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COMPARATIVE STUDY ON THE DESIGN OF ELEVATED SPHERICAL CONCRETE WATER TANK

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ABSTRACT

Water is essential for all living things to survive. Water provision is critical in areas where water is scarce. Water supplied to such locations is kept in a tank. This sort of water tank is built publicly. People get water from tanks via pipes. These tanks come in a variety of shapes, including spherical and rectangular. It may be built at various heights.In this project, raised spherical water tanks are manually developed using the limit state design approach and codes (IS 3370-2009(part I-IV) and IS 456-2000), with software design done using ETABS. Finally, compare the findings achieved manually and using software. At the conclusion of the project, it is noticed that the use of etabs results in a decrease in steel when compared to manual design.

Key Words: Elevated spherical 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, spherical 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).

spherical water tank are good for store large quantities of water and are economical. For elevated storage structure generally spherical water tank are commonly employed. Generally, spherical 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. spherical 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 spherical 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 spherical 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 spherical 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.

2.3 DESIGN OF spherical 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.

Material

M30 - Grade of Concrete

Fe 415 - Grade of HYSD Reinforcement

PRELIMINARY DIMENSIONS

Storage volume for 450000 liters = 450 m^3 Volume of water tank , V = π x r^2 x h Assume height, h = 4 m

450 = π x r^2 x 4 r = 6 m

D = 12 m

By putting the value of h and r Volume = π x 6^2 x h

= π x 6^2 x 4

= 450 m^2 Free board = 0.3 m

Height of Staging from Ground = 10 m

PERMISSIBLE STRESSES

As per IS:3370 (part II) Table 1, Table 2 and Table 4 σ cbc = 10 N/mm²

σ cc = 8 N/mm²

σ st = 130 N/mm² σ ct = 1.5 N/mm

DESIGN CONSTANTS

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

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

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

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

2.4 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 (θ) = $\sin^{-}(\frac{\text{Radius of water tank}}{r})$

= 43.60°

Cosθ = 0.724

Calculation For Loads (for 1 m length of dome)

Length = 1 m

Dead load = Width x Thickness x Density

= 2.5 KN/m²

Live load = Width x Live load (assuming live load = 1.5 KN/m²)

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= 1.5 KN/m² Total load (W) = 4 KN/m²

Ultimate load = 1.5 x 4 = 6 KN/m2

Stresses in Dome

T1 = (W x R)/(1+cosθ) = 30.27 KN/m

Meridonial Stress = T1/(b x t) = 0.302 N/mm²

0.302 N/mm² < σ cc = 8 N/mm²

T2 = WxR[cosθ-1/(1+cosθ)] = 8 KN/m Hoop Stress = T2/(b x t) = 0.08 N/mm²

0.08 N/mm² < σ cc = 8 N/mm²

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 mm²

Using 8 mm ø bar, Aø = 50 mm² Spacing = 1000 x Aø/Ast = 208 mm

Hence provide 8 mm ø bars @ 200 mm c/c in both directions.

3. DESIGN OF TOP RING BEAM

It is designed for hoop tension W = T1cosθ = 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 mm² Provide 12 mm ø @ 110 mm

To find out Dimensions of Ring Beam

σ 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.

3.1 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 mm²

Minimum Steel, As Per IS:3370, Part II, Page No. 5 Ast(min) = 0.24% x gross area = 408 mm²

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 mm²

$\sigma ct = \frac{T}{b \times t + (m-1)Ast}$ = 0.73 N/mm²

Permissible tensile stress = 1.3 N/mm² (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 = $Coeff. \times W \times H^3$

= 0.0146 x 10 x 4³ = 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) = $\frac{Max.B.M.}{\sigma st \times j \times d(provided)}$ = 601 mm² 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

3.2 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/m²

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) spherical slab simply supported and subjected to water pressure plus self weight of slab.

(ii) spherical 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.

B.M. due to U.D.L.

p = 8372 KN

Now, to convert p to U.D.L.

$\frac{8372}{(\frac{\pi}{4} x\ 12^2)}$= 74 KN/m²

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 = + $\frac{3}{16}$ pa² ; (Mr)e = 0

Mr = $\frac{3}{16}$ p (a² - r²)

= $\frac{3}{16}$ x 74(6² - r²)

(Mθ)c = + $\frac{3}{16}$ pa² ; (Mθ)e = + $\frac{2}{16}$ pa² Mθ = + $\frac{p}{16}$ (3a² - r²)

= $\frac{74}{16}$ x (3(6)² - r²)

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

B.M. due to upward load W = 10595 KN For r ≤ b

Mr = (Mr)b = Mθ = (Mθ)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]

Mθ = - $\frac{w}{8\pi}$ [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

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

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 = $\frac{\sqrt{Mu,max}}{R\ x\ b}$ = 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

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

= 1702.06 mm²

Using 20 mm diameter bars, Aø = 314 mm² Spacing = $\frac{1000\ x\ 314}{1702.6}$ = 184 mm

Provide 20 mm ø @ 180 mm c/c

At Ring Beam (Mr)

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

= 552 mm²

Using 12 mm diameter bars, Aø = 113 mm² Spacing = $\frac{1000 \times 113}{552.42}$ = 204 mm

Provide 12 mm ø @ 200 mm c/c

At Ring Beam (Mθ)

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

= 913 mm²

Using 16 mm diameter bars, Aø = 201 mm² 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 mm² Spacing = $\frac{1000 \times 113}{912}$ = 123 mm

Povide 12 mm ø @ 115 c/c

DESIGN OF BOTTOM SPHERICAL BEAM

The tank is supported on a spherical 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,

2θ = (360˚)/n n = 8

2θ = 45˚= π/4

θ = 22.5˚ = $\frac{\pi}{8}$

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

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

WR².2θ = 387.5 x 4.5² x(π/4) = 6163 KNm

Max. Negative Bending Moment at Support, M_n = C1 x WR²(2θ) = 406.75 KNm

Max. Positive Bending Moment at mid-span, M_p = C2 x WR²(2θ) = 184.89 KNm

Max. Torsional Moment at an angle of 9.5˚ from support, T = C3 x WR²(2θ) = 30.81 KNm

Max. Shear force at support, V = $\frac{w \times R \times 2\theta}{2}$ = 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 = $\frac{Ast}{A\o} = \frac{1223}{\frac{\pi}{4} x\ (20)^2}$ = 4 Nos. Provide 4 bars of 20 mm ø reinforcement $Ast_{provided}$ = 1256 mm²

Nominal shear strength (τv) $\tau v = \frac{Vu}{bd}$

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

$\tau v > \tau c$

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

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

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

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 mm²

12 mm ø bars having , Aø = 113 mm² . No. of bars = $\frac{477}{113}$ = 4.2

Provide 3 - 12 ø bars on each vertical face

4. MANUAL DESIGN RESULT DETAILS

Table – 1: Manual Design Result

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

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 spherical 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.

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Table – 2: Water Tank Model Details

Sl.No	Description	spherical 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/m³
15	Material	M30 Grade Concrete and Fe415

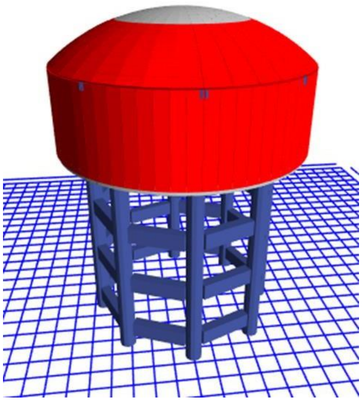

Fig – 1: 3 D Rendered Model

4.1 LOADS ACTING ON THE WATER TANK

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.

Live load:

Load exerted by the living beings. In water tank load of water also consider as live load.

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

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

4.3 STRESS DIAGRAM AFTER ANALYSIS

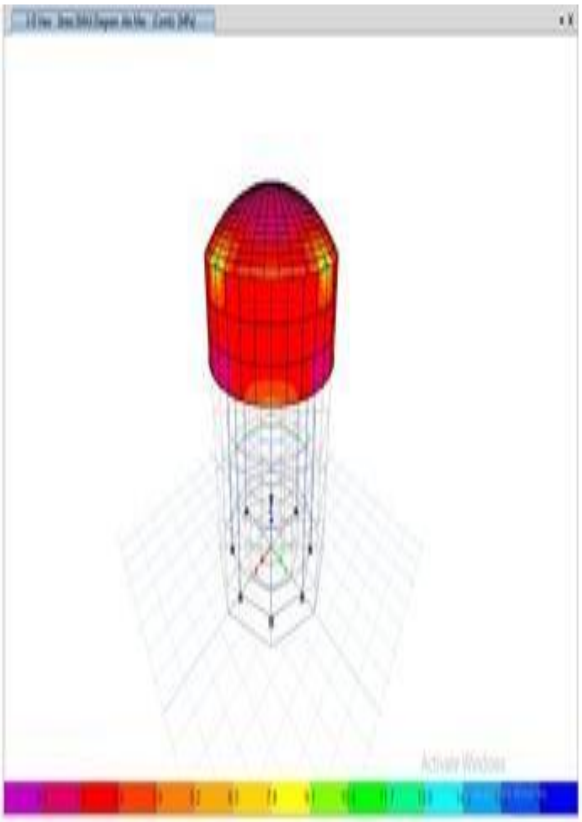

Fig-2: Absolute Maximum Stress Diagram

Maximum absolute stress is 15.15 N/mm2.

4.4 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

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5. RESULT AND DISCUSSION

In this study, elevated spherical 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 spherical water tank

Table-4: Comparison Result

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

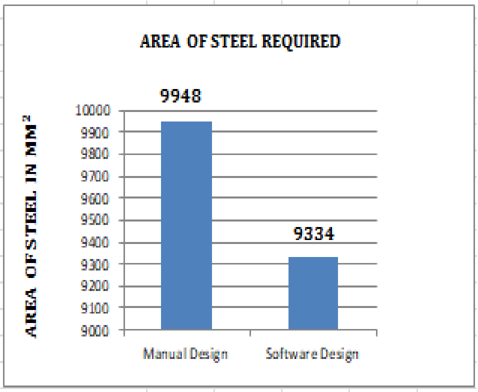

Chart-1: Steel Distribution

6. CONCLUSIONS

In this project a study is made to compare the design of elevated spherical 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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