Economical Solution for Water Tanks by using Different types of Stiffeners

Kshirsagar Lalit Nitin[1], Patil. S.K.[2], Pujari. A. B.[3]

*[1]Post Graduate Student, KJ's Educational Institute
KJCOEMR, Pune, Maharashtra, India.
[2]Associate Professor and HOD of Civil Engineering Dept, KJ's Educational Institute
KJCOEMR, Pune, Maharashtra, India.
[3]Associate Professor of Civil Engineering Dept, KJ's Educational Institute
KJCOEMR, Pune, Maharashtra, India.*

Abstract – *In this paper the circular water tank is analyzed by using finite element method. The wall of the circular water tank is analyzed for parameters such as moment and hoop tension at various levels subjected to hydrostatic pressure by using eccentric stiffeners. The wall is divided into number of 4 noded rectangular(quadrilateral) plate elements. The vertical beam elements are attached to the wall up to 40% height of the tank. Then the tank is subjected to triangularly varying hydrostatic load. The analysis is carried out for different H^2/Dt ratios such as 16 and 25.5. Vertical eccentric stiffeners are attached to the tank having H^2/Dt ratio 25.5 and tank having H^2/Dt 16 is analyzed without stiffeners.*

Key Words: **Water Tank, Stiffeners, FEM, STAAD-Pro.**

1. INTRODUCTION

There is Always a need of some improved kind of structural forms in the construction industry. One such common form is stiffened shell. Because of their improved performance under different load conditions stiffened structural elements have found wide application in modern structures. The primary advantage of stiffened shell is structural efficiency. The stiffened structural system achieves conservation of weight with no sacrifice of strength or reduction of critical buckling load. Economy is usually simultaneously achieved and appearance of structure is enhanced as bonus. Here, a stiffened cylindrical wall of circular water tank is considered and analyzed by finite element method by using STAAD-Pro software

Water tank parameters include the general design of the tank, and choice of construction materials, linings. Reinforced Concrete Water tank design is based on IS 3370: 2009 (Parts I – IV). The design depends on the location of tanks, i.e. overhead, on ground or underground water tanks. The tanks can be made of RCC or even of steel. The overhead tanks are usually elevated from the ground level using number of columns and beams. On the other hand the underground tanks rest below the ground level.

1.1 STIFFENERS

Stiffeners are secondary plates or sections which are attached to structures to stiffen them against out of plane deformations. Almost all main bridge beams will have stiffeners. However, most will only have transverse web stiffeners, i.e. vertical stiffeners attached to the web. Deep beams sometimes also have longitudinal web stiffeners. Flange stiffeners may be used on large span box girder bridges but are unlikely to be encountered elsewhere.

TYPES OF STIFFENERS

1. Longitudinal Stiffener
2. Transverse Stiffener

- Longitudinal web stiffeners are the stiffeners which are aligned in the span direction. Transverse stiffeners are the stiffeners which are aligned normal to the span direction of the beam.

- Transverse web stiffeners are usually provided at bearing positions and these are known as bearing stiffeners. For future maintenance it is good practice to provide bearing stiffeners at jacking points (for when girders have to be raised to free bearings for replacement). Other transverse stiffeners are called intermediate transverse web stiffeners.

2. OBJECTIVES OF THE STUDY

1) To make the study about the analysis and design of water tanks.
2) To study the behaviour of different type of stiffeners in different position under different load conditions.
3) To compare the conventional design of water tank with the design of water tank using different type of stiffeners.
4) To know economical design of water tank.

3. PROBLEM STATEMENT

The basic purpose of this work is to "analyze the wall of cylindrical tank for moment and tension values at various levels along the height of wall subjected to hydrostatic pressure by using eccentric stiffeners."

For the analysis of wall finite element method is used. The analysis is to be carried out on the wall of cylindrical water tank with vertical stiffeners. For the analysis of wall 8, 12 and 16 numbers of vertical stiffeners are used along the periphery of tank and height of stiffener is kept up to 40% of the wall height.

4. METHODOLOGY

In this dissertation it is proposed to analyze the wall of cylindrical water tank resting on ground and study its structural behavior under the influence of hydrostatic loads when stiffened by eccentric stiffeners. The objectives are to find out moments and tension in stiffened cylindrical wall of water tank. To obtain these following variable parameters are used for cylindrical wall and stiffeners. Convergence study is conducted for different no of elements. In this analysis the stiffening effect is considered by stiffening the shell element by introducing a beam element as a stiffener. With the same mesh size, analysis is performed for H^2/Dt ratio 25.5 and different stiffener width.

For cylindrical wall

a) H – Height of cylindrical wall
b) D – Diameter of tank
c) t – Thickness of cylindrical Wall

For stiffeners

a) n – Number of stiffeners

b) b – Width of stiffeners

c) d – Depth of stiffeners

Hydrostatic load is applied on the wall as per depth of water.

4.1 DETAILS OF STRUCTURE

A) WALL

Wall of cylindrical water tank is considered as Shell. The element considered is four nodded (quadrilateral) flat shell element. Flat shell element is considered because as we divide shell into number small element its curved surface becomes flat. The following geometry related modelling roles must be considered while using the plate/shell element.

- Element aspect ratio should not be excessive. The ratio should be almost to the order of 1 : 1.
- Individual element should not be distorted.
- Angles between two element side should not be larger than 90^0 and never larger than 180^0.

B) VERTICAL STIFFENER

The height of vertical stiffeners are considered as 40% of the height of wall of water tank from bottom of tank. The stiffener is connected to the common nodes to tank of wall. The stiffeners are placed at the equal angle. Beam element is taken to assign the stiffener, various numbers of stiffeners are used for modelling such as 8, 12 and 16 number of stiffeners.

Section of stiffeners

Section of stiffener is decided by using b/t_s and d/b ratios

Here, t_s = Thickness of stiffener considered = 0.3 m

For various combinations of above ratio stiffener sections will be as below.

a) For rectangular section stiffeners:

Table No 1: Sectional Properties of Rectangular Section Stiffeners

Ratio combinations	Width of Stiffener (b)	Depth of Stiffener (d)
bt$_s$1db1.5	0.300 m	0.675 m
bt$_s$1db2	0.300 m	1.200 m
bt$_s$1.5db1.5	0.450 m	0.675 m
bt$_s$1.5db2	0.450 m	1.200 m
bt$_s$2db1.5	0.600 m	0.675 m
bt$_s$2db2	0.600 m	1.200

b) For trapezoidal section stiffeners:

For trapezoidal section no ratio is used to decide the section properties, from the above ratios the depth at top and bottom are decided, there is no variation in depth, the depth is kept constant.

Table No 2: Sectional Properties of Trapezoidal Section Stiffeners.

Width of Stiffener	Depth of Stiffener at top	Depth of Stiffener at bottom
0.300 m	0.675 m	1.200 m
0.450 m	0.675 m	1.200 m
0.600 m	0.675 m	1.200 m

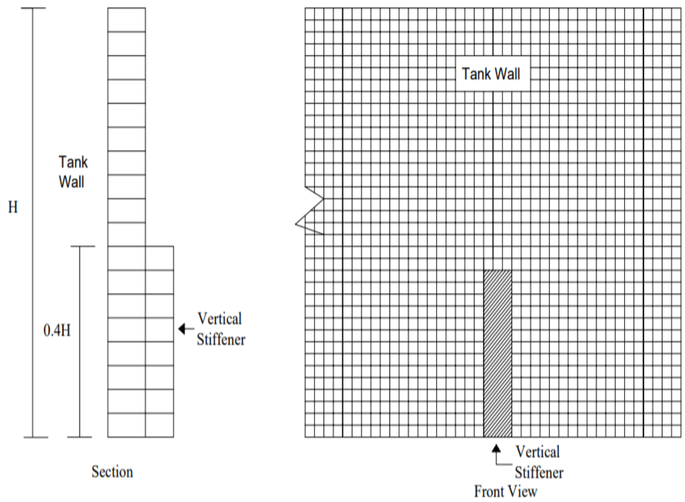


Fig No 1: Cylindrical Wall of Tank with Vertical Stiffeners

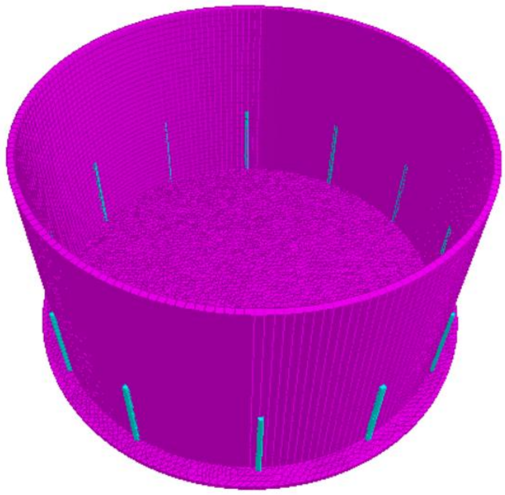


Fig No 4: Tank with 12 No of Vertical Stiffeners

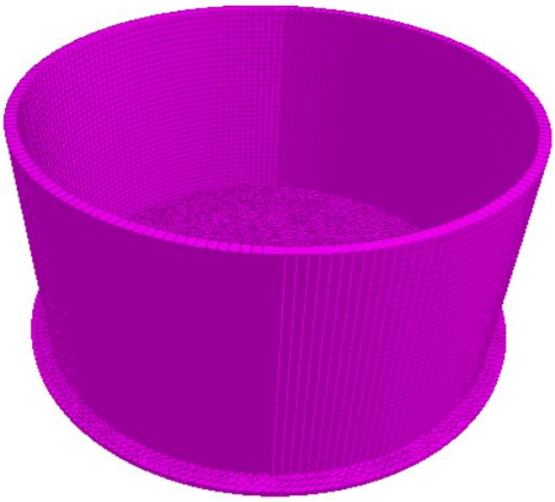


Fig No 2: Tank without Vertical Stiffeners

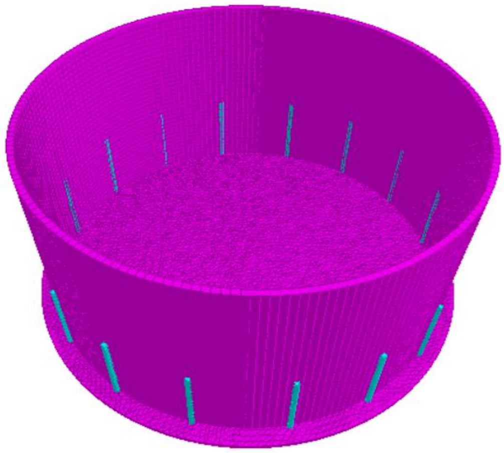


Fig No 5: Tank with 16 No of Vertical Stiffeners

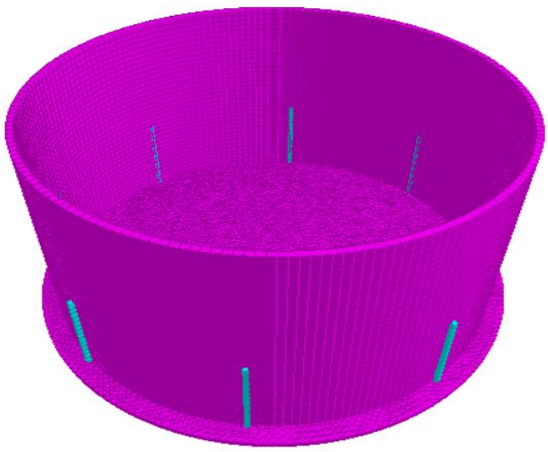


Fig No 3: Tank with 8 No of Vertical Stiffeners

5. RESULT AND DESCUSSION

The results for moments and hoop tension for vertically stiffened tank having $H^2/Dt=25.5$ and for tank without stiffeners having $H^2/Dt=16$

Table No 3: Moments for circular water tank with rectangular stiffeners and without stiffeners.

Height	Moment (KN.m/m)									
(m)	bt$_s$1db1.5			bt$_s$1db2			bt$_s$1.5db1.5			Without Stiffeners
No of Stiffeners	8	12	16	8	12	16	8	12	16	
0.1h	-0.11	-0.083	-0.084	-0.173	-0.137	-0.131	-0.122	-0.084	-0.086	-0.158
0.2h	0.108	0.093	0.07	0.101	0.129	-0.114	0.125	0.101	0.116	-0.493
0.3h	0.094	0.076	0.05	-0.437	-0.84	-0.948	0.097	0.071	-0.034	-2.383
0.4h	-0.748	-0.794	-0.789	-1.61	-2.386	-2.81	-0.831	-0.912	-0.917	-5.095
0.5h	-3.278	-3.494	-3.601	-4.532	-4.125	-4.168	-3.367	-3.678	-3.835	-7.635
0.6h	-3.647	-3.396	-2.952	10.441	10.88	10.923	-3.821	-3.46	-2.823	2.582
0.7h	11.346	11.27	11.208	16.88	17.667	18.226	13.048	12.986	12.932	32.059
0.8h	46.709	46.446	46.439	50.471	49.082	46.359	46.914	46.528	46.089	112.418
0.9h	86.167	85.705	84.243	89.17	87.34	82.111	86.446	85.8	83.805	176.767
1.0h	46.194	46.21	46.262	44.714	43.546	43.149	46.294	46.279	46.374	92.618

Table No 4: Moments for circular water tank with rectangular stiffeners and without stiffeners.

Height	Moment (KN.m/m)									
(m)	bt$_s$1.5db2			bt$_s$2db1.5			bt$_s$2db2			Without Stiffeners
No of Stiffeners	8	12	16	8	12	16	8	12	16	
0.1h	-0.2	-0.16	-0.148	-0.132	-0.086	-0.089	-0.223	-0.179	-0.16	-0.158
0.2h	-0.12	-0.217	-0.203	0.138	0.108	0.122	-0.17	-0.292	-0.279	-0.493
0.3h	-0.632	-1.201	-1.37	-0.11	-0.104	-0.087	-0.793	-1.499	-1.719	-2.383
0.4h	-1.962	-2.997	-3.585	-0.911	-1.031	-1.05	-2.24	-3.491	-4.212	-5.095
0.5h	-5.05	-4.452	-4.006	-3.394	-3.792	-3.996	-5.453	-4.669	-3.767	-7.635
0.6h	13.226	14.005	14.211	-3.966	-3.502	-2.681	16.439	17.568	17.901	2.582
0.7h	16.84	17.545	18.51	14.321	14.285	14.246	16.412	17.009	18.204	32.059
0.8h	51.562	49.778	46.15	47.106	46.598	45.761	52.35	50.204	45.775	112.418
0.9h	90.107	87.911	81.514	86.704	85.883	83.42	90.81	88.291	80.923	176.767
1.0h	44.793	43.479	43.226	46.406	46.385	46.522	44.994	43.648	43.549	92.618

Table No 5: Moments for circular water tank with trapezoidal stiffeners and without stiffeners.

Height	Moment (KNm/m)									
(m)	300 MM WIDTH			450 MM WIDTH			600 MM WIDTH			Without Stiffeners
No of Stiff	8	12	16	8	12	16	8	12	16	
0.1h	-0.147	-0.097	-0.097	-0.166	-0.106	-0.104	-0.182	-0.113	-0.11	-0.158
0.2h	0.136	0.148	0.148	0.148	0.162	0.144	0.155	0.171	0.135	-0.493
0.3h	-0.154	-0.306	-0.313	-0.257	-0.484	-0.523	-0.358	-0.646	-0.728	-2.383
0.4h	-1.133	-1.538	-1.697	-1.341	-1.914	-2.162	-1.521	-2.238	-2.574	-5.095
0.5h	-3.863	-4.198	-4.718	-4.236	-4.322	-4.986	-4.542	-4.375	-5.127	-7.635
0.6h	5.942	5.772	5.53	8.615	8.936	8.399	10.715	11.881	10.718	2.582

0.7h	20.502	21.022	21.32	22.345	22.892	23.536	23.214	23.714	24.678	32.059
0.8h	48.763	48.016	46.62	49.513	48.454	46.432	50.1	48.742	46.166	112.418
0.9h	87.934	86.316	81.79	88.631	86.599	81.001	89.18	86.79	80.318	176.767
1.0h	-19.107	-20.513	-19.430	-19.851	-21.437	-19.772	-20.299	-21.939	-19.658	92.618

Table No 6: Hoop Tension for circular water tank with rectangular stiffeners and without stiffeners.

Height	**Hoop Tension (N/mm^2)**									
(m)	**bt$_s$1db1.5**			**bt$_s$1db2**			**bt$_s$1.5db1.5**			**Without Stiffeners**
No of Stiffeners	**8**	**12**	**16**	**8**	**12**	**16**	**8**	**12**	**16**	
0.1h	0.674	0.674	0.674	0.677	0.673	0.674	0.675	0.674	0.674	0.417
0.2h	1.244	1.244	1.244	1.248	1.241	1.240	1.244	1.244	1.244	0.768
0.3h	2.001	2.001	2.001	2.009	2.001	1.997	2.002	2.001	2.001	1.244
0.4h	2.570	2.570	2.570	2.587	2.592	2.591	2.571	2.570	2.571	1.617
0.5h	3.368	3.369	3.373	3.428	3.463	3.498	3.374	3.375	3.381	2.167
0.6h	4.319	4.320	4.333	4.431	4.453	4.507	4.322	4.327	4.343	2.795
0.7h	5.075	5.080	5.095	5.125	5.116	5.125	5.088	5.095	5.114	3.249
0.8h	5.645	5.623	5.611	5.566	5.442	5.375	5.641	5.611	5.590	3.47
0.9h	4.813	4.764	4.733	4.712	4.492	4.414	4.807	4.740	4.692	2.861
1.0h	0.613	0.614	0.609	0.581	0.572	0.554	0.605	0.605	0.600	0.358

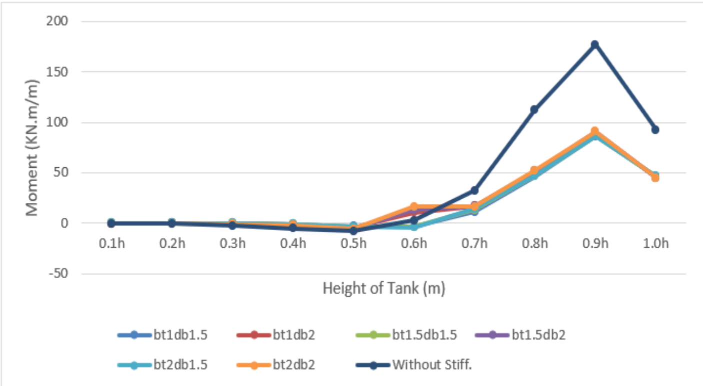
Table No 7: Hoop Tension for circular water tank with rectangular stiffeners and without stiffeners.

Height	**Hoop Tension(N/mm^2)**									
(m)	**bt$_s$1.5db2**			**bt$_s$2db1.5**			**bt$_s$2db2**			**Without Stiffeners**
No of Stiffeners	**8**	**12**	**16**	**8**	**12**	**16**	**8**	**12**	**16**	
0.1h	0.678	0.673	0.674	0.675	0.674	0.674	0.678	0.673	0.673	0.417
0.2h	1.249	1.240	1.238	1.244	1.244	1.244	1.250	1.239	1.236	0.768
0.3h	2.011	2.002	1.997	2.002	2.001	2.000	2.013	2.003	1.996	1.244
0.4h	2.593	2.603	2.604	2.571	2.571	2.572	2.598	2.611	2.614	1.617
0.5h	3.454	3.500	3.551	3.380	3.381	3.390	3.477	3.529	3.594	2.167
0.6h	4.470	4.499	4.564	4.334	4.338	4.360	4.499	4.534	4.609	2.795
0.7h	5.126	5.110	5.117	5.097	5.106	5.128	5.121	5.101	5.104	3.249
0.8h	5.544	5.367	5.275	5.638	5.599	5.572	5.527	5.304	5.190	3.47
0.9h	4.687	4.414	4.294	4.801	4.720	4.654	4.669	4.358	4.195	2.861
1.0h	0.569	0.568	0.545	0.597	0.597	0.591	0.563	0.556	0.530	0.358

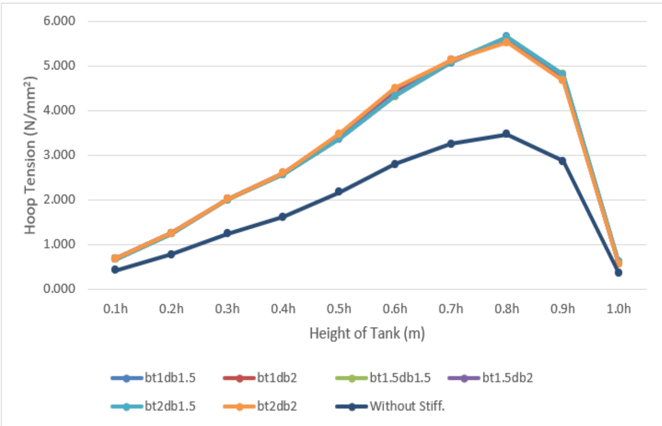
Table No 8: Hoop Tension for circular water tank with trapezoidal stiffeners and without stiffeners.

Height	**Hoop Tension (N/mm^2)**									
(m)	**300 MM WIDTH**			**450 MM WIDTH**			**600 MM WIDTH**			**Without Stiffeners**
No of Stiffeners	**8**	**12**	**16**	**8**	**12**	**16**	**8**	**12**	**16**	
0.1h	0.675	0.674	0.675	0.676	0.674	0.675	0.676	0.674	0.675	0.417
0.2h	1.246	1.242	1.242	1.247	1.241	1.241	1.247	1.241	1.240	0.768
0.3h	2.005	1.998	1.997	2.006	1.998	1.996	2.007	1.998	1.995	1.244
0.4h	2.577	2.572	2.570	2.580	2.576	2.573	2.583	2.580	2.578	1.617
0.5h	3.386	3.406	3.414	3.399	3.427	3.443	3.411	3.445	3.469	2.167

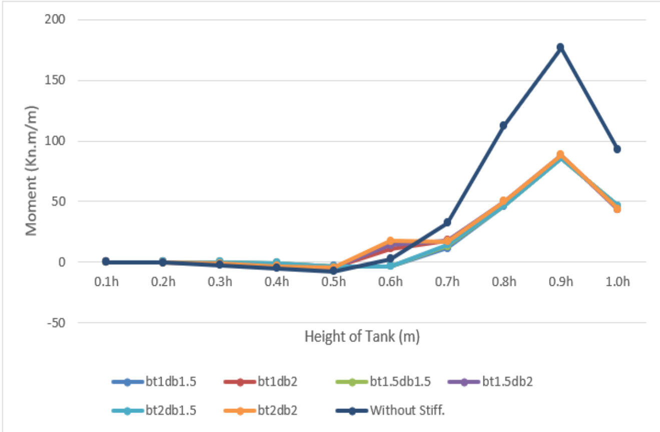
0.6h	4.379	4.397	4.443	4.411	4.433	4.491	4.437	4.463	4.528	2.795
0.7h	5.151	5.157	5.182	5.164	5.172	5.199	5.169	5.183	5.206	3.249
0.8h	5.602	5.546	5.502	5.586	5.493	5.433	5.574	5.445	5.373	3.47
0.9h	4.746	4.575	4.507	4.726	4.514	4.406	4.711	4.468	4.321	2.861
1.0h	0.579	0.572	0.558	0.574	0..566	0.549	0.571	0.555	0.536	0.358



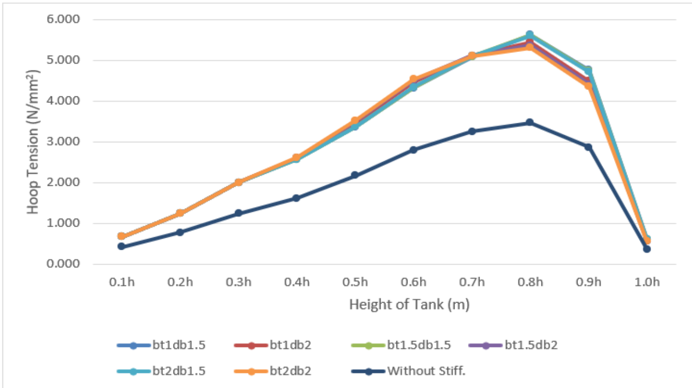
Graph No 1: Moment Comparison of Tank with 8 No of Stiffeners & Raft



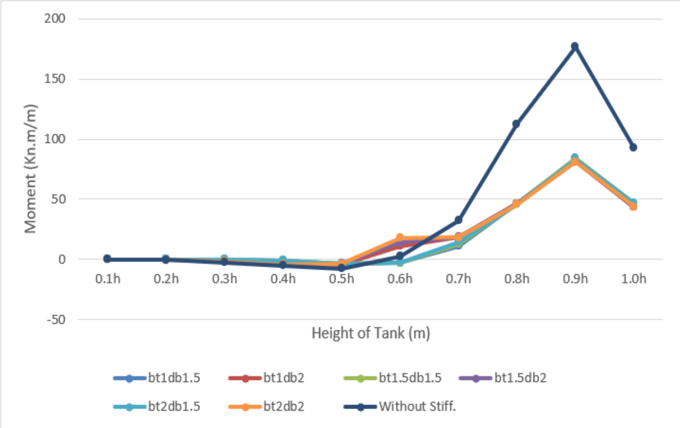
Graph No 2: Hoop Tension Comparison of Tank with 8 No of Stiffeners & Raft



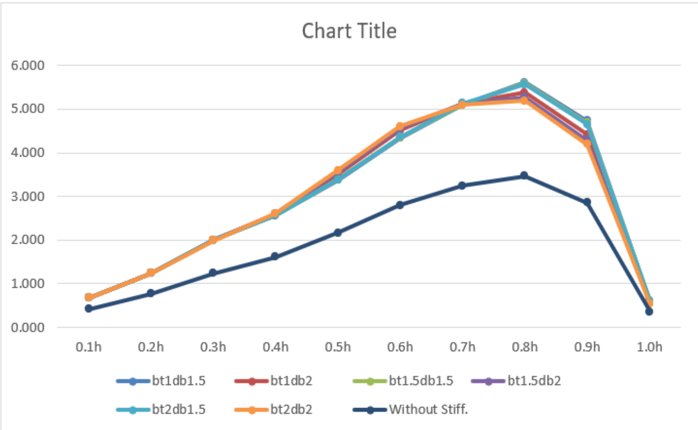
Graph No 3: Moment Comparison of Tank with 12 No of Stiffeners & Raft



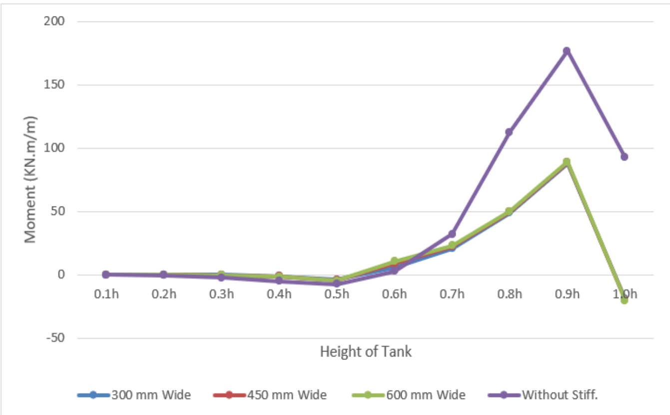
Graph No 4: Hoop Tension Comparison of Tank with 12 No of Stiffeners & Raft



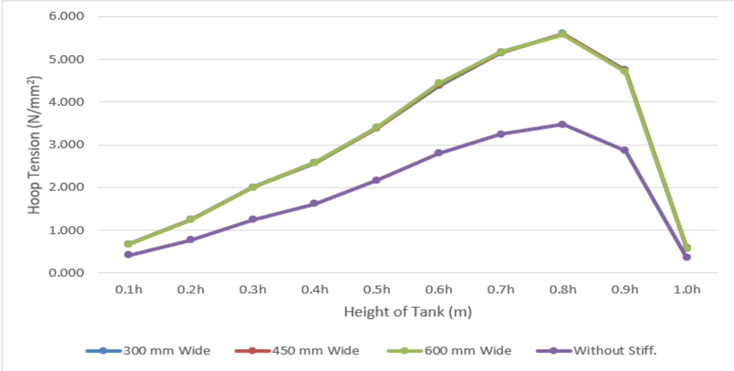
Graph No 5: Moment Comparison of Tank with 16 No of Stiffeners & Raft



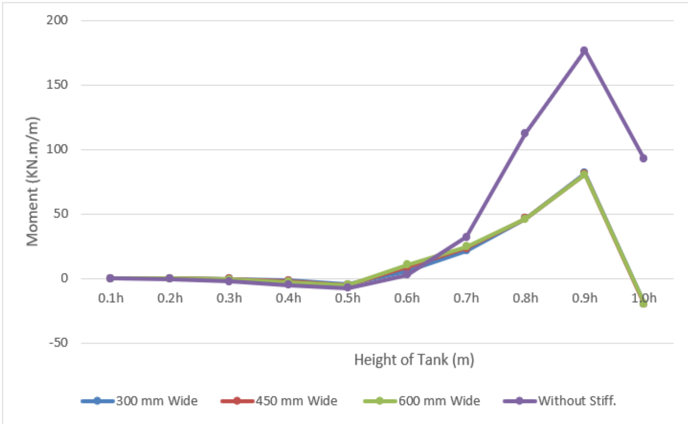
Graph No 6: Hoop Tension Comparison of Tank with 16 No of Stiffeners & Raft



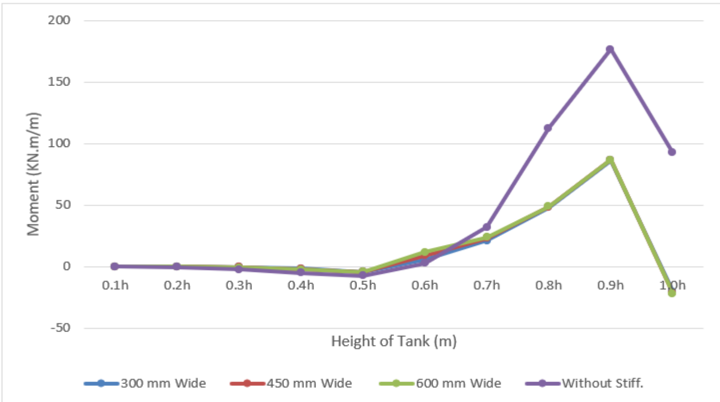
Graph No 7: Moment Comparison of Tank with 8 No of Tapered Stiffeners & Raft



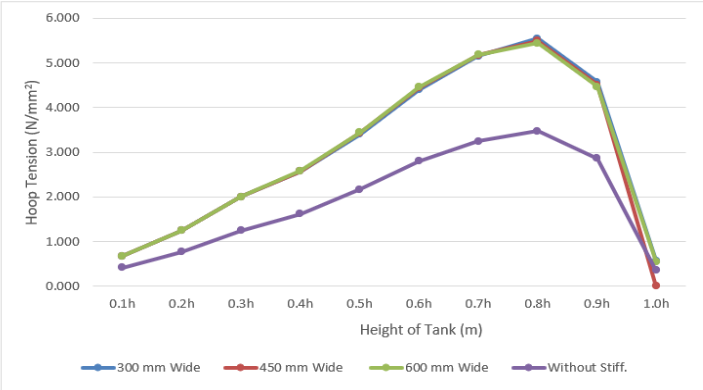
Graph No 8: Hoop Tension Comparison of Tank with 8 No of Tapered Stiffeners & Raft



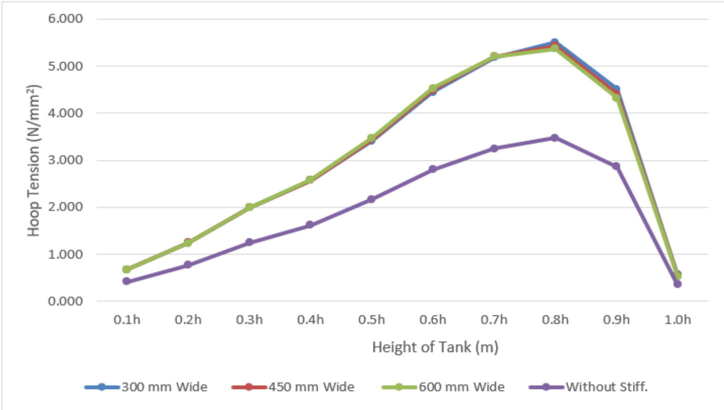
Graph No 9: Moment Comparison of Tank with 12 No of Tapered Stiffeners & Raft



Graph No 10: Hoop Tension Comparison of Tank with 8 No of Tapered Stiffeners & Raft



Graph No 11: Moment Comparison of Tank with 16 No of Tapered Stiffeners & Raft



Graph No 12: Hoop Tension Comparison of Tank with 12 No of Tapered Stiffeners & Raft

5.1 COST COMPARISION:

Rate of Concrete: 5500 Rs /Cu.m Rate of Steel: 41200 RS /M.T

a) For Tank with Rectangular Stiffeners:

Table No 9: Cost comparison of circular water tank having rectangular stiffeners with circular tank without stiffeners.

Stiffeners		Cost of Concrete / (cu.m)		Cost of Steel / (M.T)		Total Cost (Lakh)	Savings (%)
Size (m)	No	Quantity	Cost	Quantity	Cost		
Without Stiffeners		1472.628	80.995	71.924	29.633	110.627	**0.00**
bt$_s$1db1.5	8	1061.510	58.383	109.974	45.309	103.692	**6.27**
	12	1063.975	58.519	110.483	45.519	104.038	**5.96**
	16	1066.440	58.654	110.992	45.729	104.383	**5.64**
bt$_s$1db2	8	1070.922	58.901	121.904	50.224	109.125	**1.36**
	12	1078.094	59.295	135.286	55.738	115.033	**-3.98**
	16	1085.265	59.690	136.047	56.051	115.741	**-4.62**
bt$_s$1.5db1.5	8	1063.975	58.519	111.381	45.889	104.408	**5.62**
	12	1067.673	58.722	112.021	46.152	104.874	**5.20**
	16	1071.371	58.925	112.660	46.416	105.341	**4.78**
bt$_s$1.5db2	8	1078.094	59.295	140.981	58.084	117.380	**-6.10**
	12	1088.850	59.887	141.797	58.421	118.307	**-6.94**
	16	1099.607	60.478	142.613	58.757	119.235	**-7.78**
bt$_s$2db1.5	8	1066.440	58.654	113.416	46.728	105.382	**4.74**
	12	1071.371	58.925	121.453	50.038	108.964	**1.50**
	16	1076.301	59.197	115.008	47.383	106.580	**3.66**
bt$_s$2db2	8	1085.265	59.690	137.830	56.786	116.475	**-5.29**
	12	1099.607	60.478	145.419	59.913	120.391	**-8.83**
	16	1113.950	61.267	140.094	57.719	118.986	**-7.56**

b) Results for Tank with Tapered Section Stiffeners:

Table No 10: Cost comparison of circular water tank having trapezoidal stiffeners with circular tank without stiffeners.

Stiffeners		Cost of Concrete / (cu.m)		Cost of Steel / (M.T)		Total Cost (Lakh)	Savings (%)
Size (m)	No	Quantity	Cost	Quantity	Cost		
Without Stiffeners		1472.628	80.995	71.924	29.63269	110.627	**0.00**
(0.675 x 1.2)	8	1066.217	58.642	125.702	51.78937	110.431	**0.18**
300 MM WIDTH	12	1071.035	58.907	132.928	54.76636	113.673	**-2.75**
	16	1075.854	59.172	126.778	52.23244	111.404	**-0.70**
450 MM WIDTH	8	1071.031	58.907	128.283	52.8524	111.759	**-1.02**
	12	1078.257	59.304	135.650	55.88799	115.192	**-4.13**
	16	1085.482	59.702	136.330	56.16813	115.870	**-4.74**
600 MM WIDTH	8	1075.854	59.172	134.423	55.38237	114.554	**-3.55**
	12	1085.490	59.702	141.992	58.50074	118.203	**-6.85**
	16	1095.127	60.232	142.873	58.86366	119.096	**-7.65**

6. CONCLUSIONS

In this paper circular water tank is analyzed for various H^2/Dt ratio, circular water tank having $H^2/Dt=25.5$ is stiffened with vertical stiffeners upto 40% height of tank from bottom. This model is compared with circular tank having no stiffeners and $H^2/Dt=16$. From the analysis following conclusions are drawn.

- The stiffened structural system achieves some economy with no sacrifice to strength.
- Use of eccentric stiffeners reduces moments but there is increase in hoop tension for tank having $H^2/Dt=25.5$ as compared to tank having $H^2/Dt=16$.
- For lower b/d ratio of stiffeners there is reduction in cost as compare to higher b/d ratio.
- Maximum economy is achieved for minimum number of stiffeners.

ACKNOWLEDGMENT

The authors acknowledge Dr S. K. Patil, Head of the Department of Civil Engineering, KJ's Educational Institute K J College of Engineering and Management Research Pune, India for providing the necessary facilities for the completion of this research work. The authors also extend gratitude to Associate Professor of Civil Engg. Dept. A. B. Pujari for the support for the successful completion of the project.

REFERENCES

1) "Design and analysis of water tanks using Staad Pro", by Mr. Manoj Nallanathel Mr. B. Ramesh , L. Jagadeesh, International Journal of Pure and Applied Mathematics Volume 119 No. 17 2018, 3021-3029
2) "Implementation of water tank design using Staad Pro software", by Miss. Sunita Ahuja, Mr. Sourabh Dashore, International Journal of Scientific Research & Engineering Trends Volume 5, Issue 6, Nov-Dec-2019
3) "Economical design of concrete tanks", by Mr. Hasan Jasim Mohammed, European Journal of Scientific Research Vol.49 No.4 (2011)
4) "Cost optimization of rectangular RCC underground tank", by Mr.Aditya Wad, Mr. N. G. Gore, Mr. P. J. Salunke, Mr.V. G. Sayagav , International Journal of Recent Technology and Engineering (IJRTE), Volume-3 Issue-3, July 2014
5) "Economic design of water tank of different shapes with reference to IS: 3370-2009", by Mr. M. Bhandari, Mr. Karan Deep Singh, International Journal Of Modern Engineering Research (IJMER) Vol. 4 | Iss. 12 | Dec. 2014
6) "Parametric study of rectangular water tank using different methodology", by Mr. Mehul S. Kishori , Mr. Chirag N. Patel , IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 05, 2015
7) "Analysis and economical design of water tanks", by Thalapathy.M, Vijaisarathi. R. P, Sudhakar. P, Sridharan. V, Satheesh. V. S , IJISET - International

Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 3, March 2016

8) "Analytical and software based comparative analysis of on ground circular water tank" , by Mr. Chirag N. Patel , Mr. Mehul S. Kishori , International Journal of Civil Engineering (IJCE) Vol. 5, Issue 3, Apr - May 2016; 31-36
9) "Comparative analysis and design of RCC circular and rectangular shape water tank resting on ground" , by T. Karanjekar, A. Ghatole, Y. Pande, S. Jadhav, S. Usendi, R. K. Parve , International Journal of Research in Engineering, Science and Management Volume-2, Issue-3, March-2019
10) "The economic analysis & design of R.C.C. & prestressed concrete water tank resting on the ground" , by Mr. Novendra Kumar Verma, Mr. Kaushal Kumar Jetty, Mr. Lokesh Bhai Patel, Dr. G.P. Khare, Mr. Dushyant Kumar Sahu , International Research Journal of Engineering and Technology (IRJET) , Volume: 05 Issue: 05 | May-2018.
11) "Finite Element Analysis of Water tank Wall Using Eccentric Stiffeners", by Mr. S.P. Wagh and Prof. R.R Joshi, National Conference on "Emerging and Development in Civil Engineering March 2007.
12) IS 456-2000 Indian Standard Plane and Reinforced Concrete Code of Practice, Bureau of Indian Standards.
13) IS 3370-2009 (Part 1) Indian Standard Concrete Structures for Liquids (General Requirements)-Code of Practice, Bureau of Indian Standards.
14) IS 3370-2009 (Part 2) Indian Standard Concrete Structures for Liquids (Reinforced Concrete Structures)-Code of Practice, Bureau of Indian Standards.