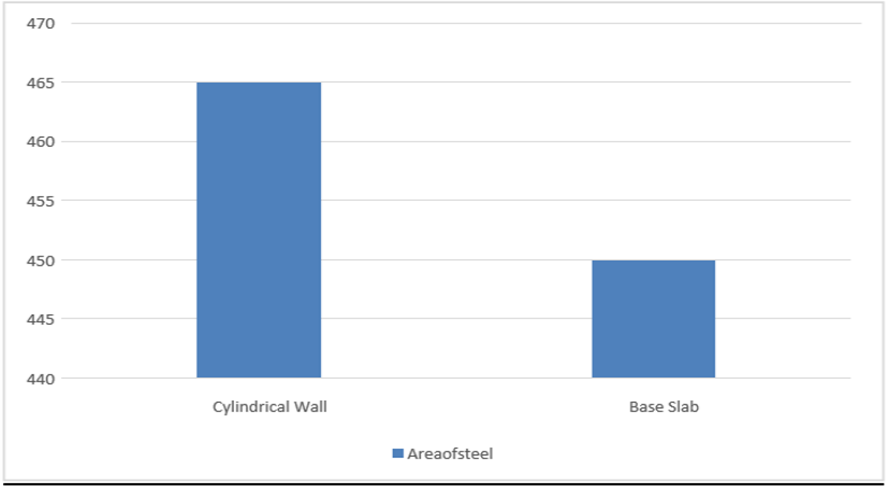

Fig-6 -Area of steel required on each component of circular water tank with flexible base

6. Result:

Results obtained from designing Intze tank and circular water tank with rigid and flexible base are

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 8, No. 3, August : 2023

comparted on the following basis

1. Comparison of Area of steel provided,

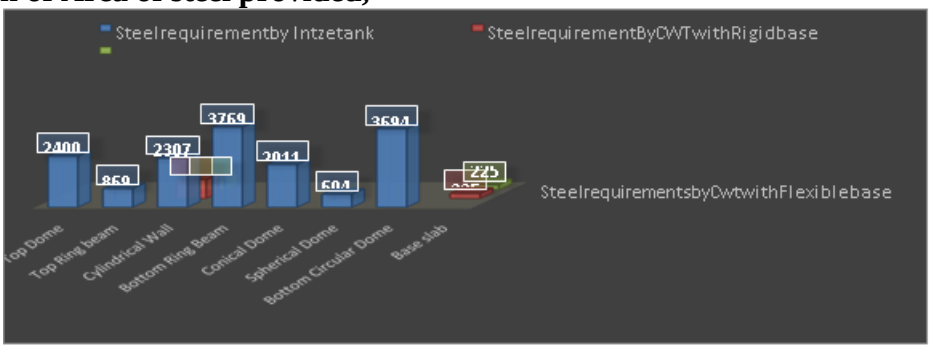

Fig-7-Area of steel tabulation

- Steel required for Intze type water tank is significantly more than that of Circular water tank for same capacity
- The walls of an Intze type water tank are subject to tensile force due to shape of the tank, which can cause cracking and weakening of structure if not properly Reinforced
- The complexity in the shape of an Intze tank creates more complex stresses and strains in concrete walls than a circular water tank
- However the Footprint of the Intze type water tank is preferred than that of a Circular water tank.

2. Comparison of thickness of cylindrical wall provided,

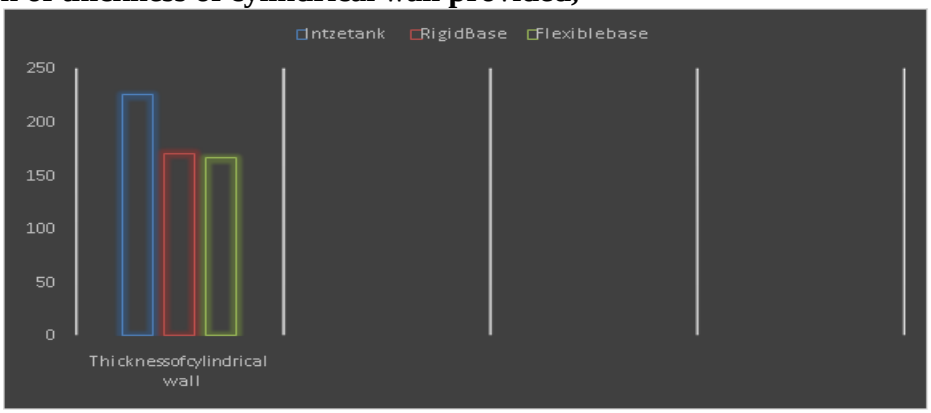

Fig 1.8 Cylindrical wall tabulation

Fig-8 Thickness of cylindrical wall tabulation

- Since the quantity water retained within the tank is kept constant, the thickness of cylindrical walls has close values to each other because design of thickness of cylindrical wall mostly depends upon the quantity of water retained.
- However the thickness of the walls of a tank is typically determined by several factors including the materials used, the shape and size of the tank and the loads and stresses that the tank will be subjected to.

3. Comparison of diameter of tanks provided,

- To compare the value of the diameters of Intze tank and circular water tanks for a given capacity, it is important to consider the intended use of the tank, the available space for the tank and cost of Construction& maintenance.
- In general, Intze tank may require less space and may be less expensive to construct and maintain, but may not be suitable for all applications.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 8, No. 3, August : 2023

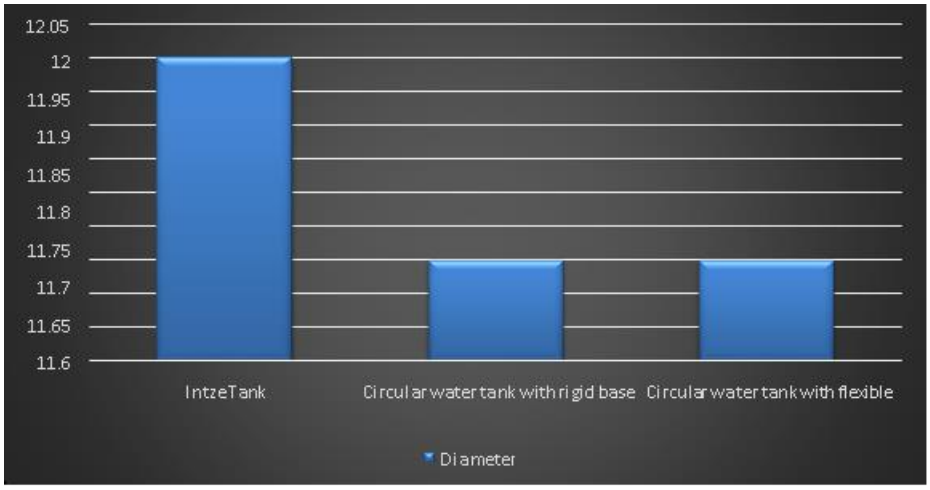

Fig -9 Diameter tabulation

4. Comparison of results of crack width:

Description	Intze tank	Rigid Base	Flexible Base
a_{cr} **Distance Up to Nearest Longitudinal Bar**	68.577 mm	69.073 mm	82.907 mm
Service stress M_s	32.663 N/mm2	5.243 N/mm2	-
Service stress T_s	186.577 N/mm2	90.799 N/mm2	109.125 N/mm2
Total stress σ_s	219.240 N/mm2	96.042 N/mm2	109.125 N/mm2
ε_1 at point considered	0.001288	0.000559	0.000642
ε_2-concrete stiffening	0.000379	0.000683	0.000529
ε_m-Average strain	0.000909	0.000124	0.000113
W_{cr}, crack width	0.171 mm	0.023 mm	0.024 mm

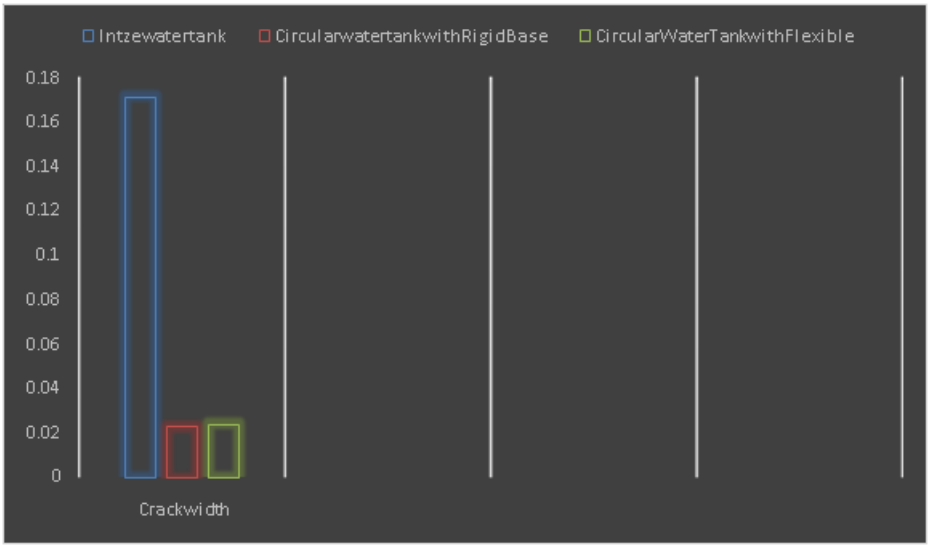

Fig -10-Crackwidth Result tabulation.

The Crack width in an Intze tank is typically greater than that of a circular water tank due to difference in their structural design and construction. Intze tanks are constructed with vertical reinforced concrete walls that curve inward at the top to form a dome shaped roof, these walls are generally thinner at the top and thicker at the base , which can result in greater stress concentration and hence higher potential for cracking.

Circular water tank on the other hand , are generally constructed with reinforced concrete walls that are of uniform thickness throughout the tank. This uniformity can help to distribute stress more evenly and reduce the potential for stress concentrations and cracking.

However, it is important to note that crack widths in both circular water tanks and intze tanks must still meet the allowable limits as per IS 3370 to ensure structural integrity of the tank.

It is important to note that IS 3370 is only a guideline, and other factors may need to be considered in determining the crack width such as choice of material, loads and stresses, workmanship etc.

7.CONCLUSION:

In conclusion, both Intze type water tank and Circular water tanks have their advantages and disadvantages

i. The complexity in the shape and design of Intze type water tank corresponds to the need of higher quantity of steel bars which can increase the cost of the construction, while a circular water tank with similar characteristics can be found a bit lower as per the cost point of view
ii. The component design of Intze type water tank are found to be tedious ,yet it is mostly preferred over the circular type water tank due to its less requirement of space on the ground and better aesthetics.
iii. The Crack width in Intze tank was found to be significantly more than that in Circular water tank of flexible and rigid bases, hence there is a requirement of frequent maintenance.
iv. The crack width check was performed as per the IS codes, and it was found that all the sections in the water tank are deemed to satisfy the serviceability criteria of limit state design.
v. The Best selection of the shape, size and type of water tank is governed by various factors such as required capacity, availability of space, budget and local building codes.

8.FUTURE SCOPE:

A. The demand for liquid storage structures is likely to continue to grow, which could lead to the need of new guidelines for the design and construction of different types of structures.
B. Furthermore crack width calculation of mature concrete is calculated above does not incorporate the thermal and moisture parameters of immature concrete.
C. Design of staging of intze tank has been relegated and seismic and earthquake forces are not taken into account while a detailed reinforced tank schematic is presented.
D. Formulation of crack width done as per the new IS code includes incorporation of thin and thick sections corresponding to related clauses

9. ACKNOWLEDGEMENT:

I wish to express my sincere appreciation to my guide, Mr. Pukhraj Sahu (Assistant Professor) postgraduation civil department for his inspiration, encouragement, enthusiastic guidance and invaluable suggestions. Without his continued support and interest in this project, this would not have been the same as presented here. His constant support and interest in the subject helped me with a great understanding of different aspects of the required planning for the project work. He has shown keen interest in this dissertation work right from the beginning and has a great motivating factor in outlining the flow of my work. I wish to acknowledge a deep sense of hearty gratitude to Dr. A.K. Dubey Principal of Government Engineering college, Jagdalpur (C.G.), who gave me this opportunity and valuable suggestions during this project which has been invaluable. I am thankful to all researchers of this field and my batch mates whose valuable support helped me all through.

References:

1. IS CODE 3370: 2009.
2. IS CODE 370: 2021 New version
3. Parag R. Chopade, Dr. P. O. Modani, "A review on comparative study of design of water tank with IS code 3370:1965 and IS 3370:2009", International research journal of engineering and technology – JAN 2019.
4. Anjana M.V., Lakshmi Baliga, "Comparative study on the design of elevated circular concrete water tank", International research journal of engineering and technology – SEP 2021.
5. Sapan Chawla, Sagar Jamle and Kundan Meshram, "An analytical approach to find out the efficient design of Intze water tank as per different breeze speed of India", International journal of current engineering and technology – FEB 2020.
6. Tejaswini R, Mamatha A, "Design and analysis of elevated water tank", International research journal of engineering and technology – AUG 2020.
7. Prasad B. Karad, Dr. Paresh V. Patel, "Parametric study of crack width in reinforced concrete circular water tank under direct tension as per IS code 3370:2009", International conference on innovative advancement in engineering and technology – 2020.
8. Kanan D. Prajpati, Nirmal S. Mehta, Ronak N. Modi, "Comparative study of water tank by WSM and LSM", International journal of creative research thoughts- JULY- 2021
9. Vineet Kumar Saha, Ashish Nim, "Design of RCC rectangular water tank: A comparative study between approximate and IS code method", Research gate