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Parametric Study on Cylindrical Water Tanks by Varying their Aspect Ratios

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ABSTRACT:

This study is carried out to analyze the cost of overhead water tanks of a fixed capacity, having different heights and diameters so as to determine the most economical height to diameter (H/D) ratio to be adopted in the design of the tank. To optimize the results and check the accuracy of design, six circular water tanks of 500 kL, with top and bottom dome pattern, were designed by varying H/D ratio from 0.15 to 1.05 in STAAD.Pro. After assuring the safety of all the structures, further analysis is done to calculate the cost-effectiveness of the structures by comparing the approximate total cost of materials. It was found that the aspect ratio (H/D) of 0.60 led to the most efficient design.

Keywords: Water tank, Earthquake, wind load, Hydrostatic load, Staad pro

1. INTRODUCTION

Water is human basic needs for daily life. Sufficient water distribution depends on design of a water tank in certain area. An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to pressurization the water distribution system. The liquid storage tanks are particularly subjected to the risk of damage due to earthquake-induced vibrations. A large number of overhead water tanks damaged during past earthquake. Majority of them were shaft staging while a few were on frame staging type Elevated water tanks consist of huge water mass at the top of a slender staging which are most critical consideration for the failure of the tank during earthquakes. Elevated water tanks are critical and strategic structures and damage of these structures during earthquakes may endanger drinking water supply, cause to fail in preventing large fires and substantial economical loss. Since, the elevated tanks are frequently used in seismic active regions also hence, seismic behavior of them has to be investigated in details. Due to the lack of knowledge of supporting system some of the water tank were collapsed or heavily damages. So there is need to focus on seismic safety of lifeline structure using with respect to alternate supporting system which are Safe during earthquake and also take more design forces. Hydrodynamic pressures on tanks under earthquake forces play an important role in the design of the tank. When the tank is in full condition, earthquake forces almost govern the design of these structures in zones of high seismic activity. The failure of these structures may cause some hazards for the health of the citizens due to the shortage of water or difficulty in putting out fire during the earthquake golden time. The performance of elevated water tanks during earthquakes is of much interest to engineers, not only because of the importance of these tanks in controlling fires, but also because the simple structure of an elevated tank is relatively easy to analyse and, hence, the study of tanks can be informative as to the behaviour of structures during earthquak

2. PROJECT OBJECTIVE

The objective of this research is as follows:

1. To analyze the cost of resting on ground water tanks of a fixed capacity, having different heights and diameters so as to determine the most economical height to diameter ratio to be used in the design of the tank.

3. PROBLEM FORMULATION

S.NO	CASE	MODEL	ASPECT RATIO h/d
1		Model-1	0.15
2		Model-2	0.30

3	**Case A – Water Tank with half full water (soil pressure + wind pressure + surcharge).**	Model-3	0.45
4		Model-4	0.60
5		Model-5	0.75
6		Model-6	0.90
7		Model-7	1.05

4. METHDOLOGY

The objective of present work is to study of tanks are analyzed for different aspect ratios (h/d) interaction under the seismic loads, Wind Load & Hydro Test. For this, Seven Tanks are considered in different aspect ratio. The performance, behaviour and economy of all seven tanks on the parametric studies of all ground supported tanks are done.

In this attempt, following main cases will be analyzed:

1. An extensive survey and review of the literature on the response and behaviour of Water tank under seismic loading is performed.
2. Provisions for Side Wall and Base slab interaction related to seismic analysis are presented.
3. Modelling of different height & depth of tanks which is seven tanks are presented.
4. Also for different thickness & different height of side wall, models are presented.
5. A problem of side wall is taken and analyzed for static analysis for different storey.
6. Plot graph between Mx, My, &Sx Moments and different aspect ration of tank for Tank 1 to tank 7.
7. Plot graph between Moments &Shear for without Seismic zone to with Seismic zone (Zone II to Zone V).

5. MODELLING APPROACH

Case A – Water Tank with half full water (soil pressure + wind pressure + surcharge).

1. Model I - Aspect ratio (h/d=0.15).
2. Model II – Aspect ratio (h/d=0.30).
3. Model III – Aspect ratio (h/d=0.45).
4. Model IV -Aspect ratio (h/d=0.60).
5. Model V - Aspect ratio (h/d=0.75).
6. Model VI – Aspect ratio (h/d=0.90).
7. Model VII – Aspect ratio (h/d=1.05).

6. RESULT & DISCUSSION

6.1 - Case A – Water Tank with half full water (soil pressure + wind pressure + surcharge).

Table 4.1- Moment in X Direction

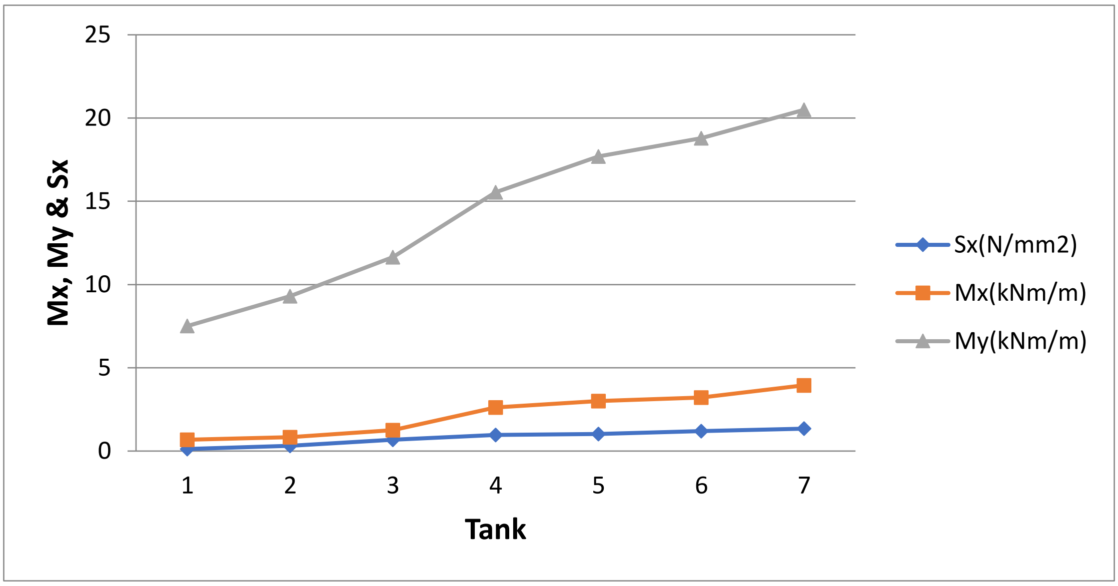
Tank	**Aspect Ratio**	**Mx(kNm/m)**
1	0.15	0.68
2	0.3	0.837
3	0.45	1.25
4	0.6	2.615
5	0.75	3.009
6	0.9	3.215
7	1.05	3.95

Table 6.2- Moment in Y Direction

Tank	**Aspect Ratio**	**My(kNm/m)**
1	0.15	7.51
2	0.3	9.3
3	0.45	11.654
4	0.6	15.55
5	0.75	17.7
6	0.9	18.8
7	1.05	20.498

Table 6.3- Shear Force

Tank	**Aspect Ratio**	**Sx(N/mm2)**
1	0.15	0.124
2	0.3	0.322
3	0.45	0.674
4	0.6	0.97
5	0.75	1.022
6	0.9	1.201
7	1.05	1.344



Graph 1 Moments & Shear forces behaviour in soil pressure + wind pressure + surcharge.

6.2- The Various Seismic Zone Water Tank Behaviours:-

Table 6.4- Water tank behaviour in without Seismic Zone

Tank	Seismic Zone	Aspect Ratio	Sx(N/mm2) (Shear)	Mx(kNm/m)	My(kNm/m)
1	-	0.15	0.331	1.632	9.602
2	-	0.3	0.661	2.676	15.446
3	-	0.45	0.925	3.061	18.003
4	-	0.6	1.127	3.38	19.883
5	-	0.75	1.302	3.811	22.417
6	-	0.9	1.441	3.9	22.944
7	-	1.05	1.567	4.117	24.22

Table 6.5 - Water tank behaviour in Seismic Zone – II

Tank	Seismic Zone	Aspect Ratio	Sx(N/mm2) (Shear)	Mx(kNm/m)	My(kNm/m)
1	2	0.15	0.365	1.738	10.226
2	2	0.3	0.715	2.799	16.472
3	2	0.45	0.983	3.226	18.954

4	2	0.6	1.189	3.536	20.776
5	2	0.75	1.364	3.969	23.417
6	2	0.9	1.501	4.057	23.884
7	2	1.05	1.622	4.16	25.19

Table 6.6 - Water tank behaviour in Seismic Zone – III

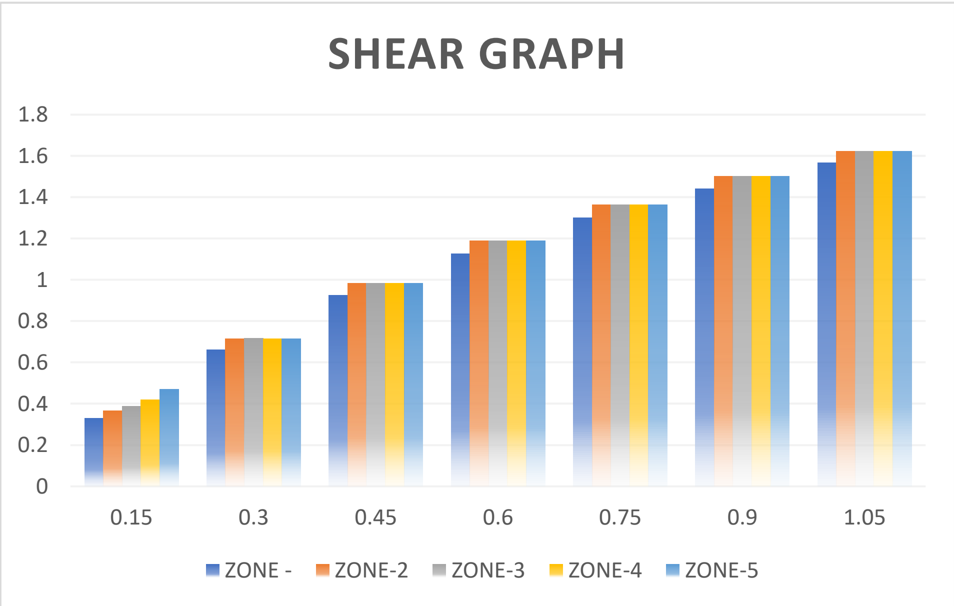
Tank	Seismic Zone	Aspect Ratio	Sx(N/mm2) (Shear)	Mx(kNm/m)	My(kNm/m)
1	3	0.15	0.387	1.801	10.6
2	3	0.3	0.717	2.804	16.498
3	3	0.45	0.984	3.228	18.962
4	3	0.6	1.189	3.536	20.776
5	3	0.75	1.364	3.981	23.427
6	3	0.9	1.501	4.057	23.884
7	3	1.05	1.622	4.26	25.019

Table 6.7 - Water tank behaviour in Seismic Zone –IV

Tank	Seismic Zone	Aspect Ratio	Sx(N/mm2) (Shear)	Mx(kNm/m)	My(kNm/m)
1	4	0.15	0.42	1.885	11.097
2	4	0.3	0.715	2.799	16.473
3	4	0.45	0.983	3.226	18.955
4	4	0.6	1.189	3.536	20.776
5	4	0.75	1.364	3.98	23.418
6	4	0.9	1.501	4.057	23.884
7	4	1.05	1.622	4.26	25.19

Table 6.8 - Water tank behaviour in Seismic Zone –V

Tank	Seismic Zone	Aspect Ratio	Sx(N/mm2) (Shear)	Mx(kNm/m)	My(kNm/m)
1	5	0.15	0.47	2.011	11.845
2	5	0.3	0.715	2.799	16.474
3	5	0.45	0.983	3.226	18.956
4	5	0.6	1.189	3.536	20.776
5	5	0.75	1.365	3.98	23.418
6	5	0.9	1.501	4.057	23.418
7	5	1.05	1.622	4.26	25.19



Graph 2 Shear forces behaviour in Various Seismic Zone on all Seven Tanks.

7. CONCLUSION

Based on the above analytical study carried out on seven different models with different diameters and heights, the following conclusions are drawn:

1. For the same capacity of tank, there exist numerous possibilities of height and diameter combinations for the tank.

2. In all the cases, the diameter was linearly decreased by an amount of 0.2 m starting from 10 m. It was seen that tanks with larger diameters had smaller heights and thus covered a larger ground span.

3. The tanks with smaller diameters generally require lesser volume of concrete. However, a linear relationship does not exist between the readings.

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