

## International Journal of Innovative Research in Science, Engineering and Technology

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# Parametric Study of Water Retaining RC Structures on Ground and Below Ground Subjected to Hydrodynamic Forces

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**ABSTRACT:** Parametric study of a structure is the process of analytical comparative study on structure with considering and changing various parameters that influence the strength and support conditions of the structure. A liquid retaining structure is nothing but a liquid storage tank. In which most probably water is been storied. However sometimes liquids other than water, i.e., oils, petroleum products, beverages, sewages are also been stored. In this paper, Parametric study is been conducted on liquid retaining structures which are made with reinforced concrete and are resting on ground and below ground and are been subjected to both static and hydrodynamic forces. Tanks which are rectangular and circular in shape are been considered for the study. Parameters considered in this paper are shape and height. Analysis been done for static pressure, hydrodynamic pressure, earth pressure, vertical and horizontal moments and hoop tension, base moments, projections to counteract upliftment.

**KEYWORDS:** Vertical moment, horizontal moment, hoop tension, base slab, hydrodynamic and upliftment.

### I. INTRODUCTION

Liquid retaining structures are none other than liquid storage tanks. In which besides water, sometimes liquids other than water, like oils, petroleum products, sewages, beverages are also been stored in these storage tanks. In this Paper they are often termed as tanks. These tanks are manmade constructions. These structures are standing more or less permanently in one place. Tanks came in variety of shapes, sizes and function, and have been adapted throughout history for a wide number of factors, from building materials available, to weather conditions, to land prices, ground conditions, specific uses and aesthetic reasons. To better understand the term tank compares the list of structures. Tanks are part and parcel for living and sub structure for every construction. Tanks serve several needs of society – primarily as drinking, and to wash and cleaning. A tank is must for a physical division of the human habitat (a place of storage of water) and the outside (a place that at times may be harsh and harmful). In recent years, interest in sustainable planning and storage practices has also become an intentional part of the design process of many new buildings. A slab is a flat two dimensional planar structural element having thickness small compared to its other two dimensions. Similarly steel plates are also arranged as steel slabs in order to meet the requirement as said in above reinforced concrete tanks. This paper deals with reinforced concrete tanks only. Tanks comprises of four walls closed side by side and closed at base. Walls and base slab is of reinforced concrete. Water is been filled inside the tank which is our consideration and sometimes earth which is in contact with partially of fully with walls and fully with slab. Water may be partially filled inside the tank and also hits the walls of tank when dynamic forces like earthquake comes into scenario which leads for hydrodynamic forces to act inside the tank. This paper deals with reinforced concrete tanks only. Tanks comprises of four walls closed side by side and closed at base. Walls and base slab is of reinforced concrete. Water is been filled inside the tank which is our consideration and sometimes earth which is in contact with partially of fully with walls and fully with slab. Water may be partially filled inside the tank and also

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hits the walls of tank when dynamic forces like earthquake comes into scenario which leads for hydrodynamic forces to act inside the tank.

The work is been done by calculating static pressure, hydrodynamic pressure, earth pressure and by adding all the pressures with respective to its directions horizontal and vertical moments are calculated for rectangular tank and vertical moment and hoop tension are calculated for circular tank. After that calculation for base slab and uplift are carried out. These results are been compared with each other. Two capacities are considered those are 10,00cubic meters, 15, 00 cubic meters. For each capacity, same volumes of rectangular and cylindrical tanks are accounted. Volume for each tank is kept constant and dimensions of both shaped tanks are changed by keeping 3m, 4m heights. And also for both on ground and below ground tanks are been considered and compared. Total 16 tanks are been compared for both presence and absence of hydrodynamic forces. Underground tanks with empty condition also mentioned here. For calculations IS 3370 part 4 and for hydrodynamic forces iitk-gsdma guidelines for seismic design of liquid storage tanks are been used in this paper. Under Section II literature done by different people which is similar to this work are been mentioned. Under Section III methodology, approach how to calculate, discussions are been mentioned. Under Section IV Experimental Results are been tabulated always at five intermediate points of the element of structure with comparing among themselves are been mentioned. And comparisons are only done for walls of both tanks not for base slab and upliftment. Under Section V Conclusions drawn from this work are extracted and been mentioned. And finally References taken to do this work are been mentioned.

## II. LITERATURE SURVEY

The related works to this project title are been surveyed and presenting some of them as the literature review as follows:

- 1) M. Bhandari, Karan Deep Singh, in December 2014, discussed the study in "Economic Design of Water Tank of Different Shapes with Reference To IS: 3370 2009", The traditional technique for planning water tanks which is working anxiety strategy illustrated in the past variant of IS: 3370 1965 is nonsensical and prompts generally thicker areas with a considerable measure of support. Point of confinement state technique which is generally utilized has been as of late embraced in the new form of IS 3370-2009 solid structures for capacity of fluids – code of training. For speedy cost forecast of tanks, this investigation consequently inspects the cost adequacy as far as measure of materials and formwork utilized for Circular, Square and Rectangular overhead water tanks each of three limits of 100kl, 150kl, 200kl and draw sensible deductions on tank's shape plan viability . Each water tank was composed by Limit State technique and after that the break width was checked by confine condition of serviceability IS 3370 (2009). The outcomes have been introduced as charts and tables and it has been watched that Circular-formed tank devoured lesser of every material when contrasted with Square and Rectangular ones. The measure of formwork required for round tank is additionally not as much as that for square and rectangular tanks in this way giving Circular-moulded tanks a more positive choice over the rectangular and square moulded tanks.
- 2) A. Dogangun and R. Livaoglu, in October 2008, discussed the study in "A Comparative study of the seismic analysis of rectangular tanks according to different codes", As known from extremely disquieting encounters, fluid stockpiling tanks were fell or intensely harmed amid the quakes everywhere throughout the word. Harm or crumple of the tanks causes some undesirable occasions, for example, deficiency of drinking and using water, uncontrolled flames and spillage of hazardous liquids. Because of this reason various investigations accomplished for dynamic conduct of liquid compartments; the vast majority of them are worried about barrel shaped tanks. However, not very many investigations on the seismic reaction of rectangular compartments exist. Accordingly this examination is to be for the most part about rectangular tanks. Similar seismic investigations are completed for a rectangular tank considering necessities and articulations given in seismic codes arranged for USA, European Community and New Zealand. Turkish seismic code is additionally talked about. Hydrodynamics weights, sloshing removals, base shears, parallel relocations, bowing and toppling minutes are resolved for considered codes and determinations. At last, comes about acquired this examination are assessed and a few conclusions identified with the experienced contrasts and similitude for seismic investigation and plan of rectangular tanks.

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- 3) Viral Desani, Dipak Jivani, in November 2014, discussed the study in "Parametric Study of Hydrodynamic Pressure for Ground Rested RC Tank", Ground bolstered tanks are vital parts of help and modern offices as it is utilized to store water and different fluids, for example, oil based good, condensed petroleum gas, compound liquid and wastage of various structures in colossal limits. In this paper a parametric report on ground rested round RC tank is completed considering distinctive tallness to width proportion for various limits. The seismic examination of tank has been performed considering water mass in two sections as imprudent mass and convective mass proposed by GSDMA rules. The reaction of tank has been thought about in type of Time period in incautious and convective mode, Design even seismic coefficient, Base shear, Base minute and Hydrodynamic weight because of indiscreet and convective mode. From the outcomes, it has been discovered that base shear, construct minute and hydrodynamic weight in light of divider are increments with expanding proportion of most extreme profundity of water to the distance across of tank (h/D) .
- 4) Yash chaliawala, gunvant solanki, Anuj.K.Chandiwala, in December 2015, discussed the study in "Comparative Study of Cantilever and Counter fort Retaining divider", In this paper the investigation of the conduct and ideal plan of two sorts of fortified solid dividers of changing statures to be specific cantilever holding divider, counter fortification holding divider. Cost against each ideal plan of divider for specific stature is figured by utilizing the volume of cement and the measure of steel. In the midst of the cost assessments of all the two ideal plans for specific stature, a near report is completed and the option with the slightest cost appraise is picked as the best outline arrangement.
- 5) Thalapathy.M, Vijaisarathi.R.P, Sudhakar.P, Sridharan.V, Satheesh.V.S, in March 2016, discussed the study in "Analysis and Economical Design of Water Tanks ", Storage supplies and water tanks are utilized to store water, fluid oil, oil based commodities and comparative fluids. The compel investigation of the supplies or tanks is about the same regardless of the substance idea of the item. All tanks are planned as break free structures to wipe out any spillage. This venture gives the nitty gritty investigation of the plan of fluid holding structure utilizing working anxiety technique. The venture thinks about the outline of store for the accompanying cases: 1) Underground Tank, 2) Tank Resting on ground and 3) Overhead water tank. The scientific outline has been made with Microsoft Excel sheet. The paper gives thought for safe plan with least cost of the tank and give the architect relationship bend between outline variable. Along these lines outline of tank can be more temperate, dependable and straightforward. The paper helps in understanding the plan theory for the sheltered and sparing outline of water tank.
- 6) Mehul S. Kishori, Chirag N. Patel, in May 2015, discussed the study in "Parametric Study of Rectangular Water Tank utilizing Different Methodology", This paper introduces a parametric report concerning conduct and outline of ground Rectangular solid tank subjected to static stacking conditions with exceptional accentuation on IS:3370, PCA , and STAAD-Pro. The impact of the diverse tank perspective proportion, end condition for same limit is explored and considered in the Analysis and Design. Definite procedure of investigation of Rectangular solid tank is completed by IS 3370:2009, PCA Table for the tank computing minutes at better place on dividers. Isolate display with the distinctive end conditions, were created on STAAD-Pro with a similar parameter computed by the IS 3370:2009 and PCA. Ascertain the investigation by spread sheet program in light of IS: 3370 and PCA have been fused. An essential point of this report is to decide the parametric investigation of the IS 3370:2009, PCA and STAAD-Pro examination and outline. Catchphrases: IS 3370, PCA, Staad Pro, Rectangular Water Tank, Ground Tank, Concrete Tank.

### III. METHODOLOGY AND DISCUSSIONS

Analysis of tanks are determined for design of themselves in such a manner that they should sound enough to with stand for all the loads and moments, should give good support condition, be more durable for many years, safe and also in economy. Analysis is been carried out in such manner that we should cover in all and every manner. Water inside the tank pushes the walls of tank towards outwards. One wall is connected to other two perpendicular walls which are going to experience a horizontal pull effect. And base one third portion of the wall portion is going to experience a cantilever effect as at top those walls are been not fixed. This also makes changes in the base slab analysis of the tank. Dead weight of tank and water filled in tank gives downward pressure on the entire base slab.

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This is all due to static water or hydro pressure. When dynamic force like earth quake comes into the picture, the water filled inside the tank is going to hit the tank wall called as slashing wave. This statically remained water termed hydro when got into dynamic action is called as hydrodynamic force per unit area called hydrodynamic pressure. Here, again four sub pressures are going to act in this hydrodynamic pressure. Those are impulsive pressure, convective pressure, wall pressure and vertical excitation. The top layer of partially filled water inside the tank which hits the wall called impulsive pressure. The bottom layer of water inside the tank hits the bottom portion of wall by means in intermolecular colliding is called convective pressure. The dead weight of wall which is been inclined going to be experience a gravity load of its dead weight called wall pressure. And the water inside the tank which is going to be excited vertically called as vertical excitation. And by summing all the pressures with respective to their directions moments are been determined in horizontal and vertical directions for rectangular tank wall panel and vertical moment and hoop tension for the circular tank monolithic wall. Apart from these pressures earth pressure is going to be acted on the wall of tanks from outside portion pushing towards inside of tank. Earth pressure alone is considered for tank empty condition. And also depth of the tank penetrated into the ground is been lifted upwards by earth in the presence of ground water table directly under the tank when upward force is greater than the dead weight of the tank. Thus, analysis of upliftment also plays important role in the analytical study of the tank.

Study Parameters:

- 1) Rectangular on ground tank of dimensions: Length = 21m, Width = 16m, Height = 3m, capacity = 1000 m<sup>3</sup>
- 2) Rectangular on ground tank of dimensions: Length = 23m, Width = 11m, Height = 4m, capacity = 1000 m<sup>3</sup>
- 3) Rectangular on ground tank of dimensions: Length = 25m, Width = 20m, Height = 3m, capacity = 1500 m<sup>3</sup>
- 4) Rectangular on ground tank of dimensions: Length = 21m, Width = 18m, Height = 4m, capacity = 1500 m<sup>3</sup>
- 5) Rectangular below ground tank of dimensions: Length = 21m, Width = 16m, Height = 3m, capacity = 1000 m<sup>3</sup>
- 6) Rectangular below ground tank of dimensions: Length = 23m, Width = 11m, Height = 4m, capacity = 1000 m<sup>3</sup>
- 7) Rectangular below ground tank of dimensions: Length = 25m, Width = 20m, Height = 3m, capacity = 1500 m<sup>3</sup>
- 8) Rectangular below ground tank of dimensions: Length = 21m, Width = 18m, Height = 4m, capacity = 1500 m<sup>3</sup>
- 9) Circular on ground tank of dimensions: Diameter = 21m, Height = 3m, capacity = 1000 m<sup>3</sup>
- 10) Circular on ground tank of dimensions: Diameter = 18m, Height = 4m, capacity = 1000 m<sup>3</sup>
- 11) Circular on ground tank of dimensions: Diameter = 26m, Height = 3m, capacity = 1500 m<sup>3</sup>
- 12) Circular on ground tank of dimensions: Diameter = 22m, Height = 4m, capacity = 1500 m<sup>3</sup>
- 13) Circular below ground tank of dimensions: Diameter = 21m, Height = 3m, capacity = 1000 m<sup>3</sup>
- 14) Circular below ground tank of dimensions: Diameter = 18m, Height = 4m, capacity = 1000 m<sup>3</sup>
- 15) Circular below ground tank of dimensions: Diameter = 26m, Height = 3m, capacity = 1500 m<sup>3</sup>
- 16) Circular below ground tank of dimensions: Diameter = 22m, Height = 4m, capacity = 1500 m<sup>3</sup>

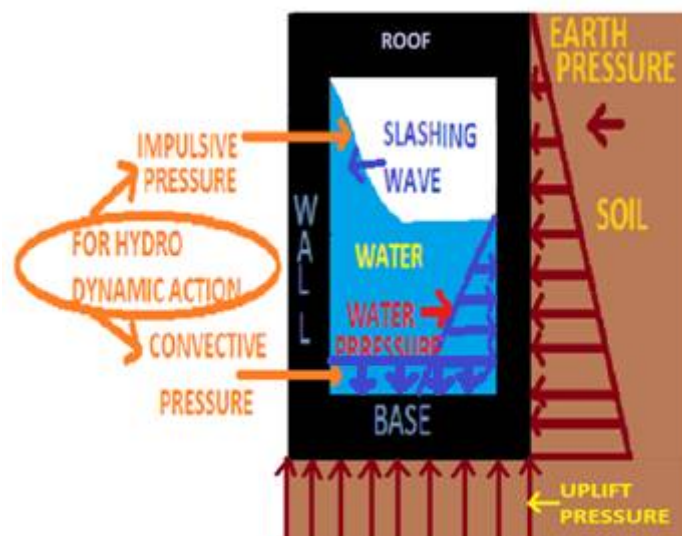


Figure.1- Represents philosophy of tank analysis



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In this Figure.1 we could see the water inside tank is going to be experience a dynamic effect. Water hits the wall of tank in a slashing wave pattern. This generates impulsive pressure at top layer of the tank and convective pressure at bottom layer of the tank. Also static water is creating water pressure on the wall also at base. We could clearly see the upliftment pushing at base of tank towards upwards and earth pressure of soil pushing outer side walls of tank towards inwards. This earth pressure and upliftment we could consider for underground tanks.

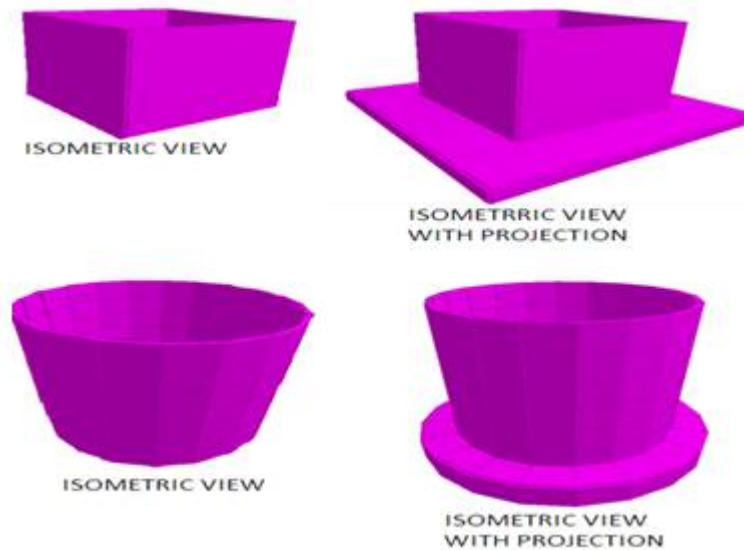


Figure.2 - Represents various views of tanks modellings

In this Figure.2 we could see various tanks in isometric view. Isometric view of rectangular tank and circular tank can be seen. Also the base projection which will counter acts the upliftment of tank by retaining dead weight of soil on it also been seen for both rectangular and circular tanks in this figure.

Hydrodynamic Forces:

When dynamic force like earth quake comes into the picture, the water filled inside the tank is going to hit the tank wall called as slashing wave. This statically remained water termed hydro when got into dynamic action is called as hydrodynamic force per unit area called hydrodynamic pressure. Here, again four sub pressures are going to act in this hydrodynamic pressure. Those are impulsive pressure, convective pressure, wall pressure and vertical excitation. The top layer of partially filled water inside the tank which hits the wall called impulsive pressure. The bottom layer of water inside the tank hits the bottom portion of wall by means in intermolecular colliding is called convective pressure. The dead weight of wall which is been inclined going to be experience a gravity load of its dead weight called wall pressure. And the water inside the tank which is going to be excited vertically called as vertical excitation.

Sample Calculations of hydrodynamic forces:

Weight of tank wall = 1989 KN,

Mass of tank wall= 304128 Kg,

Mass of base slab = 99301 Kg,

Volume of water = 1500 m<sup>3</sup>,

Weight of water = 14715 KN,

Mass of water = 1500000 Kg,

Thickness in mm = 250 mm,

Parameters of spring mass model,

$h = 4.5$

$h/D = 0.225$

$m1/m = 0.26$

$m1 = 390000$

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$mc/m = 0.694$   
 $mc = 1041000$   
 $h1/h = 0.375$   
 $hc/h = 0.526734603$   
 $h1^*/h = 0.240774$   
 $hc^*/h = 1.831$   
 $h1 = 1.6875$   
 $hc = 2.370305714$   
 $h1^* = 0.053505333$   
 $hc^* = 8.239989548$   
 $Ci = 4.38$   
 $E = 27387$   
 $Cc = 3.38$   
 $D, \text{ deflection} = 0.004584586$   
 $Ti, \text{ Time period of impulsive mode} = 0.03$   
 $Tc, \text{ Time period of convective mode} = 4.83$   
 $Ah1, \text{ Horizontal specific coefficient for impulsive mode} = 0.225$   
 $Ahc, \text{ Horizontal specific coefficient for convective mode} = 0.045$   
 $Av, \text{ Horizontal specific coefficient for vertical round acceleration} = 0.21$   
 $\text{Hydrodynamic pressure} = \text{sq root} (\text{Impulsive pressure} + \text{wall pressure})^2 + \text{convective pressure}^2 + \text{vertical excitation}^2$   
 Hydrodynamic Calculations are done for five intermediate points of tank wall.

Table for Hydrodynamic force calculations:

X	x/h	Qiw	Qcw	impulsive pressure	Convective pressure	Wall pressure	Vertical excitation	Maximum hydrodynamic force
4	1	0	0.5625	0	3.327429	1.40625	0	3.612385
3	0.75	0.379137	0.506969	3.347403	2.998937	1.40625	2.0601	5.986222
2	0.5	0.64995	0.468593	5.738405	2.771932	1.40625	4.1202	8.700905
1	0.25	0.812437	0.446076	7.173006	2.63873	1.40625	6.1803	10.89783
0	0	0.866599	0.438654	7.651206	2.594824	1.40625	8.2404	12.51698

### Design Parameters:

- For all Tanks thickness = 250mm
- Base slab thickness = 300mm
- Seismic zone = 4
- Foundation Type = Mat foundation
- Concrete grade = M30
- Steel grade = Fe415
- Diameter of bar = 12mm
- Clear cover = 20mm
- Angle of Inclination of soil =  $30^\circ$
- Soil unit Weight =  $18000 \text{ N/m}^3$
- Tanks penetration for below ground = Total height of Tank
- Roof considered = No.

### Modellings:

We have to model the tanks for betterment in analysing them. Here the work starts.

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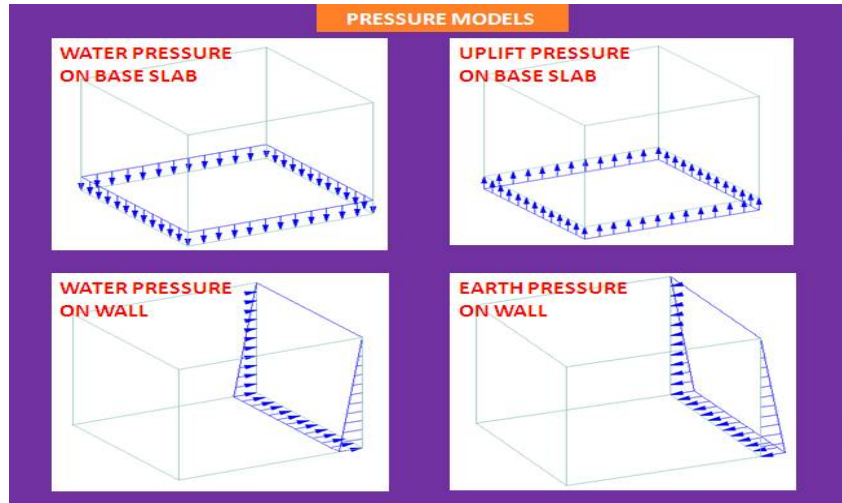


Figure.3 - Pressure models on rectangular tanks

In this Figure.3 we could clearly see the modellings of the rectangular tanks. Those are water pressure acting on the base slab of rectangular tank pushing it downwards, water pressure acting on the wall of rectangular tank pushing it outwards, upliftment pressure acting on the base slab of rectangular tank pushing it upwards and earth pressure acting on the wall of rectangular tank pushing it inwards.

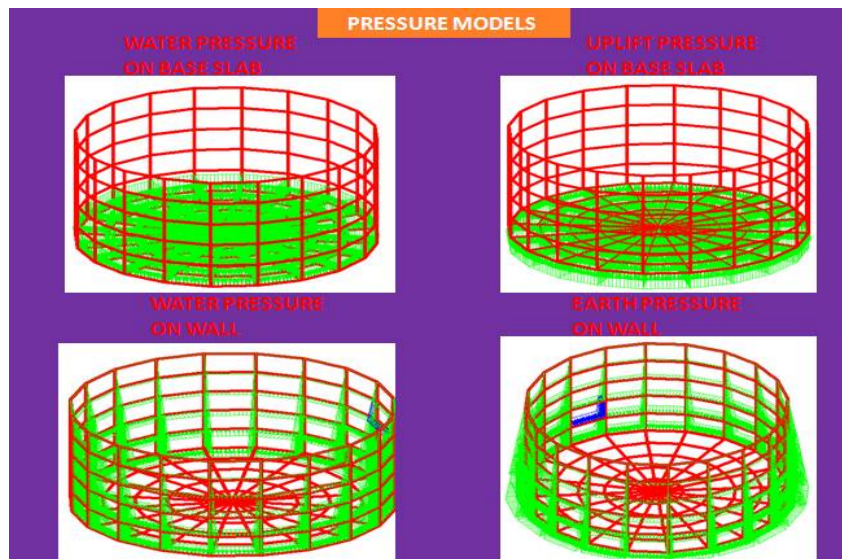


Figure.4- Pressure models on circular tanks

In this Figure.4 we could clearly see the modellings of the circular tanks. Those are water pressure acting on the base slab of circular tank pushing it downwards, water pressure acting on the wall of circular tank pushing it outwards, upliftment pressure acting on the base slab of circular tank pushing it upwards and earth pressure acting on the wall of circular tank pushing it inwards.

Discussions:

Coefficients are been taken from the IS code 3370 part 4 and remaining three parts are also been utilized.

For more understandings on Hydrodynamic force calculations please refer IITK-GSDMA guidelines for seismic design of liquid storage tanks as these calculations are been done by using its guidelines.

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Remaining formulas are been taken from design philosophy. Analysis alone is been mentioned here not the design and detailing part.

For base projection iterations should be done or we should approach in a quadratic equation way.

## IV. EXPERIMENTAL RESULTS

Rectangular tanks are considered as wall panels which are intermediate at every 4 or 5 meters. They are having moments at both liquid face and outer face. Here maximum values are been given. Similarly it also contains behaviour of long and short walls. Here behaviour of long wall is been mentioned as it comprises of maximum moments. But circular tank is considered as monolithic wall which comprises moment at only one face at a single point. From table 1 to 4 comparisons of moments between presence and absence of hydrodynamic forces are been mentioned, which are at a condition of fully filled with water. For table 5 comparisons of moments between capacities are mentioned instead of hydrodynamic forces interferences because empty conditions of tanks are been mentioned there, so hydrodynamic forces wont exists without the presence of water. For first five tables moments are determined for five intermediate points from top to bottom. Here negative values of moments shows for liquid face and positive for outer face.

Moments pattern:

We have to analyse the tanks for betterment in results. Here the work starts.

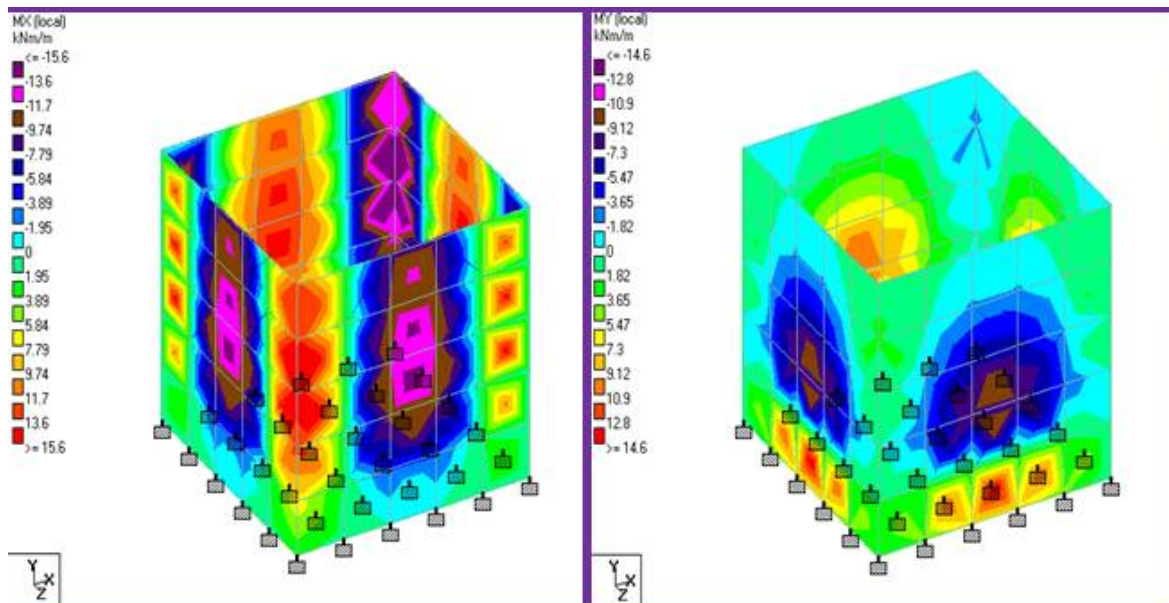


Figure.5- Moments of rectangular tank

In this Figure.5 we could clearly see the moments of the rectangular tanks. Moments are been replaced with colours for better analysing. Left side picture comprises of horizontal moments of rectangular tank. And right side of picture comprises of vertical moments of rectangular tank.



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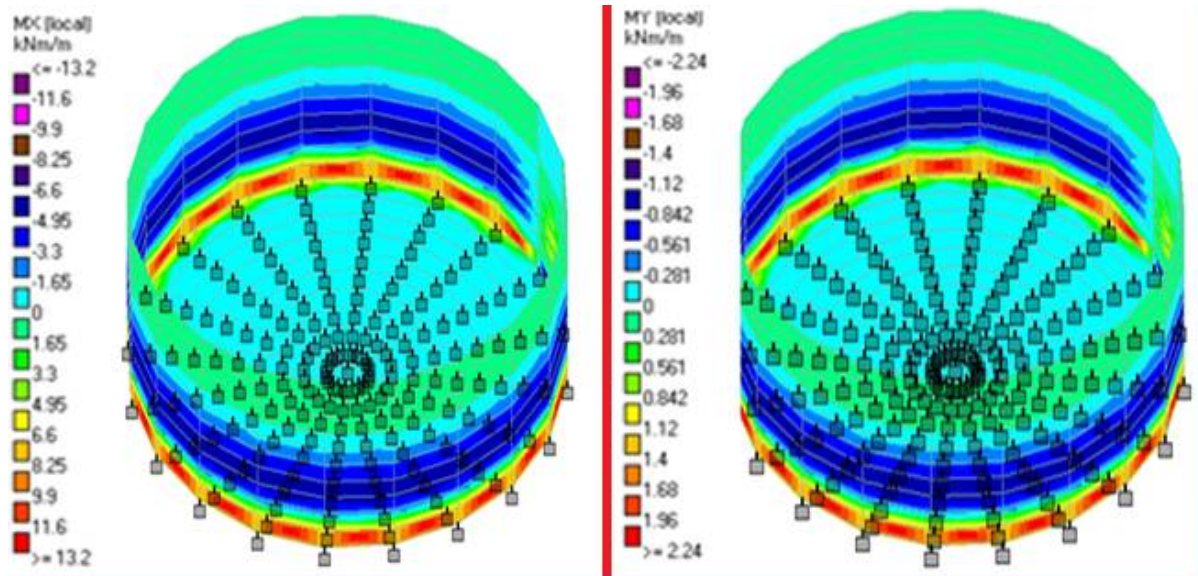


Figure.6- Moments of circular tank.

In this Figure.6 we could clearly see the moments of the circular tanks. Moments are been replaced with colours for better analysing. Left side picture comprises of horizontal moments of circular tank. And right side of picture comprises of vertical moments of circular tank.

For rectangular tank vertical moment and horizontal moment will be there and for circular Tank vertical moment and hoop tension will be there. Units of moments are KNm and units of hoop tension are in KN. For all tables dia = diameter of circular tank, L & W are length and width of rectangular tanks.

VM = vertical moment, HT = hoop tension, HM = horizontal moment.

No roof considered. These are taken constant for all tanks so as to compare their output.

Results are been Tabulated:

Table.1- 1000 cubic meter capacity on ground resting tanks

		PRESENCE OF HYDRO DYNAMIC				ABSENCE OF HYDRO DYNAMIC				
At Height of both tanks	y Frm Tp of F.B. (m)	y/h	circular tank		rectangular tank		circular tank		rectangular tank	
			dia =21m	L=21m, w=16m	dia =21m	L=21m, w=16m	dia =21m	L=21m, w=16m	dia =21m	L=21m, w=16m
			VM	HT	VM	HM	VM	HT	VM	HM
3m	0	0	0.372536	103.9043	0	12.44009	0.289286	80.685	0	9.612
	0.75	0.25	1.952087	108.0188	-2.86541	13.97763	1.515857	83.88	-2.214	10.8
	1.5	0.5	4.197235	105.469	5.311498	13.97763	3.259286	81.9	4.104	10.8
	2.25	0.75	0.355151	69.62691	-1.7472	8.805904	0.275786	54.0675	-1.35	6.804
	3	1	-16.8734	10.25715	-19.1493	3.773959	-13.1027	7.965	-14.796	2.916
4m	y Frm Tp of F.B. (m)	y/h	circular tank		rectangular tank		circular tank		rectangular tank	
			dia =18m	L=23m, w=11m	dia =18m	L=23m, w=11m	dia =18m	L=23m, w=11m	dia =18m	L=23m, w=11m
			VM	HT	VM	HM	VM	HT	VM	HM
	0	0	0.354454	44.52834	0	20.19307	0.277333	34.84	0	15.744
	1	0.25	2.267599	101.7352	-5.08931	24.29736	1.774222	79.6	-3.968	18.944
	2	0.5	6.271117	176.0173	9.85028	27.74495	4.906667	137.72	7.68	21.632
3	0.75	3.708138	155.4913	5.581825	18.38719	2.901333	121.66	4.352	14.336	
4	1	-24.2847	29.29361	-34.6402	6.731025	-19.0009	22.92	-27.008	5.248	

For table.1 Units of Hoop tension are in KN and Units of bending moment are in KNm.

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Here table.1 shows differences of results between presence and absence of hydrodynamic forces for 1000 cubic meter capacity of on ground resting tanks of both circular and rectangular shapes. For heights of both 3 meters and 4 meters and by varying their dimensions such that it remains with the same capacity.

Table.2- 1000 cubic meter capacity below ground resting tanks.

	PRESENCE OF HYDRO DYNAMIC					ABSENCE OF HYDRO DYNAMIC				
	y Frm Tp	y/h	circular tank		rectangular tank		circular tank		rectangular tank	
	of F.B.(m)		dia =21m	L=21m, w=16m	dia =21m	L=21m, w=16m	dia =21m	L=21m, w=16m	dia =21m	L=21m, w=16m
		VM	HT	VM	HM	VM	HT	VM	HM	
At Height of both tanks 3m	0	0	0.198964	55.49333	0	17.47203	0.115714	32.274	0	13.5
	0.75	0.25	1.042573	57.69078	4.193288	18.17091	0.606343	33.552	3.24	14.04
	1.5	0.5	2.241664	56.32898	5.59105	16.07427	1.303714	32.76	4.32	12.42
	2.25	0.75	0.189679	37.18641	-1.7472	9.434897	0.110314	21.627	-1.35	7.29
	3	1	-9.01175	5.478148	-25.8586	5.24161	-5.24109	3.186	-19.98	4.05
At Height of both tanks 4m	0	0	0.188054	23.62434	0	20.19307	0.110933	13.936	0	15.744
	1	0.25	1.203066	53.97523	-5.08931	24.29736	0.709689	31.84	-3.968	18.944
	2	0.5	3.327117	93.38529	9.85028	27.74495	1.962667	55.088	7.68	21.632
	3	0.75	1.967338	82.49531	5.581825	18.38719	1.160533	48.664	4.352	14.336
	4	1	-12.8841	15.54161	-34.6402	6.731025	-7.60036	9.168	-27.008	5.248

For table.2 Units of Hoop tension are in KN and Units of bending moment are in KNm.

Here table.2 shows differences of results between presence and absence of hydrodynamic forces for 1000 cubic meter capacity of below ground resting tanks of both circular and rectangular shapes. For heights of both 3 meters and 4 meters and by varying their dimensions such that it remains with the same capacity.

Table.3- 1500 cubic meter capacity on ground resting tanks.

	PRESENCE OF HYDRO DYNAMIC					ABSENCE OF HYDRO DYNAMIC				
	y Frm Tp	y/h	circular tank		rectangular tank		circular tank		rectangular tank	
	of F.B.(m)		dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m
		VM	HT	VM	HM	VM	HT	VM	HM	
At Height of both tanks 3m	0	0	0.402827	138.5216	0	16.33702	0.311538	107.13	0	12.6
	0.75	0.25	2.053073	133.6534	3.734176	17.27056	1.587808	103.365	2.88	13.32
	1.5	0.5	4.055122	114.9369	5.601264	15.63686	3.136154	88.89	4.32	12.06
	2.25	0.75	-0.75194	69.84268	-1.75039	9.335439	-0.58154	54.015	-1.35	7.2
	3	1	-19.4538	9.697678	-24.2721	4.901106	-15.0452	7.5	-18.72	3.78
At Height of both tanks 4m	0	0	0.521789	80.66304	0	16.57264	0.407273	62.96	0	12.928
	1	0.25	3.030105	133.8576	-4.43031	20.67478	2.365091	104.48	-3.456	16.128
	2	0.5	7.603216	197.5578	8.204278	25.10509	5.934545	154.2	6.4	19.584
	3	0.75	3.518351	162.0435	6.235251	17.0649	2.746182	126.48	4.864	13.312
	4	1	-28.0723	28.23719	-30.684	6.071166	-21.9113	22.04	-23.936	4.736

For table.3 Units of Hoop tension are in KN and Units of bending moment are in KNm.

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Here table.3 shows differences of results between presence and absence of hydrodynamic forces for 1500 cubic meter capacity of on ground resting tanks of both circular and rectangular shapes. For heights of both 3 meters and 4 meters and by varying their dimensions such that it remains with the same capacity.

Table.4- 1500 cubic meter capacity below ground resting tanks

	PRESENCE OF HYDRO DYNAMIC					ABSENCE OF HYDRO DYNAMIC				
	y Frm Tp	y/h	circular tank		rectangular tank		circular tank		rectangular tank	
	of F.B.(m)		dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m
		VM	HT	VM	HM	VM	HT	VM	HM	
At Height of both tanks 3m	0	0	0.215904	74.24364	0	16.27227	0.124615	42.852	0	12.6
	0.75	0.25	1.100389	71.6344	3.719377	17.20212	0.635123	41.346	2.88	13.32
	1.5	0.5	2.173429	61.60288	5.579065	15.57489	1.254462	35.556	4.32	12.06
	2.25	0.75	-0.40302	37.43368	-1.74346	9.298442	-0.23262	21.606	-1.35	7.2
	3	1	-10.4267	5.197678	-24.1759	4.881682	-6.01809	3	-18.72	3.78
At Height of both tanks 4m	0	0	0.277426	42.88704	0	26.04858	0.162909	25.184	0	20.32
	1	0.25	1.611051	71.1696	-6.15321	29.94561	0.946036	41.792	-4.8	23.36
	2	0.5	4.042489	105.0378	11.8962	31.38136	2.373818	61.68	9.28	24.48
	3	0.75	1.870642	86.15555	-4.10214	20.10048	1.098473	50.592	-3.2	15.68
	4	1	-14.9255	15.01319	-41.2265	7.999171	-8.76451	8.816	-32.16	6.24

For table.4 Units of Hoop tension are in KN and Units of bending moment are in KNm.

Here table.4 shows differences of results between presence and absence of hydrodynamic forces for 1500 cubic meter capacity of below ground resting tanks of both circular and rectangular shapes. For heights of both 3 meters and 4 meters and by varying their dimensions such that it remains with the same capacity.

Table.5- Below ground resting tanks of both capacities in empty condition

	1000 cubic meters					1500 cubic meters				
	y Frm Tp	y/h	circular tank		rectangular tank		circular tank		rectangular tank	
	of F.B.(m)		dia =21m	L=21m, w=16m	dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m	dia =26m	L=25m, w=20m
		VM	HT	VM	HM	VM	HT	VM	HM	
At Height of both tanks 3m	0	0	-0.17357	-48.411	0	8.1	-0.18692	-64.278	0	7.56
	0.75	0.25	-0.90951	-50.328	1.944	8.424	-0.95268	-62.019	1.728	7.992
	1.5	0.5	-1.95557	-49.14	2.592	7.452	-1.88169	-53.334	2.592	7.236
	2.25	0.75	-0.16547	-32.4405	-0.81	4.374	0.348923	-32.409	-0.81	4.32
	3	1	7.861629	-4.779	-11.988	2.43	9.027138	-4.5	-11.232	2.268
At Height of both tanks 4m	0	0	-0.1664	-20.904	0	9.4464	-0.24436	-37.776	0	12.192
	1	0.25	-1.06453	-47.76	-2.3808	11.3664	-1.41905	-62.688	-2.88	14.016
	2	0.5	-2.944	-82.632	4.608	12.9792	-3.56073	-92.52	5.568	14.688
	3	0.75	-1.7408	-72.996	2.6112	8.6016	-1.64771	-75.888	-1.92	9.408
	4	1	11.40053	-13.752	-16.2048	3.1488	13.14676	-13.224	-19.296	3.744

For table.5 Units of Hoop tension are in KN and Units of bending moment are in KNm.

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Here table.5 shows differences of results between 1000 cubic meter capacity and 1500 cubic meter capacity of below ground resting tanks of both circular and rectangular shapes. For heights of both 3 meters and 4 meters and by varying their dimensions such that it remains with the same capacity. Here they are been considered for tank at empty condition means without water and without hydrodynamic forces.

Table.6- Base slab moments for both capacity tanks

	1000 cubic meters				1500 cubic meters			
	height =3		height =4		height =3		height =4	
	dia =21m	L=21m, w=16m	dia =18m	L=23m, w=11m	dia =26m	L=25m, w=20m	dia =22m	L=21m, w=18m
Maximum pressure	14715	14715	19620	19620	14715	14715	19620	19620
Bending Moment	4905	4905	6540	6540	4905	4905	6540	6540

For table.6 Units of pressure are in Newtons. Units of bending moment are in KNm.

Here table.6 shows maximum pressure and bending moments at base slab of tanks for both capacities and of both shapes. Here height 3 meters and height 4 meters are been considered and by varying their dimensions such that it remains with the same capacity.

Table.7- Uplift analysis for both capacity tanks

	1000 cubic meters				1500 cubic meters			
	height =3		height =4		height =3		height =4	
	dia =21m	L=21m, w=16m	dia =18m	L=23m, w=11m	dia =26m	L=25m, w=20m	dia =22m	L=21m, w=18m
Upward force	1461052 9	10877328	1073426 6	8190369	2239618 5	16186500	1603513 8	12236994
downward force	2805099	5643000	2086459	4488500	4238450	8005000	3068207	6246000
Total upliftment	1180543 0	5234328	8647807	3701869	1815773 4	8181500	1296693 1	5990994
Projection	0.350791	1.2	0.306355	1.1	0.424875	1.5	0.365606	1.3

For table.7 All force units are in Newtons. Units of Projection are in meters.

Here table.7 shows total upliftment and projection required at base slab of tanks for both capacities and of both shapes. Here height 3 meters and height 4 meters are been considered and by varying their dimensions such that it remains with the same capacity.



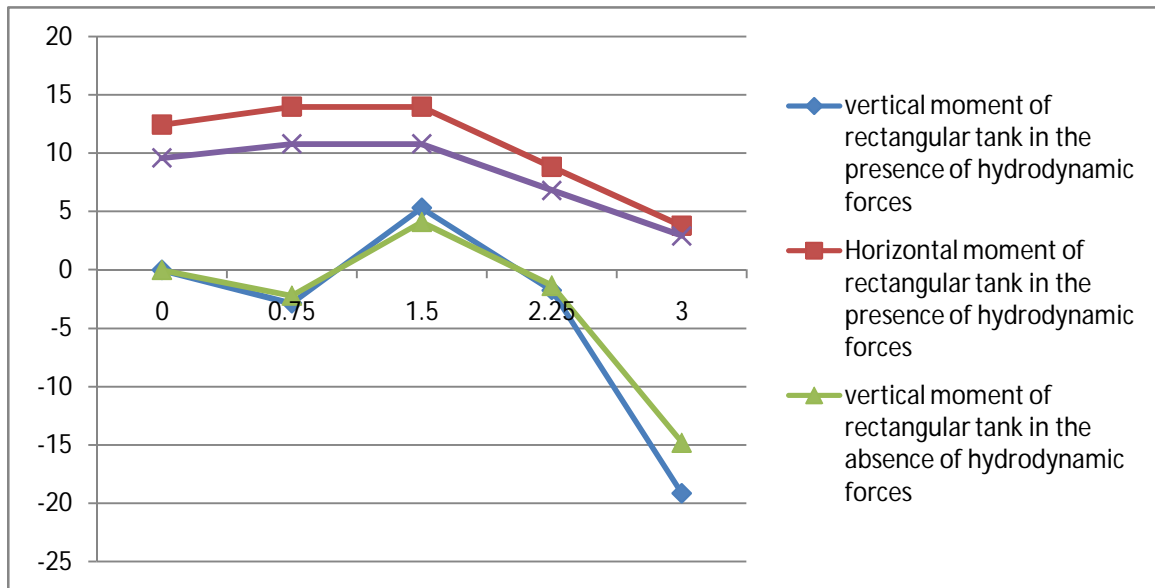
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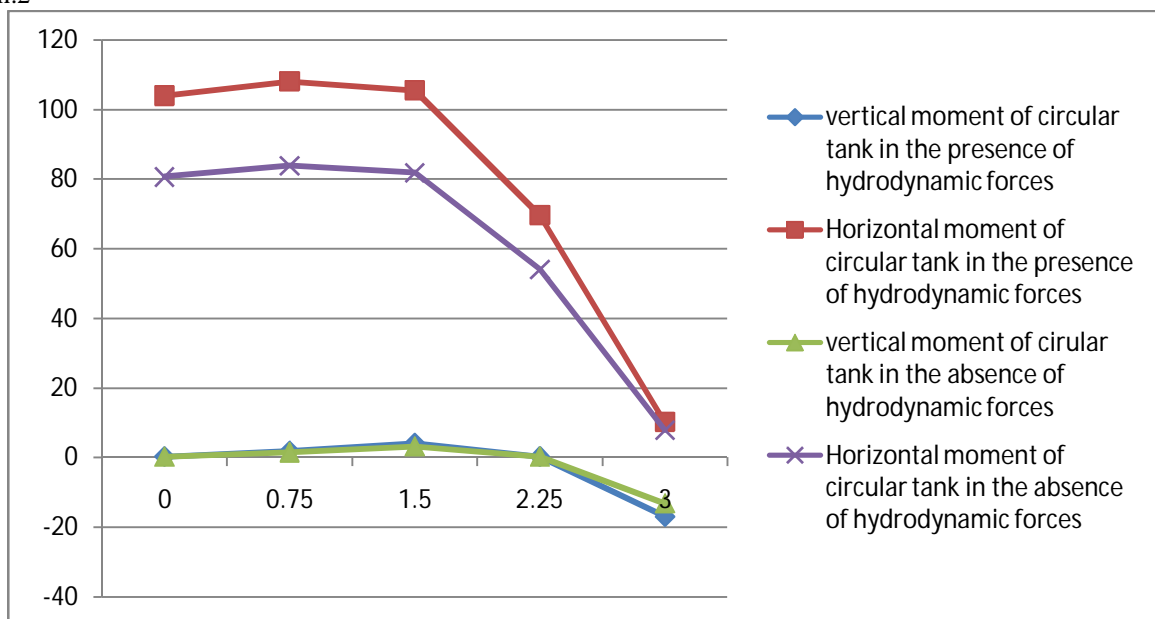
Graphs for better understandings:  
Graph.1-



Graph.1 shows comparison of moments between presence and absence of Hydrodynamic forces for rectangular tank of 21m\*16m\*3m

Here graph.1 shows comparison of vertical moments and horizontal moments between presence and absence of Hydrodynamic forces for rectangular tank of dimensions 21m\*16m\*3m which is of capacity 1000 cubic meters and which is rested on ground.

Graph.2-



Graph.2 shows comparison of moments between presence and absence of Hydrodynamic forces for circular tank of 21m\*3m

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Here graph.2 shows comparison of vertical moments and horizontal moments between presence and absence of Hydrodynamic forces for circular tank of dimensions 21m dia\* 3m height which is of capacity 1000 cubic meters and which is rested on ground.

## V. CONCLUSIONS

The conclusions of this paper are follows:

1. Vertical moments of Rectangular tank are 13.46 %more than cylindrical tank.
2. Hoop tensions of circular tanks are 6.73 times more than horizontal moments of Rectangular tank.
3. When height decreases moments also decreases by 30.52%.
4. Presence of Hydrodynamic pressure creates moments 28.77% more in circular Tanks and 29.35% more in Rectangular Tanks.
5. Per unit meter increase in height at Base slab, Maximum pressure increases 4905N more and Base slab moments increases 1635Nm more.
6. Base pressures and moments are similar for all tanks of same height irrespective to their capacities and other dimensions, as water been loaded from top to bottom.
7. Upliftment is been counteracted by base projection as soil from base projection up to ground level acts as dead weight to the tank.
8. Projections for rectangular tanks are 3.42 times more required than circular tanks of same height.

## REFERENCES

- [1] M. Bhandari, Karan Deep Singh, "Economic Design of Water Tank of Different Shapes With Reference To IS: 3370 2009", International Journal Of Modern Engineering Research (IJMER), vol.4, issue 12, Dec.2014.
- [2] A. Dogangun and R. Livaoglu, "A Comparative study of the seismic analysis of rectangular tanks according to different codes", The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.
- [3] Viral Desani, Dipak Jivani, "Parametric Study of Hydrodynamic Pressure for Ground Rested RC Tank", International Journal of Advance Engineering and Research Development (IJAERD), Volume 1, Issue 11, November -2014.
- [4] yash chaliawala, gunvant solanki, Anuj.K.Chandiwala, "Comparative Study of Cantilever and Counter fort Retaining wall", International Journal of Advance Engineering and Research Development (IJAERD), Volume 2, Issue 12, December -2015.
- [5] Punith C ,Usha, Jayalakshmi Raju, M. Adil Dar, in April 2015, "Finite Element Analysis of Underground Water Tank with different Safe Bearing Values of Soil", SSRG International Journal of Civil Engineering (SSRG-IJCE) – EFES, April 2015.
- [6] S. A. Halkude, A. A. Perampalli, "Analysis of Water Tank on Sloping Ground", International Journal of Engineering and Innovative Technology (IJEIT), Volume 3, Issue 5, November 2013.
- [7] Riyaz Sameer , Mundhada , Snehal Metkar, in December 2012, "Compariison of r.c.c. and prestressed concrete ciircular water tanks", International Journal of Emerging Technology and Advanced Engineering (IJETA), Volume 2, Issue 12, December 2012.
- [8] Snehal Wankhede, P. J. Salunke, N. G. Gore, "Optimization of water storage tank", International Journal of Engineering and Technical Research (IJETR) , Volume-3, Issue-4, April 2015.
- [9] Thalapathy.M, Vijaisarathi.R.P, Sudhakar.P, Sridharan.V, Satheesh.V.S, "Analysis and Economical Design of Water Tanks", International Journal of Innovative Science, Engineering & Technology (IJSET), Vol. 3 Issue 3, March 2016.
- [10] Tonne V. R, Mohite P. M, "Optimization and improvement in stability of counter fort retaining wall with relief shelf", International Journal of Research in Engineering and Technology (IJRET), Volume 4, Issue 4, Apr-2015.
- [11] Mehul S. Kishori, Chirag N. Patel, in May 2015, "Parametric Study of Rectangular Water Tank using Different Methodology", International Journal for Scientific Research & Development (IJSRD), Vol. 3, Issue 05, 2015.
- [12] Rupachandra J. Aware, Vageesha S. Mathada, "Seismic Analysis of Cylindrical Liquid Storage Tank", International Journal of Science and Research (IJSR), Volume 4 Issue 12, December 2015.