© 2018 IJSRST | Volume 4 | Issue 8 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Seismic Analysis and Design of INTZ Water Tank by Using Staadpro

Talari Obulapathi[1], Syed Rizwan[2], Dr. C. Rama Chandrudu[3]

*[1]M.Tech Student, Chiranjeevi Reddy Institute of Engineering & Technology, Anantapur, Andhra Pradesh, India
*[2 & *3]Assistant Professor and Professor, Civil Engineering Department , Chiranjeevi Reddy Institute of Engineering & Technology, Anantapur, Andhra Pradesh, India

ABSTRACT

Water tank is used extensively for storage water, inflammable liquids, and other chemicals. The current analysis and design of supporting structures of elevated water tanks are extremely vulnerable under lateral forces due to wind and an earthquake, By past provided illustration when a great many water tank staging's suffered damage and a few collapses. The aim of this paper is to understand the behaviour of Elevated Water Tank with the framed staging in lateral earthquake loading using Indian code guidelines by using Staad Pro. By using Rapid Assessment of Seismic Safety of Elevated Water Tank gives the optimum value of Base Shear and Base Moment and hence it is economical. The design based on above gives the most economical section and also it is safe.

Keywords : Elevated Water Tank, Intz Water Tank, Siesmic Analysis, Earthquake, Shear, Moment

I. INTRODUCTION

For storage of large quantities of liquids like water, oil, petroleum, acid and sometime gases also, containers or tanks are required. These structures are made of masonry, steel, reinforced concrete and pre stressed concrete. Out of these, masonry and steel tanks are used for smaller capacities. The cost of steel tanks is high and hence they are rarely used for water storages. Reinforced concrete tanks are very popular because, besides the construction and design being simple, they are cheap, monolithic in nature and can be made leak proof. Generally no cracks are allowed to take place in any part of the structure of Liquid Retaining R-C.C. tanks and they are made water tight by using richer mix (not less than M 30) of concrete. In addition sometimes water proofing materials also are used to make tanks water tight.

II. METHODS AND MATERIAL

1.1 OBJECTIVES

1. To make a study about the analysis and design of water tanks.
2. To make a study about the guidelines for the design of liquid retaining structure according to IS Code.
3. To know about the design philosophy for the safe and economical design of water tank.
4. To develop programs for the design of water tank of flexible base and rigid base and the underground tank to avoid the tedious calculation
5. In the end, the programs are validated with the results of manual calculation given in concrete Structure.

1.2 WATER QUANTITY ESTIMATION:

The quantity of water required for municipal uses for which the water supply scheme has to be designed requires following data:

Water consumption rate (Per Capita Demand in liters per day per head) Population to be served.
Quantity= Per Capita demand x Population

Water Consumption for Various Purposes Table (1.1)

Types of Consumption	Normal Range(lit/capita/day)	Average	%
Domestic Consumption demand	65-300	160	35
Industrial and Commercial demand	45-450	135	30
Public including Fire Demand	20-90	45	10
Losses and Waste	45-150	62	25

1.3 POPULATION FORECASTING METHODS:

The various methods adopted for estimating future populations are given below. The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discretion and intelligence of the designer.

1. Incremental Increase Method
2. Decreasing Rate of Growth Method
3. Simple Graphical Method
4. Comparative Graphical Method
5. Ratio Method
6. Logistic Curve Method
7. Arithmetic Increase
8. Geometric Increase Method

1.4 CLASSIFICATION OF R.C.C. TANKS:

In general they are classified in three categories depending on the situation.

1. Tanks resting on ground.
2. Tanks above ground level (Elevated tanks).
3. Underground tanks.

1.4.1 TANKS RESTING ON GROUND:

These are used for clear water reservoirs, settling tanks, aeration tanks etc. These tanks directly rest on the ground. The wall of these tanks is subjected to water pressure from inside and the base is subjected to weight of water from inside and soil reaction from underneath the base. The tank may be open at top or roofed. Ground water tank is made of lined carbon steel, it may receive water from water well or from surface water allowing a large volume of water to be placed in inventory and used during peak demand cycles

Fig: Tank resting on the ground

1.4.2 ELEVATED TANKS:

These tanks are supported on staging which may consist of masonry walls, R.C.C tower or R.C.C. column braced together- The walls are subjected to water pressure from inside. The base is subjected to weight of water, wt. of walls and wt. roof. The staging has to carry load of entire tank with water and is also subjected to wind loads. Water tank parameters include the general design of the tank, choice of materials of construction, as well as the following. Location of the water tank (indoors, outdoors, above ground or underground) determines color and construction characteristics. Volume of water tank will need to hold to meet design requirements.

Fig: Elevated tank

1.4.3 UNDER GROUND TANKS:

These tanks are built below the ground level such as clarifiers filters in water treatment plants, and septic tanks .The walls of these tanks are subjected to water pressure from inside and earth pressure from outside. The design principles of underground tanks are same as for tanks resting on the ground. The walls of the underground tanks are subjected to internal water pressure and outside earth pressure. The section of wall is designed for water pressure and earth pressure acting separately as well as acting simultaneously. Whenever there is possibility of water table to rise, soil becomes saturated and earth

Fig: Underground Tank

III. INTZ TANKS

This is a special type of elevated tank used for very large capacities. Circular tanks for very large capacities prove to be uneconomical when flat bottom slab is provide.

Intz type tank consist of top dome supported on a ring beam which rests on a cylindrical wall .The walls are supported on ring beam and conical slab. Bottom dome will also be provided which is also supported by ring beam. The conical and bottom dome are made in such a manner that the horizontal thrust from conical base is balanced by that from the bottom dome. The conical and bottom domes are supported on a circular beam which is in turn, supported on a number of columns. For large capacities the tank is divided into two compartments by means of partition walls supported on a circular beam.

Fig: Intz type water tank

2.1 PROVISIONS OF INDIAN CODE:

Indian Standard IS: 1893-1984 provides guidelines for earthquake resistant design of several types of structures including liquid storage tanks. This standard is under revision and in the revised form it has been divided into five parts. First part IS 1893 (Part 1): 2002; which deals with general guidelines and provisions for buildings has already been published. Second part, yet to be published, will deal with the provisions for liquid storage tanks. In this section, provisions of IS: 1893-1984 for buildings and tanks are reviewed briefly followed by an outline of the changes made in IS 1893 (Part 1): 2002.

In IS: 1893-1984, Base Shear for building is given by $V = C_S W$, where, C_S is the Base Shear

Coefficient given by

C_S = K C βI α_O. Here,

K = Performance factor depending on the structural framing system and brittleness or ductility of construction;

C = Coefficient defining flexibility of structure depending on natural period T;

β = Coefficient depending upon the soil-foundation system; I = Importance factor;

α_O = Basic Seismic Coefficient depending on Zone.

For buildings with moment resisting frames, K = 1.0. Importance factor, for buildings is usually I = 1.0.

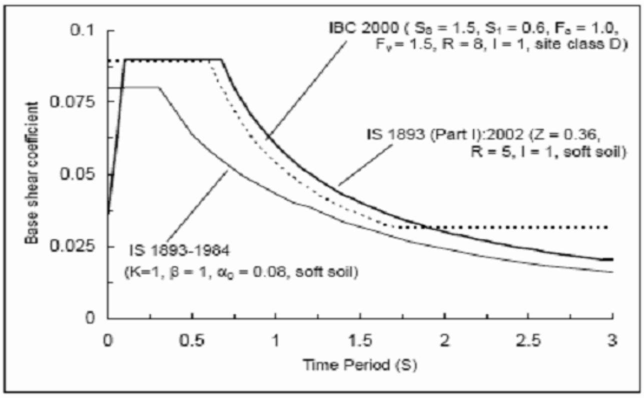
IS: 1893-1984; does not have any provision for ground-supported tanks. It has provisions for elevated tanks, for which it does not consider Convective Mode. Base Shear for elevated tank is given by V = C_S W, where, Base Shear Coefficient, C_S is given by

C_S = βI F_O (S_a/g) Here,

S_a/g = Average Acceleration Coefficient corresponding to the time period of the tank, obtained from acceleration spectra given in the code;

F_O = Seismic Zone Factor;

W = Weight of container along with its content and one-third weight of supporting structure.



Comparison of BSC of Building obtained from IS Codes & IBC 2000

IV. ANALYSIS AND RESPONSE

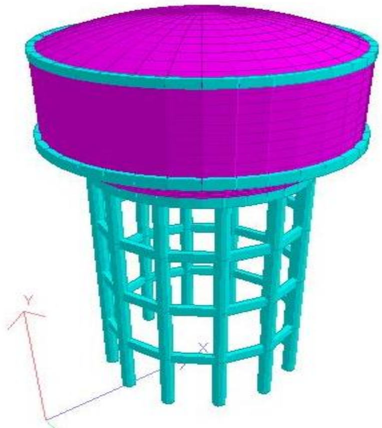


Fig: 3d Model

CENTER OF GRAVITY OF EMPTY CONTAINER

Components of empty container are: top dome, top ring beam, cylindrical wall, bottom ring beam, bottom dome, conical dome and circular ring beam. Height of CG of empty container above top of circular ring beam,

= [(209.3 x 7.22) + (52.1 x 5.9) + (552.9 x 3.8) + (107.2 x 1.65)

+ (321.3 x 1) + (185.6 x 0.92) – (148 x 0.3)] / 1,576

= 2.88 m

Height of CG of empty container from top of footing, h_{cg} = 16.3 + 2.88 = 19.18 m.

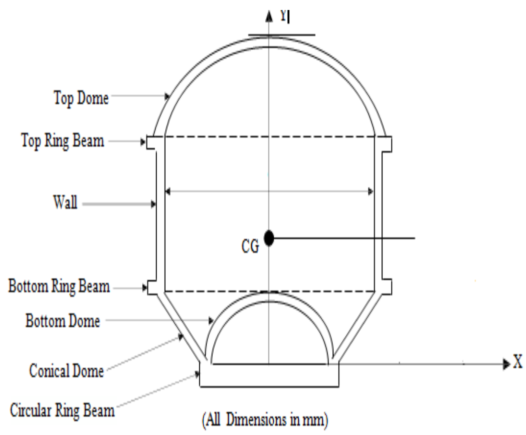


Fig: Parts of tank

MODELLING:

Creation of nodes.

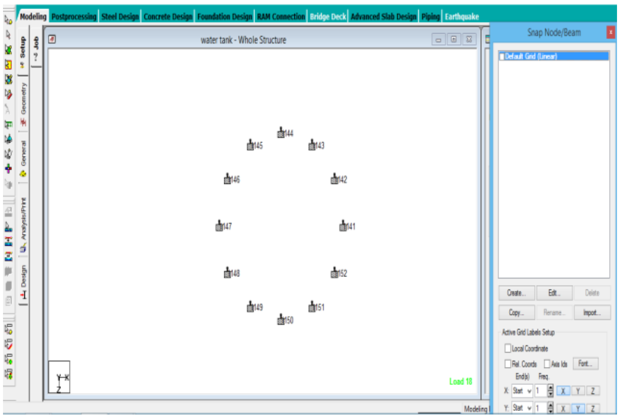


Fig: Nodes

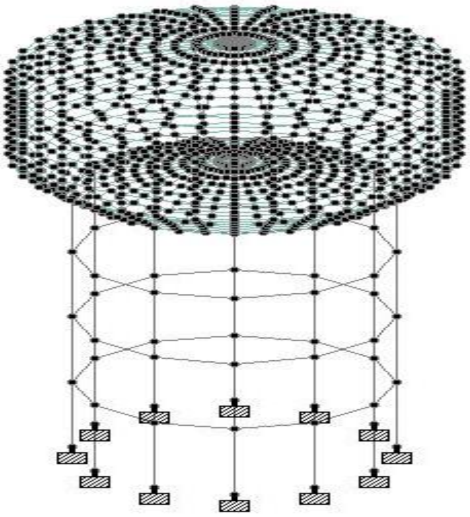


Fig: Model with nodes

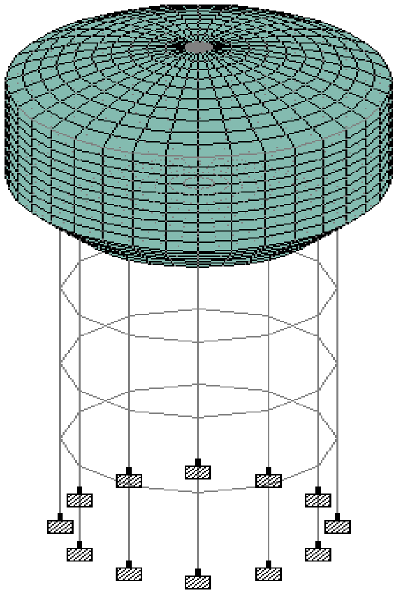


Fig: Model with beams & Plates.

V. DESIGN CONCEPT

In water retaining structure a dense impermeable concrete is 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 30 kN/m3.The design of the concrete mix shall be such that the resultant concrete issue efficiently impervious. Efficient compaction preferably by vibration is essential. The permeability of the thoroughly compacted concrete is dependent on water cement ratio. Increase in water cement ratio increases permeability, while concrete with low water cement ratio is difficult to compact. Other causes of leakage in concrete are defects such as segregation and honey combing. All joints should be made water-tight as these are potential sources of leakage. Design of liquid retaining structure is different from ordinary R.C.C, structures as it requires that concrete should not crack and hence tensile stresses in concrete should be within permissible limits. A reinforced concrete member of liquid retaining structure is designed on the usual principles ignoring tensile resistance of concrete in bending. 1. For calculation purposes the cover is also taken into concrete area. Cracking may be caused due to restraint to shrinkage, expansion and contraction of concrete due to temperature or shrinkage and swelling due to moisture effects. Such restraint may be caused by

(i) The interaction between reinforcement and concrete during shrinkage due to drying.

(ii) The boundary conditions.

(iii) The differential conditions prevailing through the large thickness of massive concrete

Use of small size bars placed properly, leads to closer cracks but of smaller width. The risk of cracking due to temperature and shrinkage effects may be minimized by limiting the changes in moisture content and temperature to which the structure as a whole is subjected. The risk of cracking can also be minimized by reducing the restraint on the free expansion of the structure with long walls or slab founded at or below ground level, restraint can be minimized by the provision of a sliding layer.

FLOORS

(i) Provision of movement joints.

Movement joints should be provided as discussed in article 3.

(ii) Floors of tanks resting on ground.

If the tank is resting directly over ground, floor may be constructed of concrete with nominal percentage of reinforcement provided that it is certain that the ground will carry the load without appreciable subsidence in any part and that the concrete floor is cast in panels with sides not more than 4.5m. with contraction or expansion joints between.

(iii) Floor of tanks resting on supports.

(a) If the tank is supported on walls or other similar supports the floor slab shall be designed as floor in buildings for bending moments due to water load and self weight

(b)When the floor is rigidly connected to the walls (as is generally the case) the bending moments at the junction between the walls and floors shall be taken into account in the design of floor together with any direct forces transferred to the floor from the walls or from the floor to the wall due to suspension of the floor from the wall.

(c) In continuous T-beams and L-beams with ribs on the side remote from the liquid, the tension in concrete on the liquid side at the face of the supports shall not exceed the permissible stresses for controlling cracks in concrete. The width of the slab shall be determined in usual manner for calculation of the resistance to cracking of T-beam, L- beam sections at supports.

(d)The floor slab may be suitably tied to the walls by rods properly embedded in both the slab and the walls. In such cases no separate beam (curved or straight) is necessary under the wall, provided the wall of the tank itself is designed to act as a beam over the supports under it.

WALLS

(i)Provision of joints:

(a)Where it is desired to allow the walls to expand or contract separately from the floor, or to prevent moments at the base of the wall owing to fixity to the floor, sliding joints may be employed.

(b)The spacing of vertical movement joints should be as discussed in article 3.3 while the majority of these joints may be of the partial or complete contraction type, sufficient joints of the expansion type should be provided to satisfy the requirements given in article

(ii)Pressure on Walls:

(a) In liquid retaining structures with fixed or floating covers the gas pressure developed above liquid surface shall be added to the liquid pressure.

(b)When the wall of liquid retaining structure is built in ground, or has earth embanked against it, the effect of earth pressure shall be taken into account.

(iii) Walls or Tanks Rectangular or Polygonal in Plan.

While designing the walls of rectangular or polygonal concrete tanks, the following points should be borne in mind.

In plane walls, the liquid pressure is resisted by both vertical and horizontal bending moments. An estimate should be made of the proportion of the pressure resisted by bending moments in the vertical and horizontal planes.

DOMES:

A dome may be defined as a thin shell generated by the revolution of a regular curve about one of its axes. The shape of the dome depends on the type of the curve and the direction of the axis of revolution. In spherical and concoidal domes, surface is described by revolving an arc of a circle. The centre of the circle may be on the axis of rotation (spherical dome) or outside the axis (concoidal dome). Both types may or may not have a symmetrical lantern opening through the top. The edge of the shell around its base is usually provided with edge member cast integrally with the shell.

Design of Reinforced Concrete Domes:

The requirements of thickness of dome and reinforcement from the point of view of induced stresses are usually very small. However, a minimum of 80 mm is provided so as to accommodate two layers of steel with adequate cover. Similarly a minimum of steel provided is 0.15% of the sectional area in each direction along the meridians as well as along the latitudes. This reinforcement will be in addition to the requirements for hoop tensile The reinforcement is provided in the middle of the thickness of the dome shell Near the edges usually some ring beam is provided for taking the horizontal component of the meridian stress.

VI. OVERHEAD WATER TANKS AND TOWERS

Overhead water tanks of various shapes can be used as service reservoirs, as a balancing tank in water supply schemes and for replenishing the tanks for various purposes. Reinforced concrete water towers have distinct advantages as they are not affected by climatic changes, are leak proof, provide greater rigidity and are adoptable for all shape

Components of a water tower consists of-

(a) Tank portion with : Roof and roof beams

(1) sidewalls
(2) Floor or bottom slab
(3) Columns
(4) Bracings
(5) Foundation

VII. CONCLUSION

Storage of water in the form of tanks for drinking and washing purposes, swimming pools for exercise and enjoyment. Design of water tank is a very tedious method. Without power also we can consume water by gravitational force. Intz water tank is designed for seismic loads.

VIII. REFERENCES

1. Rai Durgesh C; "Performance of Elevated Tanks in Bhuj Earthquake"; Proc. Indian Acad. Sci. (Earth Planet Sci.), 112, No. 3, September 2003.pp 421-429.
2. Jaiswal O. R., Rai Durgesh C and Jain Sudhir K; "Review of Code Provisions on Design Seismic Forces for Liquid Storage Tanks"; Document No.: IITK-GSDMA-EQ01-V1.0, Final Report: A - Earthquake Codes, IITK GSDMA Project on Building Codes.
3. Indian Institute of Technology Kanpur, IITK GSDMA Guidelines for Seismic Design of Liquid Storage Tanks, August 2005.
4. IS 1893:1984, criteria for earthquake resistant design of structures
5. IS 875:1987, Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 3: Wind Loads
6. Vazirani & Ratwani, "Concrete Structures", Khanna Publishers, Year of Publication 1996