
Design And Analysis Of Elevated Water Tank By Using Staad Pro

Vaseem Akhtar¹, Shaik Rehman² S Zubeeruddin³

¹P.G. Scholar, ²Guide, Assistant Professor, ³Head Of Department

^{1,2,3} Branch : Structural Engineering

^{1,2,3} Geethanjali College of Engineering and Technology, kurnool

Email: ¹ vaseemakhtarce@gmail.com, ³ avrsvr_ec@rediffmail.com

ABSTRACT

This project gives in brief, the theory behind the design of liquid retaining structure. Water tanks are the storage containers for storing water. Elevated water tanks are constructed in order to provide required head so that the water will flow under the influence of gravity the construction practice of water tanks is as old as civilized man. The water tanks project has a great priority as it serves drinking water for huge population from major metropolitan cities to the small population living in towns and villages.

The profile of water tanks begins with the application parameters, thus the type of materials used and the design of water tank was dictated by these variables: 1. Location of the water tank (indoors, outdoors, above ground or underground). 2. Volume of water tank need to hold. 3. What the water will be used for? 4. Temperature of area where will be stored, concern for freezing. 5. Pressure required delivering water. 6. How the water to be delivers to the water tank. 7. Wind and earthquake design considerations allow water tanks to survive seismic and high wind events. The present work is all about design of elevated circular water tank in staad pro. Finally we will get the results in staad pro.

INTRODUCTION

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The force analysis of the reservoirs or tanks 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 and react with concrete and, therefore, no special treatment to the surface is required. Industrial wastes can also be collected and processed in concrete tanks with few exceptions. The petroleum product such as petrol, diesel oil, etc. are likely to leak through the concrete walls, therefore such tanks need special membranes to prevent leakage. Reservoir is a common term applied to liquid storage structure and it can be below or above the ground level. Reservoirs below the ground level are normally built to store large quantities of water whereas those of overhead type are built for direct distribution by gravity flow and are usually of smaller capacity.

For storage of huge quantity of fluids like water, oil, petroleum, acid and sometime gases also, flasks or tanks are essential. These structures are ready of masonry, steel, steel-clad existing and pre-stressed concrete. Out of these, masonry and steel tanks are used for minor sizes. The rate of steel tanks is great and hence they are hardly used for water storages. Reinforced concrete tanks are actual general because, besides the structure and design being

simple, they are low-cost, massive in nature and can be made leakage proof. Generally, no cracks are allowed to take place in any portion of the structure of Liquid Retaining RCC tanks and they are made water tight by using richer mix (not $> M 30$) of concrete. In addition, occasionally water proofing resources also are used to make tanks water tight. Storage of water in the system of tanks for drinking and washing purposes, swimming pools for workout and fun and sewage sedimentation tanks are purchase increasing importance in the current day life. A water tank is used to stock water to tide over the daily necessities. Elevated tanks are supported on production which may involve of masonry walls, RCC columns braced together, counter walls subjected to water pressure. In water supply scheme, water tanks usually account for 10% to 20% of the total cost. This is fairly substantial proportion and thus, there is a essential to achieve low-cost in construction of water tanks. The mountain for storage of huge quantity of fluids like water, oil, petroleum, acid and sometime gases also, flasks or tanks are essential.

1.1 CLASSIFICATION OF R.C.C. TANKS

In common they are categorized in three types depending on the position.

- Tanks resting on ground.
- Tanks above ground level (Elevated tanks).
- Underground tanks.

1.1(a) Tanks Resting on Ground: These are used for strong water reservoirs, settling tanks, aeration tanks etc. these tanks indirectly rest on the ground. The walls of these tanks are exposed to water pressure from inside and the base is exposed to weight of water from inside and soil reaction from under the base. The tank may be exposed at upper or covered. Water tank is completed of lined carbon steel, it may accept water from water well or from surface water permitting a large volume of water to be placed in inventory and used through peak demand series.

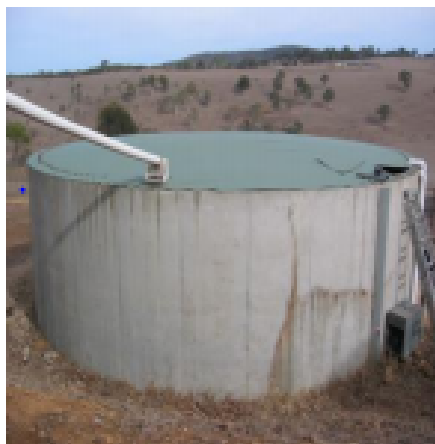


Figure 1(a): circular tank resting on ground

Due to hydrostatic pressure, the tank has tendency to increase in diameter. This increase in diameter all along the height of the tank depends on the nature of joint at the junction of slab and wall as shown in Fig 1(b).

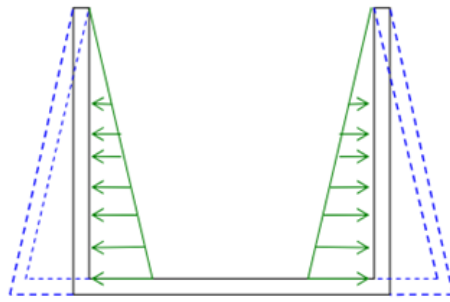


Figure 1(b): circular tank with flexible base

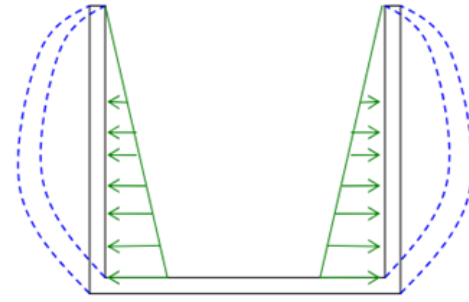


Figure 1(c): circular tank with rigid base

When the joints at base are flexible, hydrostatic pressure induces maximum increase in diameter at base and no increase in diameter at top. This is due to fact that hydrostatic pressure varies linearly from zero at top and maximum at base. Deflected shape of the tank is shown in Fig.1(b). When the joint at base is rigid, the base does not move. The vertical wall deflects as shown in Fig.1(b).

LITERATURE REVIEW

An exhaustive literature review revealed that a minimum amount of research work had been done on this topic in India. Comparison between IS 3370 :2009 and PCA Table is not Evaluated yet. Comparative study of IS 3370:2009 and Staad Pro is not accomplished. Monolithic behaviour of the tank is not occupied in the CODE.

From the review of earlier investigations, it is found that considerable work has been done on the method of analysis and design of water towers. Attempts have also been made by various designers and research workers to give the ratio of optimized geometrical parameters for the design of container and optimized parameters for the design of staging. Very little work has been made on optimized design of foundation for various types of soil conditions

- In 1956 an exact analysis of Intze tank based on membrane theory with continuity correction was formulated by Arya. This method was further generalized by Arya¹ for ax symmetric shell structures. The supporting structure of reinforced concrete overhead tanks with columns and peripheral braces is highly indeterminate for lateral loads.
- S.K.Kundodeals with a simple method of approximating the shear due to lateral loads in different part of frame. Mazhar Ali Khan has analyzed the water tower staging by the three-dimensional frame analysis approaches.
- Jain and choubé suggested a rapid method of estimating deflection at the top required for calculating the seismic force on water tower. Jain, Prakash, Singh, Saxena have carried out a detailed analysis of cost and requirements for materials for Intze tank of various capacities , staging height , bearing capacities of soil and lateral forces due to wind or earthquake on the basis of analysis of number of equations for rapid estimation of cost and materials for the Intze tanks have been presented.
- P.karunakar Rao and G.V. Sreekantiah suggest an alternative concept for the planning of large capacity water towers. For the same capacity, using twin cylindrical containers of equal capacity in place of single container achieved an overall economy.
- T.M.S. Raghawan and C.V.S.K. Rao have given the steps for the optimized design of Intze tanks on shaft.
- Structural analysis of columns and braces in the supporting frame work overhead tanks for gravity, wind and earthquake loads in compact form to minimize the calculation and

also to visualize the effect on various parameters like number of columns, number of braces etc on different quantities of interest, has been given by C.V.S.K. Rao Worldwide concern about unexpectedly low durability is being observed.

- Low durability is being perceived as one of the potential threats to the future of the concrete industry (Mehta and Gerwick 1996). A report of the U.S. National Materials Advisory Board, for instance, indicates that in 1987 approximately 253,000 concrete bridge decks, some less than 20 years old, were found to be in varying states of deterioration.
- A survey of automobile parking garages in Canada (Litvan and Bickley 1987) found that several billion dollars would be needed for the repair of concrete structures which had shown serious deterioration much earlier than their designated service life.
- Cases of premature and serious deterioration have been reported from around the world with undersea tunnels and with marine structures in California and eastern Canada (Gerwick 1989).
- Even though no such data are available for India, undoubtedly the amount spent on repair and rehabilitation of concrete structures would be staggering. Durability and service life of concrete structures is mainly governed by micro structural and transport properties of concrete and environmental exposed parameters.
- Some constitutive and simulation models for theoretical and mathematical prediction of durability and service life performance related micro structural engineering properties, e.g., porosity, permeability, surface area, volume of phases, etc., have been proposed and modified.
- Methods for analytical and experimental determination of physical and chemical characteristics affecting the durability of concrete are proposed by Papadakis et al. (1992a, b).
- Some in situ and laboratory methods are devised to measure the durability parameters. The experience in applying these in situ test methods and interpreting their results in terms of state of durability of reinforced concrete structures is limited. Of the available in situ test methods, the better known are the initial surface absorption test after (1973) water absorption and air permeation tests.
- Test methods by Pihlajavaara and Paroll (1975) and Kasai et al. (1984) are reported. In addition, many other in situ test methods based on both water and gas permeation principles are suggested.

METHODOLOGY

3.1 Design Requirement Of Concrete (I. S. I)

In water retaining structure a dense impermeable concrete is required therefore, proportion of fine and coarse 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 is sufficiently 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. Additionally, it should be ensured that tensile stress on the liquid retaining face of the equivalent concrete section does not exceed the permissible tensile strength of concrete as given in table 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. This can be provided by founding the structure on a flat layer of concrete with interposition of some material to break the bond and facilitate movement. In case length of structure is large it should be subdivided into suitable lengths separated by movement joints, especially where sections are changed the movement joints should be provided.

Where structures have to store hot liquids, stresses caused by difference in temperature between inside and outside of the reservoir should be considered.

The coefficient of expansion due to temperature change is taken as $11 \times 10^{-6}/C$ and coefficient of shrinkage may be taken as 450×10^{-6} for initial shrinkage and 200×10^{-6} for drying shrinkage.

Joints In Liquid Retaining Structures

Movement Joints: There are three types of movement joints.

1. **Contraction Joint.** It is a movement joint with deliberate discontinuity without initial gap between the concrete on either side of the joint. The purpose of this joint is to accommodate contraction of the concrete. The joint is shown in Fig.3.1 (a).

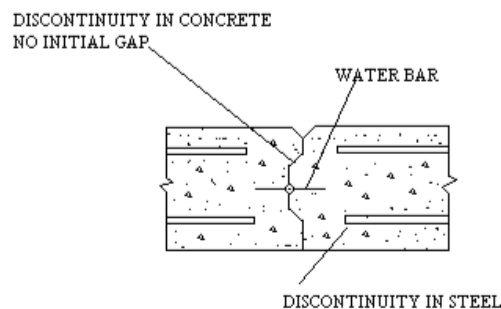


Figure3.1(a)

A contraction joint may be either complete contraction joint or partial contraction joint. A complete contraction joint is one in which both steel and concrete are interrupted and a partial

contraction joint is one in which only the concrete is interrupted, the reinforcing steel running through as shown in Fig.3.1(b).

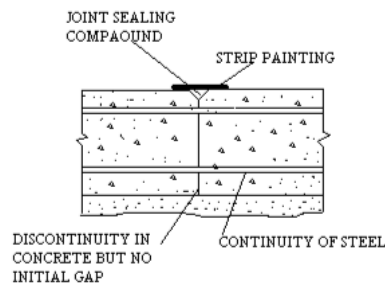


Figure3.1(b)

2. **Expansion Joint:** It is a joint with complete discontinuity in both reinforcing steel and concrete and it is to accommodate either expansion or contraction of the structure. A typical expansion joint is shown in fig3.2.

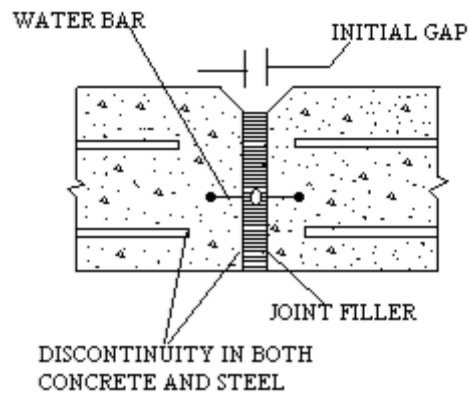


Figure:3.2

This type of joint requires the provision of an initial gap between the adjoining parts of a structure which by closing or opening accommodates the expansion or contraction of the structure.

- (iii) **Sliding Joint:** It is a joint with complete discontinuity in both reinforcement and concrete and with special provision to facilitate movement in plane of the joint. A typical joint is shown in Fig. 3.3.

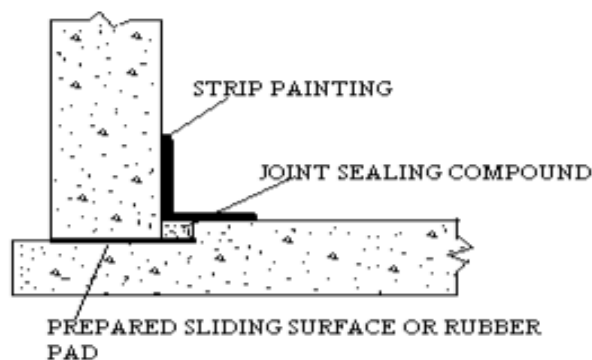


Figure:3.3

This type of joint is provided between wall and floor in some cylindrical tank designs.

CONTRACTION JOINTS

This type of joint is provided for convenience in construction. Arrangement is made to achieve subsequent continuity without relative movement. One application of these joints is between successive lifts in a reservoir wall. A typical joint is shown in Fig.3.4.

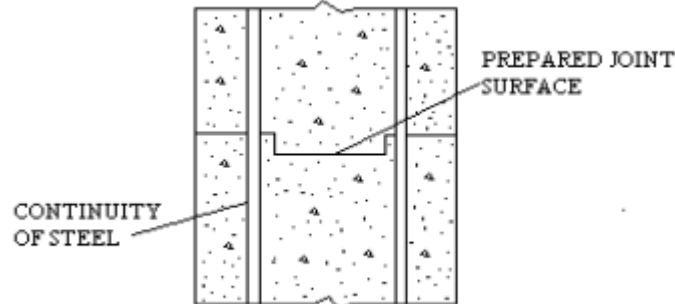
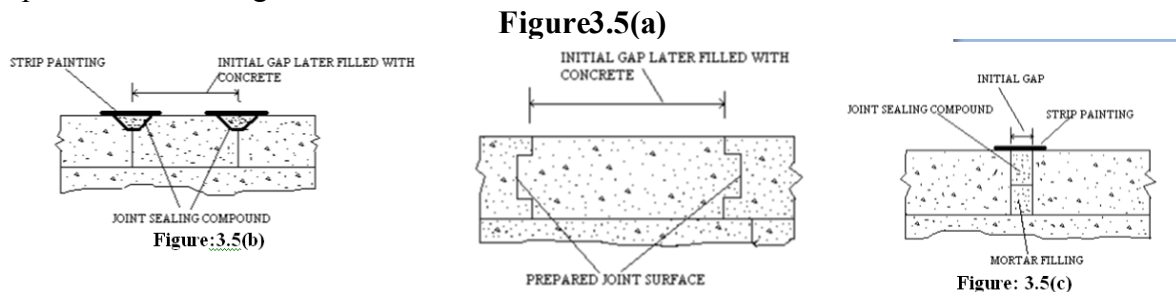


Figure:3.4

The number of joints should be as small as possible and these joints should be kept from possibility of percolation of water.

TEMPORARY JOINTS

A gap is sometimes left temporarily between the concrete of adjoining parts of a structure which after a suitable interval and before the structure is put to use, is filled with mortar or concrete completely as in Fig.3.5(a) or as shown in Fig.3.5 (b) and (c) with suitable jointing materials. In the first case width of the gap should be sufficient to allow the sides to be prepared before filling.



SPACING OF JOINTS

Unless alternative effective means are taken to avoid cracks by allowing for the additional stresses that may be induced by temperature or shrinkage changes or by unequal settlement, movement joints should be provided at the following spacing: -

(a) In reinforced concrete floors, movement joints should be spaced at not more than 7.5m apart in two directions at right angles. The wall and floor joints should be in line except where sliding joints occur at the base of the wall in which correspondence is not so important.

(b) For floors with only nominal percentage of reinforcement (smaller than the minimum specified) the concrete floor should be cast in panels with sides not more than 4.5m.

(c) In concrete walls, the movement joints should normally be placed at a maximum spacing of 7.5m. in reinforced walls and 6m in unreinforced walls. The maximum length desirable between vertical movement joints will depend upon the tensile strength of the walls, and may be increased by suitable reinforcement. When a sliding layer is placed at the foundation of a wall, the length of the wall that can be kept free of cracks depends on the capacity of wall section to resist the friction induced at the plane of sliding. Approximately

the wall has to stand the effect of a force at the place of sliding equal to weight of half the length of wall multiplied by the co-efficient of friction.

(d) Amongst the movement joints in floors and walls as mentioned above expansion joints should normally be provided at a spacing of not more than 30m between successive expansion joints or between the end of the structure and the next expansion joint; all other joints being of the construction type.

(e) When, however, the temperature changes to be accommodated are abnormal or occur more frequently than usual as in the case of storage of warm liquids or in uninsulated roof slabs, a smaller spacing than 30m should be adopted that is greater proportion of movement joints should be of the expansion type). When the range of temperature is small, for example, in certain covered structures, or where restraint is small, for example, in certain elevated structures none of the movement joints provided in small structures up to 45m length need be of the expansion type. Where sliding joints are provided between the walls and either the floor or roof, the provision of movement joints in each element can be considered independently.

3.3 GENERAL DESIGN REQUIREMENTS (I.S.I)

3.3.1 Plain Concrete Structures:

Plain concrete member of reinforced concrete liquid retaining structure may be designed against structural failure by allowing tension in plain concrete as per the permissible limits for tension in bending. This will automatically take care of failure due to cracking. However, nominal reinforcement shall be provided, for plain concrete structural members.

2.3.2. Permissible Stresses in Concrete:

(a) For resistance to cracking:

For calculations relating to the resistance of members to cracking, the permissible stresses in tension (direct and due to bending) and shear shall conform 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.

(b) For strength calculations:

In strength calculations the permissible concrete stresses shall be in accordance with Table 1. Where the calculated shear stress in concrete alone exceeds the permissible value, reinforcement acting in conjunction with diagonal compression in the concrete shall be provided to take the whole of the shear.

Table 1. Permissible concrete stresses in calculations relating to resistance to cracking

Grade of concrete	Permissible stress in KN/m ² tension		Shear
	Direct	Bending	
M ₁₅	1.1	1.5	1.5
M ₂₀	1.2	1.7	1.7
M ₂₅	1.3	1.8	1.9
M ₃₀	1.5	2.0	2.2
M ₃₅	1.6	2.2	2.5
M ₄₀	1.7	2.4	2.7

2.3.3 Permissible Stresses in Steel

(a) For resistance 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 exceeded 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.

(b) For strength calculations:

In strength calculations the permissible stress shall be as follows:

1. Tensile stress in member in direct tension	1000 Kg/cm ²
2. Tensile stress in member in bending on liquid retaining face of members or face away from liquid for members less than 225mm thick	1000 Kg/cm ²
3. On face away from liquid for members 225mm or more in thickness	1250 Kg/ cm ²
4. Tensile stress in shear reinforcement, For members less than 225mm thickness. For members 225mm or more in thickness	1000 Kg/ cm ² 1250 Kg/ cm ²
5. Compressive stress in columns subjected to direct load	1250 Kg/ cm ²

3.3.4. Stresses due to drying Shrinkage or Temperature Change.

- 1) Stresses due to drying shrinkage or temperature change may be ignored provided that
 - (a) The permissible stresses specified above in (ii) and (iii) are not otherwise exceeded.
 - (b) Adequate precautions are taken to avoid cracking of concrete during the construction period and until the reservoir is put into use.
 - (c) 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.
- 2) Shrinkage stresses may however be required to be calculated in special cases, when a shrinkage co-efficient of 300×10^{-6} may be assumed.
- 3) When the shrinkage stresses are allowed, the permissible stresses, tensile stresses to concrete (direct and bending) as given in Table 1 may be increased by 33.33 per cent.

3.3.5. 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. In such cases a screed or concrete layer less than 75mm thick shall first be placed on the ground and covered with a sliding layer of bitumen paper or other suitable material to destroy the bond between the screed and floor concrete. In normal circumstances the screed layer shall be of grade not

weaker than M_{10} , where injurious soils or aggressive water are expected, the screed layer shall be of grade not weaker than M 15 and if necessary a sulphate resisting or other special cement should be used.

(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 considered 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. If the walls are non-monolithic with the floor slab, such as in cases, where movement joints have been provided between the floor slabs and walls, the floor shall be designed only for the vertical loads on the floor.

(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.

(e) Sometimes it may be economical to provide the floors of circular tanks, in the shape of dome. In such cases the dome shall be designed for the vertical loads of the liquid over it and the ratio of its rise to its diameter shall be so adjusted that the stresses in the dome are, as far as possible, wholly compressive. The dome shall be supported at its bottom on the ring beam which shall be designed for resultant circumferential tension in addition to vertical loads.

3.3.6. 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.

(a) 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. The direct horizontal tension caused by the direct pull due to water pressure on the end walls, should be added to that resulting from horizontal bending moments. On liquid retaining faces, the tensile stresses due to the combination of direct horizontal tension and bending action shall satisfy the following condition:

$$(t/t) + (ct/ct) \leq 1$$

t = calculated direct tensile stress in concrete

t = permissible direct tensile stress in concrete (Table 1)

'ct = calculated tensile stress due to bending in concrete.

ct = permissible tensile stress due to bending in concrete.

(d) At the vertical edges where the walls of a reservoir are rigidly joined, horizontal reinforcement and haunch bars should be provided to resist the horizontal bending moments even if the walls are designed to withstand the whole load as vertical beams or cantilever without lateral supports.

(c) In the case of rectangular or polygonal tanks, the side walls act as two-way slabs, whereby the wall is continued or restrained in the horizontal direction, fixed or hinged at the bottom and hinged or free at the top. The walls thus act as thin plates subjected triangular loading and with boundary conditions varying between full restraint and free edge. The analysis of moment and forces may be made based on any recognized method.

(iv) Walls of Cylindrical Tanks:

While designing walls of cylindrical tanks the following points should be borne in mind:

(a) Walls of cylindrical tanks are either cast monolithically with the base or are set in grooves and key ways (movement joints). In either case deformation of wall under influence of liquid pressure is restricted at and above the base. Consequently, only part of the triangular hydrostatic load will be carried by ring tension and part of the load at bottom will be supported by cantilever action.

(b) It is difficult to restrict rotation or settlement of the base slab and it is advisable to provide vertical reinforcement as if the walls were fully fixed at the base, in addition to the reinforcement required to resist horizontal ring tension for hinged at base, conditions of walls, unless the appropriate amount of fixity at the base is established by analysis with due consideration to the dimensions of the base slab the type of joint between the wall and slab, and, where applicable, the type of soil supporting the base slab.

3.3.7. Roofs

(i) Provision of Movement joints:

To avoid the possibility of sympathetic cracking it is important to ensure that movement joints in the roof correspond with those in the walls, if roof and walls are monolithic. It, however, provision is made by means of a sliding joint for movement between the roof and the wall correspondence of joints is not so important.

(ii) Loading

Field covers of liquid retaining structures should be designed for gravity loads, such as the weight of roof slab, earth cover if any, live loads and mechanical equipment. They should also be designed for upward load if the liquid retaining structure is subjected to internal gas pressure. A superficial load sufficient to ensure safety with the unequal intensity of loading which occurs during the placing of the earth cover should be allowed for in designing roofs. The engineer should specify a loading under these temporary conditions which should not be exceeded. In designing the roof, allowance should be made for the temporary condition of some spans loaded and other spans unloaded, even though in the final state the load may be small and evenly distributed.

(iii) Water tightness:

In case of tanks intended for the storage of water for domestic purpose, the roof must be made water-tight. This may be achieved by limiting the stresses as for the rest of the tank, or by the use of the covering of the waterproof membrane or by providing slopes to ensure adequate drainage.

(iv) Protection against corrosion.

Protection measure shall be provided to the underside of the roof to prevent it from corrosion due to condensation.

3.3.8. Minimum Reinforcement:

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

(b) In exceptional 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.

3.3.9. Minimum Cover to Reinforcement.

(a) For liquid faces of parts of members either in contact with the liquid (such as inner faces 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 soils and water of corrosive characters the cover should be increased by 12mm but this additional cover shall not be taken into account for design calculations.

(b) 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.

3.4 FLEXIBLE BASE CIRCULAR WATER TANK

For smaller capacities rectangular tanks are used and for bigger capacities circular tanks are used. In circular tanks with flexible joint at the base tanks walls are subjected to hydrostatic pressure .so the tank walls are designed as thin cylinder. As the hoop tension gradually reduces to zero at top, the reinforcement is gradually reduced to minimum reinforcement at top. The main reinforcement consists of circular hoops. Vertical reinforcement equal to 0.3% of concrete are is provided and hoop reinforcement is tied to this reinforcement.

STEP 1

DETERMINATION OF DIAMETER OF THE WATER TANK

$$\text{Diameter} = D = \sqrt{\frac{(Q \times 0.004)}{(0.15 F_b) \times 3.14}}$$

Where

Q=capacity of the water tank

H=height of the water tank

Fb=free board of the water tank

STEP 2

DESIGN OF DOME SHAPED ROOF

Thickness of dome = t=100mm

Live load = 1.5KN/m²

Self-weight of dome = (t / 1000) * unit weight of concrete Finishes load= 0.1KN/m²

Total load = live load + self-weight + finishes load

Central rise= r =1m

Radius of dome = R= ((0.5 * D)² + r²) / (2 * r)

$$\cos A = ((R - r) / R)$$

$$\text{Meridional thrust} = (\text{total load} * R) / (1 + \cos A)$$

$$\text{Circumferential thrust} = \text{total load} * R * (\cos A - 1 / (1 + \cos A))$$

$$\text{Meridional stress} = \text{meridional thrust} / t$$

$$\text{Hoop stress} = \text{circumferential thrust} / t$$

$$\text{Reinforcement in both direction} = 0.3 * t * 10$$

$$\text{Hoop tension} = \text{meridional thrust} * \cos A * D * 0.5$$

$$\text{Reinforcement in top ring beam} = A_{s_topringbeam} \text{ hoop tension} / T_s$$

$$\text{Cross section area of top ring beam}$$

$$= (\text{hoop tension} / \text{PST direct}) - (m - 1) * A_{s_topringbeam}$$

STEP 3

DETERMINATION OF HOOP REINFORCEMENT

$$HT_i = 0.5 * (w * (H - i) * D)$$

$$A_{s_i} = HT_i / T_s$$

Where, HT_i =hoop tension at a depth of i from the top

A_{s_i} =hoop reinforcement at a depth of i from the top

STEP 4

DETERMINATION OF THICKNESS OF CYLINDRICAL WALL

$$HT = 0.5 * (w * H * D)$$

$$t = 0.001 * (HT / \text{PSTdirect} - (m - 1) * A_s)$$

Where, t =thickness of the wall

HT =hoop tension at the base of tank

PSTdirect =permissible stress due to direct tension

A_s =hoop reinforcement at base

STEP 5

DETERMINATION OF VERTICAL REINFORCEMENT

$$A_{s_v} = (0.3 - 0.1 * (t - 100) / 350) * t * 10$$

Where, A_{s_v} = vertical reinforcement of the wall

t =thickness of the wall

STEP 6

DESIGN OF BASE

$$\text{Thickness of base} = 150\text{mm} \text{ Minimum reinforcement required} = (0.3/100) * 150 * 1000\text{mm}^2$$

RESULTS AND DISCUSSIONS

RESULTS BY USING STAAD.PRO SOFTWARE

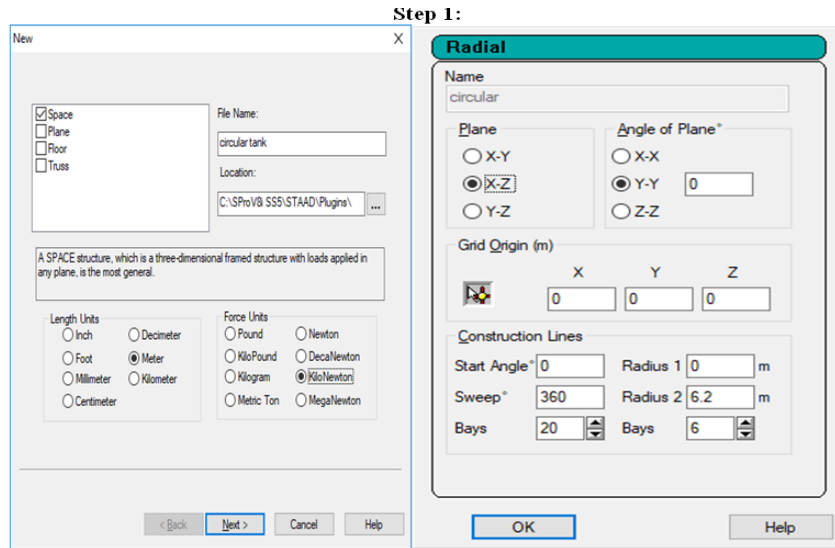
Step 1: creation of nodes and beams.

Step 2: assigning of supports and property.

Step 3: assigning of loads.

Step 4: design of concrete.

Step 5: analysis and print.



Step 1:

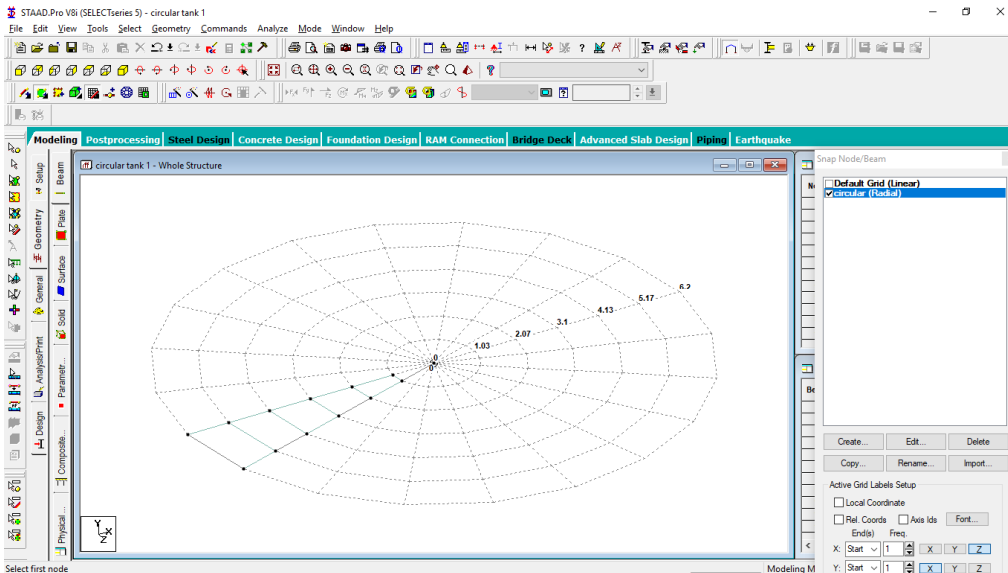


Figure 1: showing generated nodes and beams

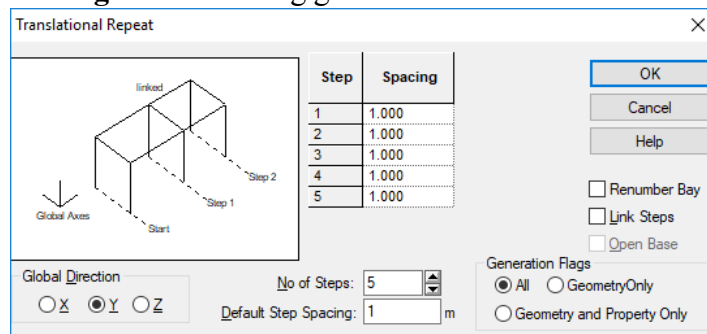


Figure 2: showing to generate tank

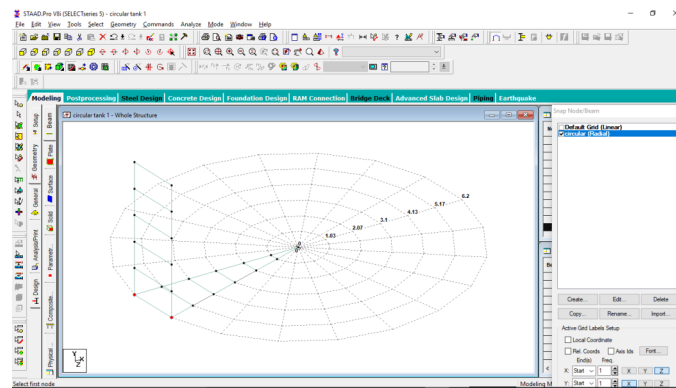


Figure 3: showing created plates

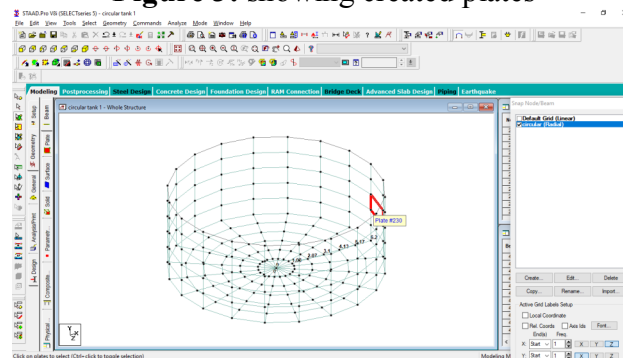


Figure 4: showing circular tank
 Step 2:

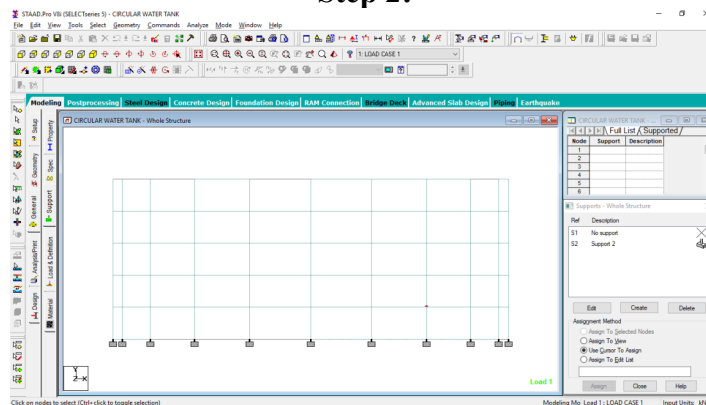


Figure 5: showing supports generated

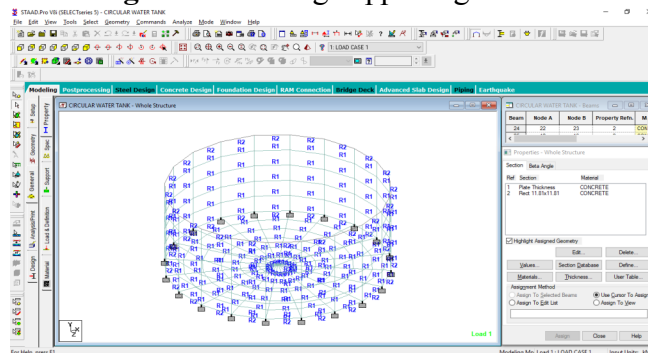


Figure 6: showing properties assigned
 Step 3:

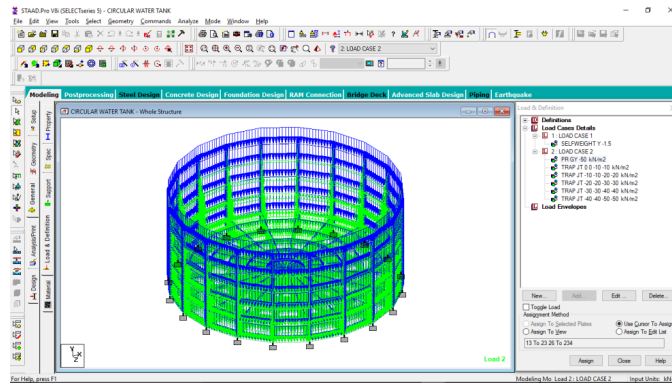


Figure 7: showing assigned loads and definitions
Step 4:

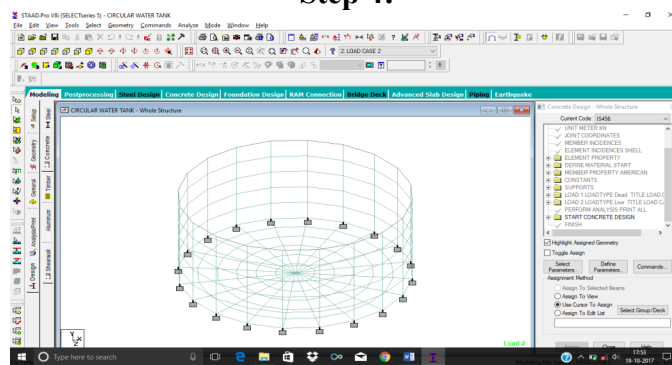


Figure 8: showing design of concrete
Step 5:

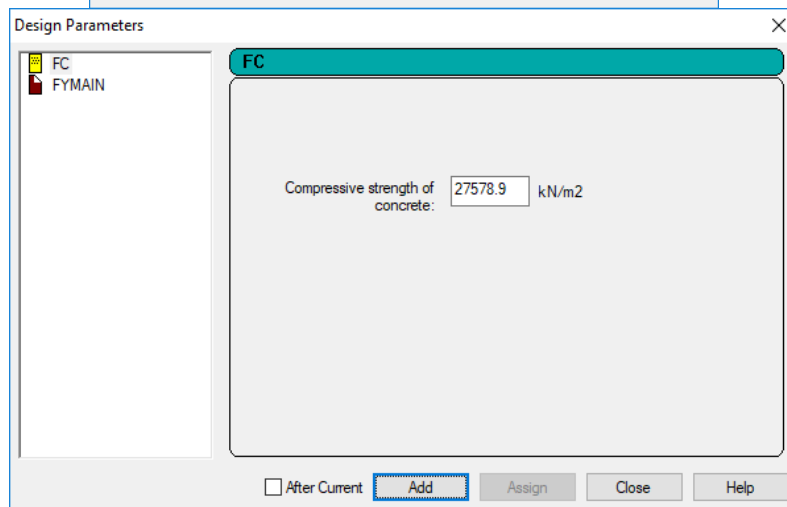
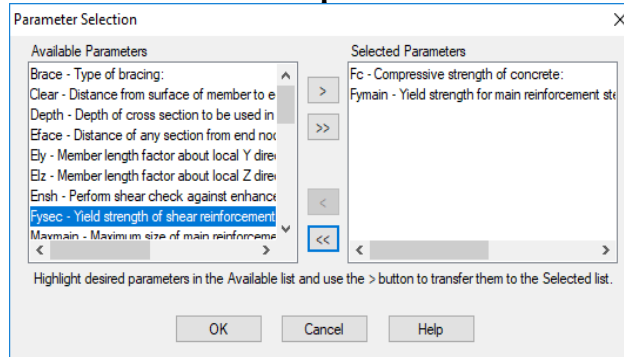


Figure 9: selection of parameters

Figure 10: define parameters

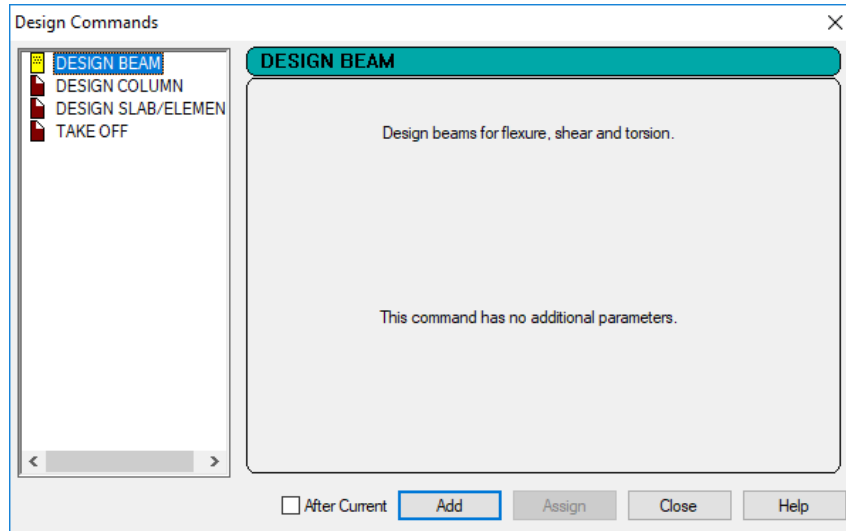


Figure 11: Activating commands
Step 6:

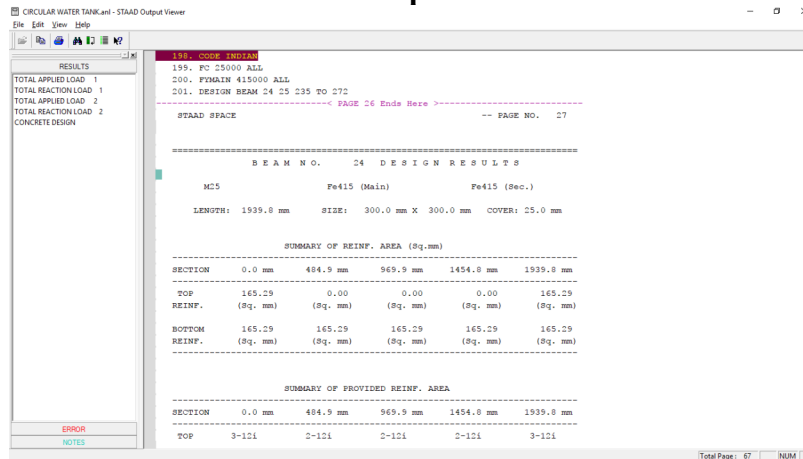


Figure 12: Results after analysis and print

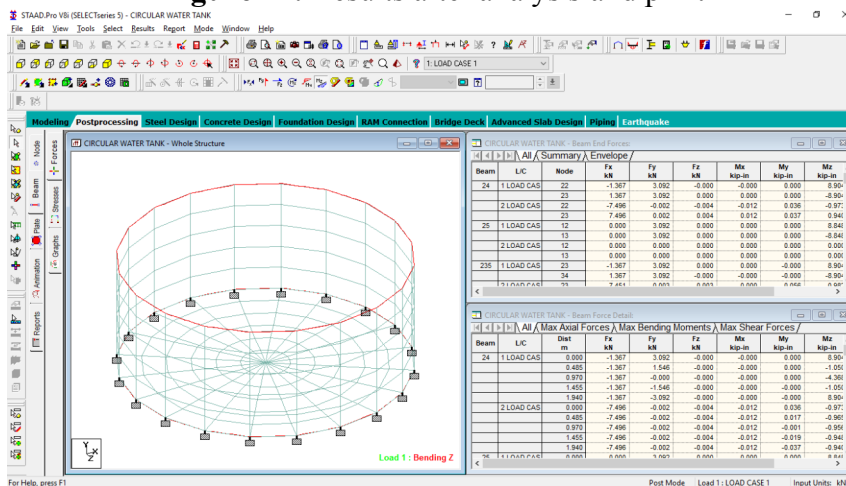


Figure 13: beam results

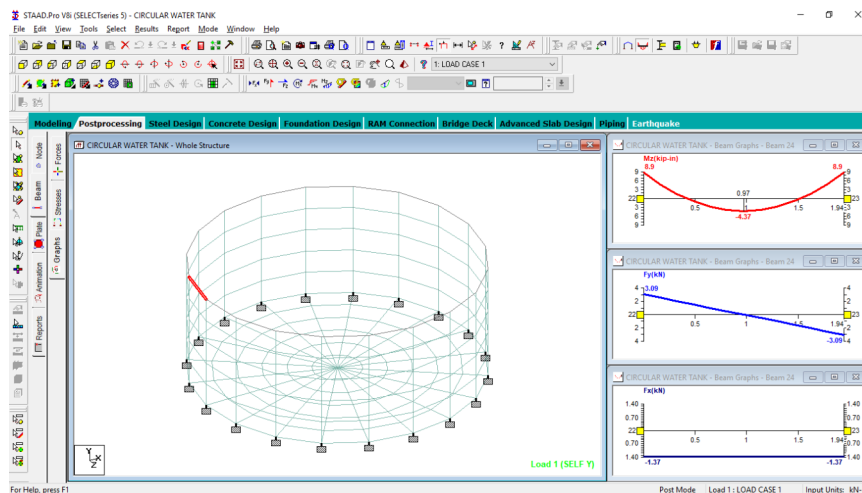


Figure 14:Graphs

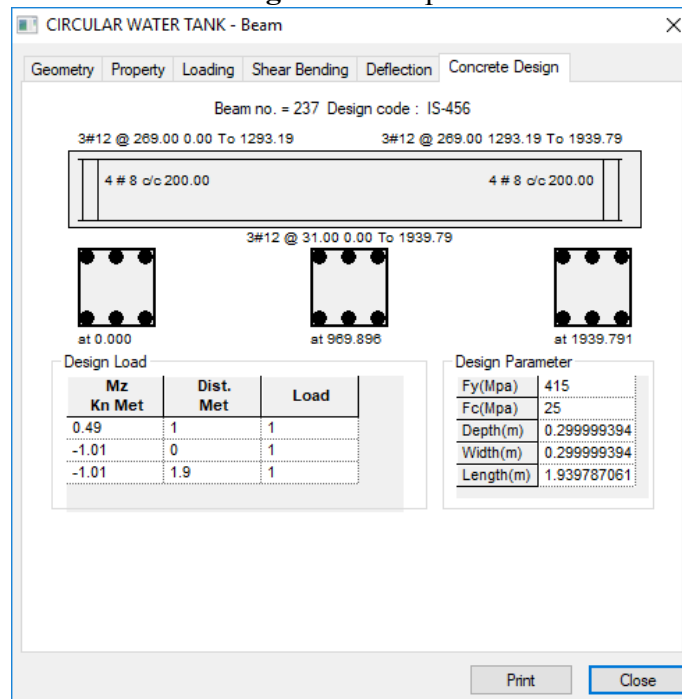


Figure 15:concrete designing

CONCLUSIONS

Storage of water in the form of tanks for drinking and washing purposes, swimming pools for exercise and enjoyment, and sewage sedimentation tanks are gaining increasing importance in the present-day life. For small capacities we go for rectangular water tanks while for bigger capacities we provide circular water tanks. Design of water tank is a very tedious method. Particularly design of under-ground water tank involves lots of mathematical formulae and calculation. It is also time consuming. Hence program gives a solution to the above problems. There is a slight difference between the design values of program to that of manual calculation. The program gives the least value for the design. Hence designer should not provide less than the values we get from the program. In case of theoretical calculation designer initially add some extra values to the obtained values to be in safer side.

REFERENCES

- Sayal & Goel. Reinforced Concrete Structures. New Delhi. S.Chand publication.2004.
- IS 456-2000 CODE FOR PLAIN AND REINFORCED CONCRETE
- IS 3370-1965 CODE FOR CONCRETE STRUCTURES FOR THE STORAGE OF LIQUIDS
- Dayaratnam P. Design of Reinforced Concrete Structures. New Delhi. Oxford & IBH publication.2000
- Vazirani & Ratwani. Concrete Structures. New Delhi. Khanna Publishers.1990.
- Ajagbe, Adedokun and Oyesile W.B.,” Comparative Study on the Design of Elevated Rectangular and Circular Concrete Water Tanks”, International Journal of Engineering Research and Development ISSN: 2278-067X Volume 1, Issue 1 (May 2012), PP 22-30.
- Chirag N. Patel and Patel,” Supporting Systems for Reinforced Concrete Elevated Water Tanks: A State-Of-The-Art Literature Review”, International Journal of Advanced Engineering Research and Studies, IJAERS/Vol. II/ Issue I/Oct.-Dec.,2012/68- 71
- Criteria For Design of RCC Staging For Overhead Water Tanks (First Revision of IS 11682): BUREAU OF INDIAN STANDARDS, Preliminary Draft code.
- Durgesh C Rai, “Performance of elevated tanks in Mw 7.7 Bhuj earth quake of January 26th, 2001”, Department of Civil Engineering, Indian Institute of Technology, Kanpur 208 016, India