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Parametric Seismic Analysis of Elevated Circular Water Tank for Various Staging Patterns

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Abstract: Elevated water tank is a major structure which should be accurately and precisely analysed and designed in earth prone regions. In this project work, parametric study of circular elevated water tank has been carried out using STAAD Pro version 8i (SS6) for 500m3 capacity of tank. The seismic behavioral effect has been observed considering various staging arrangements(bracing), variation in h/d ratio, variation in number and sizes of periphery columns. A Comparative study has been done considering above mentioned different parameters and the optimum results in terms of base shear and displacement is to be taken into account. Total 12 combinations were analysed for full tank and empty tank conditions using Response Spectrum Method. Elevated circular water tank which consists diagonal bracing, h/d ratio as 0.7 and no. of columns as 6 gives the best results as this combination provides the minimal values of base shear and displacements.

Keywords: Elevated Circular Water Tank, Seismic Analysis, Base Shear, Displacement, Response Spectrum Analysis

I. INTRODUCTION

Reinforced concrete water tanks are well suited for mass water storage because of their distinct advantages, such as resistance to climate change and any form of leakage, as well as corrosion resistance. Water can be stored in any amount and in any place with these elevated water tanks. EWT containers come in a variety of shapes, including round, conical, square, and intz. These containers are placed on a specific height staging system in order to supply water through the formed pressure head. RCC or masonry construction may be used to build a staging framework. The most common staging options are RCC frame type and shaft type stagings. The shaft type of supporting device is another choice. Shaft is a hollow column with a relatively wide diameter but a relatively small thickness. The position is one of the factors to consider when building a water tank. Elevated storage tanks should be positioned in or near the field to be served on the highest ground level possible. In a flat environment, an elevated storage tank meets this need for maintaining adequate pressure. A ground storage tank, on the other hand, may be considered if the terrain allows it to be positioned on top of a hill of appropriate height and convenience.

II. TYPES OF WATER TANKS

There are different types of water tank to depend upon the position with respect to ground level, water tanks are classified into three categories. Those are,

A. Underground tanks
B. Tanks resting on ground
C. Overhead water tanks

In most cases the underground and on ground shape of water tanks are circular or rectangular but the shape of the overhead water tanks are effected by the aesthetical view of the surroundings and as well as the design.

III. MODEL VARIATION

Here, we are going to Compare Different Water Tank Models Considering Different Variations in Bracing type, h/d Ratio, Periphery Columns.

DIMENSIONS CALCULATION

Capacity of tank (V) = 500m3, H/D = 0.8

$$V = \pi/4 \times D_2 \times H$$

$$500 = \pi/4 \times D_2 \times (0.8D)_2$$

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D = 9.3 m H = 7.5 m

Capacity of tank (V) = 500m3, H/D = 0.7
V = π/4 x D2 x H
500 = π/4 x D2 x (0.7D)2
D = 9.7 m H = 6.8 m

LOAD CALCULATION

For column no. = 4
Column dia. (D) = 650 mm
Weight = π/4 x D2 x 25 = 8.3 kN/m

For column no. = 6
Column dia. (D) = 500 mm
Weight = π/4 x D2 x 25 = 4.9 kN/m

For column no. =8
Column dia. (D) = 450 mm
Weight = π/4 x D2 x 25 = 3.98 kN/m

Weight of Bracing = 0.5 x 0.6 x 25 = 7.5 kN/m
Weight of Floor Beam = 0.9 x 1 x 25 = 22.5 kN/m
Weight of Plate = 0.3 x 25 = 7.5 kN/ m

IV. MODELLING

Here, We use STADD Pro Software for Analysis, We will take Different 16 Combinations of Water Tank Depending upon Variation in Bracing type, h/d Ratio and Periphery Columns. For Seismic Analysis, Response Spectrum Analysis has been Carried out.

Table 1 - Seismic Parameters

Seismic Zone	III
Zone Factor	0.16
Response Reduction Factor (RF)	4
Importance Factor (I)	1.5
Rock and Soil Site Factor	2
Damping Ratio	0.05

Table 2 - Sizes of various Components

Component	**Size (mm)**
Roof Slab	300 thick
Wall	300 thick
Floor Slab	300 thick
Floor Beams	900 x 1000
Braces	500 x 600
Columns	650 dia., 500 dia., 450 dia.
Diameter	9.3 m, 9.7 m
Height	7.5 m, 6.8 m
No. of columns	4, 6, 8

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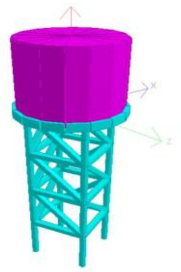

Figure 1 - Diagonal bracing with 4 columns

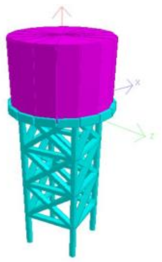

Figure 2 - Cross bracing with 4

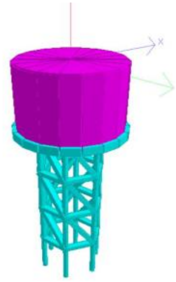

Figure 3 - Diagonal bracing with 6 columns

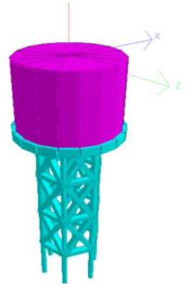

Figure 4 - Cross bracing with 6 columns

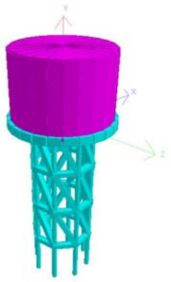

Figure 5 - Diagonal bracing with 8 columns

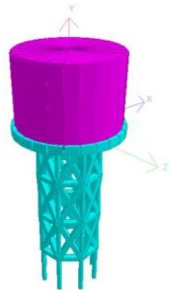

Figure 6 - Cross bracing with 8 columns

V. RESULTS

Table 3 - Results of Full Tank Condition:

Combination	**Base shear(kN)**	**Displacement(mm)**
Dia/0.8/C4	275	50
Dia/0.8/C6	210	38.5
Dia/0.8/C8	220	48
Cross/0.8/C4	326	49.5
Cross/0.8/C6	273	37.8
Cross/0.8/C8	286	46
Dia/0.7/C4	270	29.5
Dia/0.7/C6	205	35
Dia/0.7/C8	215	35.7
Cross/0.7/C4	320	29.3
Cross/0.7/C6	260	34
Cross/0.7/C8	282	34.5

Table 4 - Results of Empty Tank Condition:

Combination	**Base shear(kN)**	**Displacement(mm)**
Dia/0.8/C4	249	38.7
Dia/0.8/C6	186	29.7
Dia/0.8/C8	198	37
Cross/0.8/C4	297	38.4
Cross/0.8/C6	245	29.4
Cross/0.8/C8	261	36
Dia/0.7/C4	244	22.77
Dia/0.7/C6	183	27.5
Dia/0.7/C8	194	28.3
Cross/0.7/C4	290	22.6
Cross/0.7/C6	235	26.5
Cross/0.7/C8	256	27.3

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VI. CONCLUSIONS

- On changing the bracing type from diagonal to cross bracing Base Shear increases. Because, bracing system puts on additional mass to the structure, which results into increase in base shear value. Fig. shows the comparison of base shear values for diagonal and cross bracings for h/d ratio as 0.8 for full tank condition and average increase of 25%.

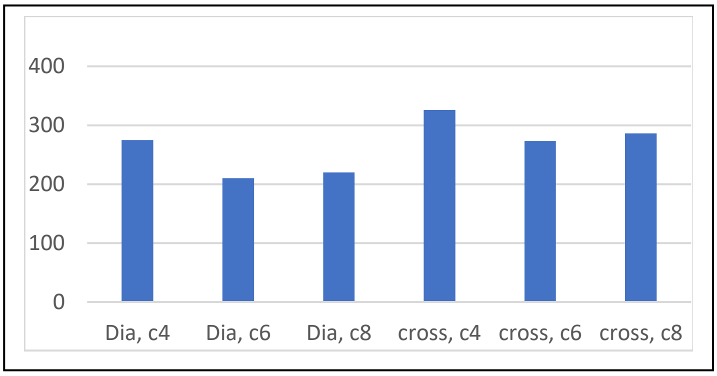

Figure 7 - base shear values for diagonal and cross bracings for h/d ratio as 0.8 for full tank condition

- On changing the bracing type from diagonal to cross bracing displacement decreases. Because, bracing systems increases the stiffness of structure, which reduces the lateral displacement. Fig. shows comparison of displacement values for diagonal and cross bracing for h/d ratio as 0.8 for full tank condition and average decrease of 2%.

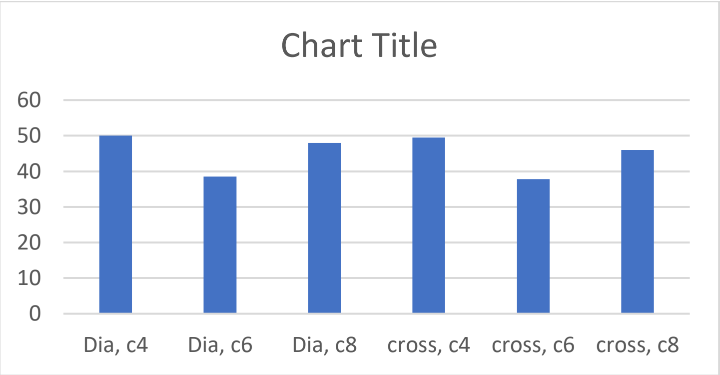

Figure 8 - Displacement values for diagonal and cross bracings for h/d ratio as 0.8 for full tank

- As the h/d ratio decreases from 0.8 to 0.7 Base Shear decreases.
- As the h/d ratio decreases from 0.8 to 0.7 displacement decreases.
- Base Shear is more for full tank condition as compared to empty tank condition. Because in empty tank condition, load due to water is deducted.
- Displacement is more for full tank condition as compared to empty tank condition.
- For diagonal bracing, h/d ratio as 0.7 and No. of columns 6, Base shear and displacement values are least, so this combination gives the best results.
- As the No. of columns and respective sizes changes, there is no fix pattern of increase or decrease in Base Shear and displacement.

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