# COMPARATIVE STUDY ON THE DESIGN OF ELEVATED CIRCULAR CONCRETE WATER TANK

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**Abstract -** *Water is an important things for all living beings to live. In the area of scarcity of water it is very important to supply water. Water supply to that places are done by water stored in tank. This type of water tank are build publicly. Water stored in the tank are supplied through pipelines to the people. This tanks are of different shape like circular, rectangular etc.. It can be constructed at different height.In this project, elevated circular water tank are designed manually using limit state design method using codes( IS 3370-2009(part I-IV) ,IS 456-2000) and software design also done using ETABS. Finally compare both the results obtained from manually and software. At the end of the project it is noted that there is some reduction in the steel from the design of etabs compare to manual design.*

***Key Words*: Elevated circular water tank, limit state method, ETABS.**

## 1.INTRODUCTION

A water tank is a structure which is used to store water Nowadays, the need of water tank are increasing. The water form the tank can be used for many purpose like house work, irrigation, fire safety etc.. The shape and size of a water tank are decided as per the capacities of tank. The cost and materials used for the water tank are decided according to the construction. Mostly, circular shape are more preferred for the water tank due to the uniform stress distribution. Design code used for the water tank design is IS 3370(Part I-IV).

Circular water tank are good for store large quantities of water and are economical. For elevated storage structure generally circular water tank are commonly employed. Generally, circular water tank with flat base are preferred which are more economical. The tank are generally supported on a ring beam and are supported on a number of columns. Normally, the diameter of ring beam is kept $\frac{3}{4}^{th}$ of diameter of water tank. The main forces acting on this water tank are uniformly distributed load which consist of self weight of slab and weight of water, upward ring beam load also is there. Circular water tank require less steel and concrete compare to rectangular water tank.

The main components for an elevated water tank are:

- Top Dome
- Top Ring Beam
- Cylindrical Wall
- Base Slab
- Bottom Ring Beam

### 1.1 OBJECTIVES

The objectives of this study are listed below:

1. To compare the design of elevated circular water tank done by Manually and ETABS software in reference to IS 3370 Part I-IV, IS 456- 2000.
2. To study how much amount of steel required for the water tank.
3. To study the comparison between manual design and software design.
4. To study the design steps of different element of elevated circular water tank using limit state design method using IS codes (IS 3370 Part I-IV, IS 456-2000).

## 2. MATERIALS AND METHODOLOGY

### 2.1 MATERIALS PROPERTIES

The grade of concrete is M30 and grade of steel is HYSD 415 for water tank construction.

### 2.2 METHODOLOGY

In this project work elevated circular water tank is considered.
Initially manual design are done using limit state design method as per code IS 3370:2009(part I-IV) and IS 456:2000, from the manual design the dimensions and area of steel are obtained. The water tank model were done in ETABS software based on the dimensions from manual design . Analysis was carried out for various components of water tank using ETABS software. The analysis were done by applying all the loads acting on the water tank. After the analysis software design and detailing were done. Finally compare both the design results which are obtained from software and manually.

## 3. DESIGN OF CIRCULAR WATER TANK

The code used for the design are IS 1172(1993),IS:3370-2009(part II-IV) and IS 456-2000.
In this study, for the design of water tank 4.5 lakh liter capacity is assumed.

### 3.1 Material

M30 - Grade of Concrete
Fe 415 - Grade of HYSD Reinforcement

### 3.2 PRELIMINARY DIMENSIONS

Storage volume for 450000 liters = 450 $m^3$
Volume of water tank , V = $\pi$ x $r^2$ x h
Assume height, h = 4 m
450 = $\pi$ x $r^2$ x 4
r = 6 m
D = 12 m
By putting the value of h and r
Volume = $\pi$ x $6^2$ x h
= $\pi$ x $6^2$ x 4
= 450 $m^2$
Free board = 0.3 m
Height of Staging from Ground = 10 m

### 3.3 PERMISSIBLE STRESSES

As per IS:3370 (part II) Table 1, Table 2 and Table 4
$\sigma$ cbc = 10 N/$mm^2$
$\sigma$ cc = 8 N/$mm^2$
$\sigma$ st = 130 N/$mm^2$
$\sigma$ ct = 1.5 N/mm

### 3.4 DESIGN CONSTANTS

$$m = \frac{280}{3\ x\sigma\ cbc} = 9.33$$

$$K = \frac{1}{1+\frac{\sigma\ st}{m\ x\ \sigma\ cbc}} = 0.42$$

$$j = 1-(\frac{K}{3}) = 0.86$$

$$R = \frac{1}{2} \text{ x K x } \sigma \text{ cbc x j} = 1.81$$

### 3.5 DESIGN OF TOP DOME

(i) Meridional Force(T1)

(ii) Hoop Tension(T2)

Thickness of Dome (assuming) = 100 mm

Central rise of dome (h1) = ($\frac{1}{5}$ x diameter)= 2.4 m

Radius of curvature (R)

$R^2$ = (2r - rise) rise
r = 8.7 m

Semi Central Angle ($\theta$) = $\sin^{-}(\frac{\text{Radius of water tank}}{r})$

= 43.60°

Cos$\theta$ = 0.724

**Calculation For Loads (for 1 m length of dome)**

Length = 1 m
Dead load = Width x Thickness x Density
= 2.5 KN/$m^2$
Live load = Width x Live load (assuming live load = 1.5 KN/$m^2$)
= 1.5 KN/$m^2$
Total load (W) = 4 KN/$m^2$
Ultimate load = 1.5 x 4 = 6 KN/m2

**Stresses in Dome**

T1 = (W x R)/(1+cos$\theta$) = 30.27 KN/m
Meridonial Stress = T1/(b x t) = 0.302 N/$mm^2$
0.302 N/$mm^2$ < $\sigma$ cc = 8 N/$mm^2$
T2 = WxR[cos$\theta$-1/(1+cos$\theta$) ] = 8 KN/m
Hoop Stress = T2/(b x t) = 0.08 N/$mm^2$
0.08 N/$mm^2$ < $\sigma$ cc = 8 N/$mm^2$
Stresses is within safe limits. As per IS:3370 (part 2 ) Table 2

**Reinforcement in Dome**

The stresses are within safe limit. However provide minimum reinforcement of 0.24% area in each direction
Ast = 0.24% x b x t = 240 $mm^2$
Using 8 mm ø bar, Aø = 50 $mm^2$
Spacing = 1000 x Aø/Ast = 208 mm
Hence provide 8 mm ø bars @ 200 mm c/c in both directions.

### 3.6 DESIGN OF TOP RING BEAM

It is designed for hoop tension
W = T1cos$\theta$ = 22 KN/m
Total hoop tension in beam = W x $\frac{D}{2}$ = 132 KN

**Area of Reinforcement**

$$Ast = \frac{\text{Hoop Tension}}{\sigma\ st} = 1015\ mm^2$$

Provide 12 mm ø @ 110 mm
To find out Dimensions of Ring Beam

$$\sigma\ ct = \frac{T}{Ag+(m-1)Ast}$$

Ag = b x D
Assume b = 250 mm

$$1.5 = \frac{132\ x\ 10^3}{250\ x\ D+(9.33-1)x\ 1028}$$

$$\frac{132\ x\ 10^3}{250xD+8563} < 1.5$$

$132\ x10^3$< 375 D + 12844

318 < D

Consider D = 400 mm
Size of beam = 250 mm x 400 mm
Provide min. shear reinforcement
8 mm ø – 2 legged vertical stirrups
From IS:456-2000, Page No – 48

$$Sv = \frac{0.87\ x\ fy\ x\ Asv}{0.4\ x\ b} = 362.96\ mm$$

Spacing limit
(i) 0.75 x D = 0.75 x 400 = 300 mm
(ii) 300 mm
Adopt a ring beam of size 250 mm x 400 mm with 12 mm diameter as hoop reinforcement and 8 mm ø - 2 legged vertical stirrups @300 mm c/c.

### 3.7 DESIGN OF TANK WALL

Thickness of wall
T = 150 mm
T = (30 H + 50 ) = 170 mm
Take the value of T. i.e, T = 170 mm

**Design of Tank Wall for Hoop Tension**

$\frac{H^2}{DT} = 8$

As Per IS:3370 (part IV), Page No. 35, Table 9
Coefficient = 0.575
Hoop Tension = Coeff. x W x H x R
= 0.575 x 10 x 4 x 6 = 138 KN
i.e, Maximum Hoop Tension occurs at 0.6 H = 0.6 x 4 = 2.4 m from the top

**Area of Steel for Tank Walls**

Ast(req) = $\frac{\text{Max.Hoop Tension}}{\text{Permissible Tensile Stress}}$ = 1061 $mm^2$

Minimum Steel, As Per IS:3370, Part II, Page No. 5
Ast(min) = 0.24% x gross area = 408 $mm^2$
Provide 12 mm diameter bar

Spacing = $\frac{1000 \times Asv}{Ast} = \frac{1000 \times 113}{1061}$ = 107 mm

Provide 12 mm ø bar @ 100 mm c/c (As per IS:3370, Part II, Page No. 5)

**Check for Tensile Stress in Concrete**

Ast(provided) = $2 \times \frac{1000 \times 113}{100}$ = 2260 $mm^2$

σct = $\frac{T}{b \times t+(m-1)Ast}$ = 0.73 $N/mm^2$

Permissible tensile stress = 1.3 $N/mm^2$ (As per IS:3370, Part 2, Table 1)
i.e, Actual tensile stress < Permissible stress
Design is safe

**Design of Tank Wall for Bending Moment**

As Per IS:3370, Part 4, Table 10
Coefficient = -0.0146
Bending Moment = Coeff. x W x $H^3$
= 0.0146 x 10 x $4^3$ = 9.34 kNm
Maximum Bending Moment = 9.34 kNm

**Check for effective depth d**

d(required) = $\sqrt{\frac{Mmax}{R \times b}} = \sqrt{\frac{9.34 \times 10^6}{1.81 \times 1000}}$ = 72 mm

d(provided) = 170-25-12/2 = 139 mm > d(required)
Hence, it is safe

**Area of steel for Bending Moment**

Ast(required) = $\frac{\text{Max.B.M.}}{\sigma\ st \times j \times d(provided)}$ = 601 $mm^2$

Provide 12 mm ø bars

Spacing = $\frac{1000 \times Asv}{Ast} = \frac{1000 \times 113}{601}$ = 188 mm

Provide 12 mm ø bar @ 170 mm c/c

### 3.8 DESIGN OF BASE SLAB

Assuming thickness of base slab as 350 mm.
Outer diameter = 12 + 0.34 = 12.34 m
Load from Dome = T1 sinθ x 2π x $\frac{D}{2}$ = 787 KN
Load from Ring Beam = (.25X .40) x π x 12 x 25 = 94 KN
Load of wall = 0.170 x (4-0.3) x π x 12.17 x 25 = 601.22 KN
Total circumferential load on the periphery of slab = 1482 KN
Ultimate load on periphery of slab= 1482 x 1.5 =2223 KN
Weight of water = $(\frac{\pi}{4} \times D^2 \times H)$ = 4523.90 KN
Self weight of slab = 0.35 x 25 = 8.75 $KN/m^2$
Total weight of slab = $(\frac{\pi}{4} \times D^2) \times sw$ = 989.60 KN
Finishing load = $(\frac{\pi}{4} \times 12^2) \times 0.6$ = 67.86 KN
Total load on slab = 5581.36 KN
Ultimate load on slab = 5581.36 x 1.5 = 8372 KN
Total upward force on Ring Beam = 2223 + 8372 = 10595 KN
For the design of slab two cases are considered.

(i) Circular slab simply supported and subjected to water pressure plus self weight of slab.
(ii) Circular slab simply supported and subjected to upward ring load.

**Calculation of B.M. and S.F.**

The radial and circumferential bending moments are calculated with the help of formulae given below.
(i) B.M. due to U.D.L.

p = 8372 KN
Now, to convert p to U.D.L.

$\frac{8372}{(\frac{\pi}{4} \times 12^2)}$ = 74 $KN/m^2$

a = radius of slab = $\frac{12}{2}$ = 6 m

Normally, the diameter of supporting circle is kept 3/4 times the diameter of the tank.

Diameter of beam = 9 m
Radius of beam, b = 4.5 m

$(Mr)c = +\frac{3}{16}pa^2$ ; $(Mr)e = 0$

$Mr = \frac{3}{16}p(a^2 - r^2)$

$= \frac{3}{16} \times 74(6^2 - r^2)$

$$(M\theta)c = +\frac{3}{16}pa^2 \; ; \; (M\theta)e = +\frac{2}{16}pa^2$$

$$M\theta = +\frac{p}{16}(3a^2 - r^2)$$

$$= \frac{74}{16} \times (3(6)^2 - r^2)$$

The values of Mθ and Mr at various locations are tabulated below

| r (m) | 0 | 2.25 | 4.5 | 6 |
|---|---|---|---|---|
| Mr ( KNm) | 499.5 | 429.26 | 218.53 | 0 |
| Mθ (KNm) | 499.5 | 476.19 | 405.84 | 333 |

(ii) B.M. due to upward load W = 10595 KN

For $r \le b$

$$Mr = (Mr)b = M\theta = (M\theta)0 = -\frac{w}{8\pi}[\,2\log(\frac{a}{b}) + 1 - (\frac{b}{a})^2\,]$$

For $r > b$

$$Mr = -\frac{w}{8\pi}[\,2\log(\frac{a}{r}) - (\frac{b}{a})^2 + (\frac{b}{r})^2\,]$$

$$M\theta = -\frac{w}{8\pi}[2\log(\frac{a}{r}) - (\frac{b}{r})^2 + 2 - (\frac{b}{a})^2\,]$$

The values of Mθ and Mr at various locations are tabulated below

| r (m) | 0 | 2.25 | 4.5 | 6 |
|---|---|---|---|---|
| Mr ( KNm) | -289.77 | -289.77 | -289.77 | 0 |
| Mθ (KNm) | -289.77 | -289.77 | -289.77 | -369 |

(iii) Net Moments:

The net moments will be the algebraic sum of the two, and are tabulated below

| r (m) | 0 | 2.25 | 4.5 | 6 |
|---|---|---|---|---|
| Mr (KNm) | 209.73 | 139.5 | -71.24 | 0 |
| Mθ (KNm) | 209.73 | 186.42 | 116.07 | -36 |

The maximum shear force

$$F = \frac{pb}{2} - \frac{W}{2\pi b} = \frac{74 \times 4.5}{2} - \frac{10595}{2 \times \pi \times 4.5} = -208.22 \text{ KN}$$

### 3.9 DESIGN OF SLAB

The slab is to be designed for a maximum B.M. of 209.73 KNm.

From B.M. point of view, $d = \frac{\sqrt{Mu,max}}{R \times b} = 340$ mm

Let us keep total thickness =380 mm

Using 20 mm ø bars,

Provide d = 380 – 25 + 10 = 365 mm

Effective depth d = 365 mm

$$\text{Area of steel} = \frac{0.5\,fck}{fy}[1 - \sqrt{1 - \frac{4.6\,Mu,max}{fck\,bd^2}}\;]\,bd$$

= 1702.06 $mm^2$

Using 20 mm diameter bars, Aø = 314 $mm^2$

Spacing = $\frac{1000 \times 314}{1702.6}$ = 184 mm

Provide 20 mm ø @ 180 mm c/c

**At Ring Beam (Mr)**

$$\text{Area of steel} = \frac{0.5\,fck}{fy}[1 - \sqrt{1 - \frac{4.6\,Mu,max}{fck\,bd^2}}\;]\,bd$$

= 552 $mm^2$

Using 12 mm diameter bars, Aø = 113 $mm^2$

Spacing = $\frac{1000 \times 113}{552.42}$ = 204 mm

Provide 12 mm ø @ 200 mm c/c

**At Ring Beam (Mθ)**

$$\text{Area of steel} = \frac{0.5\,fck}{fy}[1 - \sqrt{1 - \frac{4.6\,Mu,max}{fck\,bd^2}}\;]\,bd$$

= 913 $mm^2$

Using 16 mm diameter bars, Aø = 201 $mm^2$

Spacing = $\frac{1000 \times 201}{912.78}$ = 220 mm

Provide 16 mm ø @ 210 mm c/c

Provide min. steel at other remaining surface

Ast(min) = $\frac{0.24}{100}$ x 1000 x 380 = 912 $mm^2$

Spacing = $\frac{1000 \times 113}{912}$ = 123 mm

Povide 12 mm ø @ 115 c/c

### 3.10 DESIGN OF BOTTOM CIRCULAR BEAM

The tank is supported on a circular beam which in turn is supported on eight equally spaced columns. The diameter of supporting circle, upto the centre of the beam = 9 m. The total load W on the beam = 10595 KN.

For the design of Bottom Ring Beam

Super - imposed load on beam = $\frac{10595}{\pi \times 9}$= 374.72 KN/m

Assuming the beam to have a section of 1000 mm x 500 mm,

Self Weight of Beam = 0.1 x 0.5 x 25 = 12.5 KN/m

Total Weight , W = 374.72 + 12.5 = 387.5 KN/m

For θ,

$2\theta = (360^\circ)/n$

n = 8

$2\theta = 45^\circ = \pi/4$

$\theta = 22.5^\circ = \frac{\pi}{8}$

C1 = 0.066 , C2 = 0.030 , C3 = 0.005, øm = $9\frac{1^\circ}{2}$

Radius of beam = $\frac{9}{2}$ = 4.5 m

$WR^2.2\theta = 387.5 \times 4.5^2 \times (\pi/4) = 6163$ KNm

Max. Negative Bending Moment at Support,

$M_n$ = C1 x $WR^2(2\theta)$ = 406.75 KNm

Max. Positive Bending Moment at mid-span,
$M_p$ = C2 x $WR^2(2\theta)$ = 184.89 KNm
Max. Torsional Moment at an angle of 9.5˚ from support,
T = C3 x $WR^2(2\theta)$ = 30.81 KNm
Max. Shear force at support, V = $\frac{w\,x R\,x\,2\theta}{2}$ = 684.76 KN

Shear force at section of maximum torsional moment (øm = 9.5˚ = 0.1658 radians) is given by :
$V_T$ = wR (θ-øm) = 387.5 x 4.5 ( $\frac{\pi}{8} - 0.1658$) = 395.65 KN

**Design of support section**
Mmax = 406.75 KN, D = 1000 mm , V = 684.76 KN
Using 20 mm ø bars and a clear cover 35 mm ,
d = 1000 – 10 – 35 = 955 mm
Min. depth required:
Mu,lim = 0.36 x $\frac{Xu,max}{d}$ (1 – 0.42 $\frac{Xu,max}{d}$) bd² fck

d = 443 mm
Hence, provide $d_{eff}$ = 955 mm
Area of Steel required
$M_u$ = 0.87 fy Ast d ( $1 - \frac{Ast\ fy}{bd\ fck}$)

Ast = 1223 mm²
$Ast_{min}$ = $\frac{0.85\ x\ bd}{fy}$

$Ast_{min}$ = 978 mm²
No. of bars = $\frac{Ast}{A\text{ø}}$ = $\frac{1223}{\frac{\pi}{4} x\ (20)^2}$ = 4 Nos.

Provide 4 bars of 20 mm ø reinforcement
$Ast_{provided}$ = 1256 mm²
Nominal shear strength (τv)
τv = $\frac{Vu}{bd}$

τv = 1.4 N/mm²
Compressive shear strength(τc)
Percentage of reinforcement (p%) = 100 $\frac{Ast}{bd}$ = 0.26

Thus, from table 19 IS 456:2000
τc = 0.3752 N/mm²
τc < τv
Thus, shear reinforcement is required
Vus = Vu – τc bd
Vus =684.76 – 0.3752 x 500 x 955
Vus = 505.76 KN
Vus = $\frac{0.87\ x\ fy\ Asv\ d}{Sv}$
Using 10 mm ø stirrups (2 – legged)
Asv = 2 x $\frac{\pi}{4}$ x (10)² = 157 mm²

Sv = $\frac{0.87\ x\ 415\ x\ 157\ x\ 955}{505.76\ x\ 10^3}$ = 107.03 mm ≈ 107 mm
Provide 10 mm ø 2 – legged stirrups @ 105 mm c/c

**Design of Mid- Span Section**
M = 184.89 KNm
$M_u$ = 0.87 fy Ast d ( $1 - \frac{Ast\ fy}{bd\ fck}$)

Ast = 544 mm²
But min area of steel is 978 mm²
Hence, adopt Ast = 978 mm²
Using 16 mm ø bars (Aø = 201 mm²)
No. of bars = $\frac{978}{201}$ = 5 Nos.

Provide 6 bars of 16 mm ø reinforcement

**Design of section subjected to Max. Torsional and Shear**
Equivalent Bending Moment
Mel = Mu + Mt
Mu = 0
Mt = Tu $\frac{(1+\frac{D}{b})}{1.7}$

Mt = 30.81 x $\frac{(1+\frac{1000}{500})}{1.7}$

Mt = 54.37 KNm
Mel = 54.37 KNm
Area of Reinforcement
$M_u$ = 0.87 fy Ast d ( $1 - \frac{Ast\ fy}{bd\ fck}$)

Ast = 158 mm²
But $Ast_{min}$ = 978 mm²
Hence, adopt Ast = 978 mm²
Using 20 mm ø bars (Aø = 314 mm²)
No. of bars = $\frac{978}{314}$ = 3 Nos.

Provide 3 bars of 20 mm ø reinforcement

**Transverse reinforcement**
Shear reinforcement
Equivalent Shear
Ve = Vu + 1.6 $\frac{Tu}{b}$

Ve = 395 + 1.6 x $\frac{30.81}{0.5}$

Ve = 493.6 KN
τv = $\frac{Vu}{bd}$

τv = 1 N/mm²
Percentage of reinforcement = 100 $\frac{Ast}{bd}$ = 0.205

Thus, from table 19 IS 456:2000
τc = 0.334 N/mm²
τv > τc
Shear reinforcement is required
Using 10 mm ø 2 – legged stirrups (Ast = 157 mm²)
$b_1$ = 500 - 35 -35 = 430 mm

$d_1$ = 1000 - 35-35 = 930 mm

Asv = $\frac{Tu\ Sv}{b_1\ d_1\ (0.87\ fy)} + \frac{Vu\ Sv}{2.5\ d_1\ (0.87\ fy)}$

157 = [ $\frac{30.81x\ 10^6}{430x\ \ 930\ x\ (0.87\ x\ 415)} + \frac{395\ x\ 10^3}{2.5\ \ x\ 930\ x\ (0.87\ x\ 415)}$ ] $S_v$

Sv = 229 mm

Check for spacing

(i) $x_1$ = 430 mm

(ii) $\frac{x1+y1}{4} = \frac{430\ +\ 930}{4}$ = 340 mm

(iii) 300 mm

Provide 10 mm ø 2 – legged stirrups @ 220 mm c/c

**Side face reinforcement ( As per IS 456 – 2000 )**

As = $\frac{0.10}{100}$ x 500 x 955 = 477 mm$^2$

12 mm ø bars having , Aø = 113 mm$^2$ .

No. of bars = $\frac{477}{113}$ = 4.2

Provide 3 - 12 ø bars on each vertical face

### 3.11 MANUAL DESIGN RESULT DETAILS

**Table – 1: Manual Design Result**

| SL. NO. | COMPONENTS OF WATER TANK | MANUAL DESIGN |
|---|---|---|
| | | Ast in mm² (Required) |
| 1 | Top Dome | 240 mm² |
| 2 | Top Ring Beam | 1015 mm² |
| 3 | Tank Wall | |
| a | Hoop Reinforcement | 1061 mm² |
| b | Bending Reinforcement | 601 mm² |
| 4 | Base Slab | |
| a | Reinforcement For Max. Bending Moment | 1702 mm² |
| b | Reinforcement Of Radial Moment At Ring Beam | 552 mm² |
| c | Reinforcement Of Circumferential Moment At Ring Beam | 913 mm² |
| 5 | Bottom Ring Beam | |
| a | Support Section | 1223 mm² |
| b | Mid-Span Section | 978 mm² |
| c | Maximum Torsion | 978 mm² |
| d | Transverse Reinforcement | 685 mm² |

## 4. MODEL DETAILS

For the design of water tank we have to create a model first. The modeling was done in ETABS software. Once the modeling was completed with desired material and section properties the model were subjected to analysis based on the load acting on the tank and after that design were done. The project work is focused on the Comparative Study of circular overhead water tanks by manually and software. In both cases the dimensions of tank are same. The location considered for this project is Kannur, Kerala.

**Table – 2: Water Tank Model Details**

| Sl.No | Description | Circular Elevated Water Tank |
|---|---|---|
| 1 | Diameter of Column | 800 mm |
| 2 | No. of Column | 8 |
| 3 | Bottom Ring Beam | 500 mm x 1000 mm |
| 4 | Bracing | 800 mm x 500 mm |
| 5 | Height of Staging (m) | 10 m |
| 6 | Thickness of Slab | 380 mm |
| 7 | Diameter of Tank (m) | 12 m |
| 8 | Height of Tank Wall (m) | 4 m |
| 9 | Thickness of Tank Wall | 170 mm |
| 10 | Top Ring Beam | 250 mm x 400 mm |
| 11 | Roof Slab Thickness (Dome Shape) | 100 mm |
| 12 | Center Height of Dome (m) | 2.4 m |
| 13 | Type of Soil | Moderate Soil |
| 14 | Unit Weights | Concrete = 25 KN/m$^3$ |
| 15 | Material | M30 Grade Concrete and Fe415 |

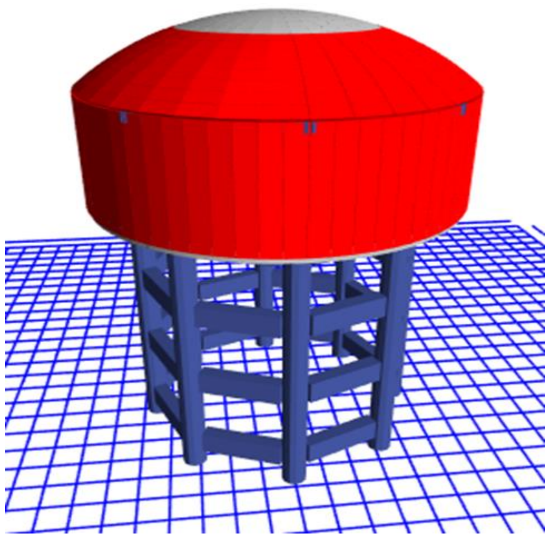

**Fig – 1: 3D Rendered Model**

## 4.1 LOADS ACTING ON THE WATER TANK

1. Dead load:
   Dead load means the load due to the materials of the construction. i.e, unit weight of material x dimension or diameter of a section. Unit weight of concrete is 25 Kn/m$^3$.
2. Live load:
   Load exerted by the living beings. In water tank load of water also consider as live load.
3. Wind load:
   Wind load details as per IS: 875 (part I-III),for the design
   Basic wind speed (Vb) = 39m/sec
   Terrain factor = 3
   windward coefficient = 0.8
   Leeward coefficient = 0.5
   risk coefficient k1= 1.06
   topography k3=1
   importance factor = 1
4. Earth quake load:
   Earth quake load as per IS:1893(part I-II), for the design
   Seismic Zone = III
   Zone factor = 0.16
   Importance factor =1.5
   Response reduction factor =1.8

## 4.2 STRESS DIAGRAM AFTER ANALYSIS

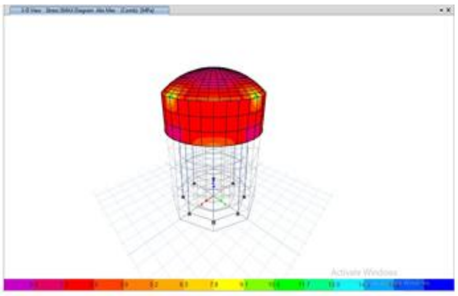

**Fig-2: Absolute Maximum Stress Diagram**

Maximum absolute stress is 15.15 N/mm2.

## 4.3 SOFTWARE DESIGN RESULT DETAILS

**Table-3: Software Design Result**

| SL. NO. | COMPONENTS OF WATER TANK | SOFTWARE DESIGN Ast in mm$^2$ (Required) |
|---|---|---|
| 1 | Top Dome | 200 mm$^2$ |
| 2 | Top Ring Beam | 983 mm$^2$ |
| 3 | Tank Wall | |
| a | Hoop Reinforcement | 942 mm$^2$ |
| b | Bending Reinforcement | 495 mm$^2$ |
| 4 | Base Slab | |
| a | Reinforcement For Max. Bending Moment | 1653 mm$^2$ |
| b | Reinforcement Of Radial Moment At Ring Beam | 526 mm$^2$ |
| c | Reinforcement Of Circumferential Moment At Ring Beam | 874 mm$^2$ |
| 5 | Bottom Ring Beam | |
| a | Support Section | 1163 mm$^2$ |
| b | Mid-Span Section | 935 mm$^2$ |
| c | Maximum Torsion | 935 mm$^2$ |
| d | Transverse Reinforcement | 628 mm$^2$ |

## 5. RESULT AND DISCUSSION

In this study, elevated circular water tank was first designed by manually using limit state design method as per IS 456-2000 and IS 3370-2009(part I-IV) and then compare that results with ETABS software design results.

Comparative result of elevated circular water tank

**Table-4: Comparison Result**

| SL. NO. | COMPONENTS OF WATER TANK | MANUAL DESIGN Ast in mm² (Required) | SOFTWARE DESIGN Ast in mm² (Required) |
|---|---|---|---|
| 1 | Top Dome | 240 mm² | 200 mm² |
| 2 | Top Ring Beam | 1015 mm² | 983 mm² |
| 3 | Tank Wall | | |
| a | Hoop Reinforcement | 1061 mm² | 942 mm² |
| b | Bending Reinforcement | 601 mm² | 495 mm² |
| 4 | Base Slab | | |
| a | Reinforcement For Max. Bending Moment | 1702 mm² | 1653 mm² |
| b | Reinforcement Of Radial Moment At Ring Beam | 552 mm² | 526 mm² |
| c | Reinforcement Of Circumferential Moment At Ring Beam | 913 mm² | 874 mm² |
| 5 | Bottom Ring Beam | | |
| a | Support Section | 1223 mm² | 1163 mm² |
| b | Mid-Span Section | 978 mm² | 935 mm² |
| c | Maximum Torsion | 978 mm² | 935 mm² |
| d | Transverse Reinforcement | 685 mm² | 628 mm² |

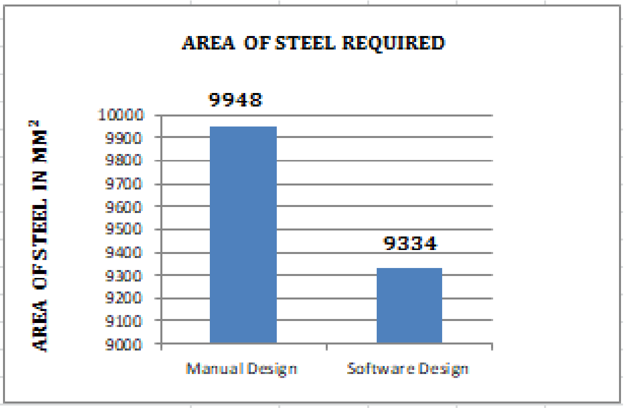


**Chart-1: Steel Distribution**

## 6. CONCLUSIONS

In this project a study is made to compare the design of elevated circular water tank by manual method and software method. To know about the area of steel required for the water tank.
From the study it is finally conclude that.

- The amount of steel required for the whole structure is less for software design compare to manual design.
- The total steel required from software design is 9334 mm2 and manual design is 9948 mm2.
- While comparing with manual design software design saves 10% of steel in whole structure.
- Manual design method require more time and complicated. Whereas the design done in etabs software require less time.

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