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Design of RCC Circular Water Tank Using Response Spectrum Analysis

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ABSTRACT: Water tanks are one of the most important lifeline structures. In most of the cities and rural areas the water tanks forms an integral part of water supply scheme. The water storage tanks possess low ductility and energy absorbing capacity as compared to the conventional buildings. So seismic safety of water storage tanks is of considerable importance. The water tanks get heavily damaged or collapsed during earthquake due to the fluid-structure interactions hence the seismic behaviour of tanks has the characteristics of complex phenomena. Water storage tanks should remain functional in the post-earthquake period to ensure potable water supply to earthquake affected regions. The main aim of this study is dynamic analysis of different types of RCC water tanks. Ground supported rectangular and circular water tanks, overhead circular and rectangular water tanks are considered. Water tank is selected for dynamic analysis where the whole mass of water is divided in to two impulsive water mass and convective water mass. Analysis is carried out to find the base shear, displacement and base moment. The manual dynamic analysis is done with varying height of water level in the tank using IS 1893 (Part 2) guide lines and study the effects due to change in height of water level. The manual dynamic analysis is compared with dynamic analysis performed in software ETABS for varying height of water level.

KEYWORDS: Soil condition, Seismic zones, Base shear, Base moment, Response Spectrum Analysis, ETABS-2016.

I. INTRODUCTION

Water tanks are the life line structures to store water for the purpose of water supply. They may be elevated or ground supported tanks with different geometries depending on the nature and topography of land. Here elevated and ground supported water tank of RCC with circular is taken into consideration. This water can be utilized for many purposes like drinking, irrigation, firefighting etc. Storing the water has gain huge importance in present conditions in the entire globe. It place major and primary role in everyone's day to day life. Badly constructed structures may fail during earthquakes. There are many examples of failure of water storage tanks in past years. The water stockpiling tanks ought to stay utilitarian during and after seismic tremor to guarantee consumable water supply to quake influenced locales. It should not damage during earthquake. Whenever design engineer designs for water retaining structure function of cracks has to be kept in mind while designing this candy adjust an accident in the site by using likely shuttering sections which helps in retaining the available water moisture by avoiding its escape from the surface of the concrete. As indicated by seismic code IS 1893:2002, over 60% of India is inclined to quakes. Thus investigate the construction for impacts of quake power. The water level in the tank affects the seismic performance of water tank. The parameters like base shear and base moment helps to understand the seismic performances of a structure. The seismic design should be based on these parameters. Water level in the tank has a important role in contributing base shear and base moment in case of water tank. During earthquake, the water inside the tank also undergoes sloshing motion. That sloshing motion depends the seismic performance of tank. Here manual dynamic analysis and software dynamic analysis were conducted to find out variation of base shear and base moment of different types of RCC water tanks of 1500cum capacity at Calicut for medium soil condition with varying height of water level in the tank. Dynamic analysis performed using the well-known software ETABS-2016.

1. Objectives

The objective of this thesis is to access the behavior of circular water tank using response spectrum analysis and carried out by creating models and analyzing in ETABS 2016.



The main objectives of this project are:

- To make a study about the design and analysis of water tanks.
- To make a study about the guidelines for the design of water retaining structure according to IS code.
- To know about the design Philosophy for the safe and economical design of water tanks.
- To study the various forces acting on a water tank. Understanding the most important factors that play role in designing of water tanks.
- Preparing a water tanks design which is economical and safe, providing proper steel reinforcement in concrete and studying its safety according to various codes.
- To study the base reactions, model periods, model frequency, story forces and displacement of the structure.

1.2 Scope of the Study

The extent of this exploration is restricted to comprehend the conduct of circular water tanks exposed to dynamic loads for example wind loads and completely consider and break down the layer hypothesis of shells in light of the fact that the rooftop and base vaults of a circular tank are circular arches with the shell thickness little contrasted and different measurements and with the ranges of recede and flow.

II. STRUCTURAL DETAILS

To study the response spectrum analysis on circular water tank. The modelling and analysis of work is done by using ETABS software. Story shear, story drifts and story Displacement is compared for different types of zones structural system.

2.1 Model description

Table 1 DIMENSIONS OF TANK

Capacity of tank	1500 Cum
Diameter of tank	18.00 m
Staging height of tank	25.00 m
Thickness of Top Dome	0.15 m
Thickness of Bottom Dome	0.30 m
Thickness of Ring Wall	0.30 m
Thickness of Shear wall	0.30 m
Height of Tank	10.00 m
Tank Wall thickness	0.3 m
Top Ring beam	0.6X0.9 m
Middle Ring beam	0.9X0.75 m
Bottom Ring beam	0.6X0.45 m
Thickness of Floor slab	250 mm
Grade of steel	Fe550
Grade of concrete	M30

Table 2 CODAL VALUES

Descriptions	Structure
Zone	II,III,IV & V
Type of soil	Medium soil
Boundary condition at bottom	Fixed

2.2 Loads on Structure

a. Dead loads: as per IS875 part-1 1987

b. Live loads: as per IS875 part-2 1987. For seismic live load taken by IS1893-2002

c. Earthquake loads: All frames are analyzed for zone 3. The earthquake load calculation is as per IS1893-2002

d. Seismic factors for lateral load analysis

- Soil profile type = medium
- Seismic zone factor = zone 3
- Response reduction factor = 5.0
- Importance factor = 1.0
- Damping = 5.0 %

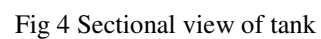
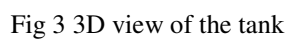
2.3 Load combinations

SL No	Factored Load Combinations	SL No	Factored Load Combinations
1	1.5(DL+HL+WL(+X))	7	1.5(DL+HL+EQ(+Y))
2	1.5(DL+HL+WL(-X))	8	1.5(DL+HL+EQ(-Y))
3	1.5(DL+HL+WL(+Y))	9	1.5(DL+HL+RS(+X))
4	1.5(DL+HL+WL(-Y))	10	1.5(DL+HL+RS(-X))
5	1.5(DL+HL+EQ(+X))	11	1.5(DL+HL+RS(+Y))
6	1.5(DL+HL+EQ(-X))	12	1.5(DL+HL+RS(-Y))

SL No	Unfactored Load Combinations	SL No	Unfactored Load Combinations
1	1.0(DL+HL+WL(+X))	7	1.0(DL+HL+EQ(+Y))
2	1.0(DL+HL+WL(-X))	8	1.0(DL+HL+EQ(-Y))
3	1.0(DL+HL+WL(+Y))	9	1.0(DL+HL+RS(+X))
4	1.0(DL+HL+WL(-Y))	10	1.0(DL+HL+RS(-X))
5	1.0(DL+HL+EQ(+X))	11	1.0(DL+HL+RS(+Y))
6	1.0(DL+HL+EQ(-X))	12	1.0(DL+HL+RS(-Y))

III. ANALYSIS AND MODELING

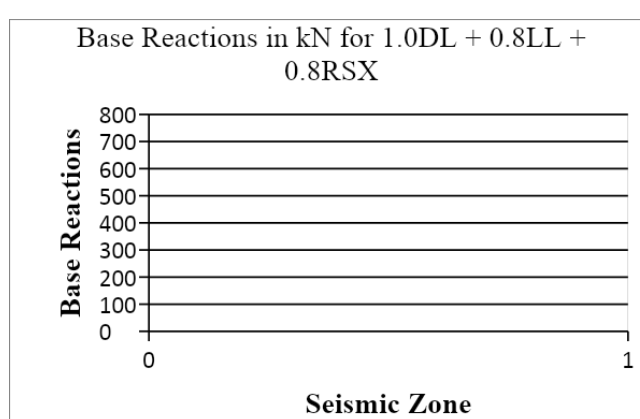
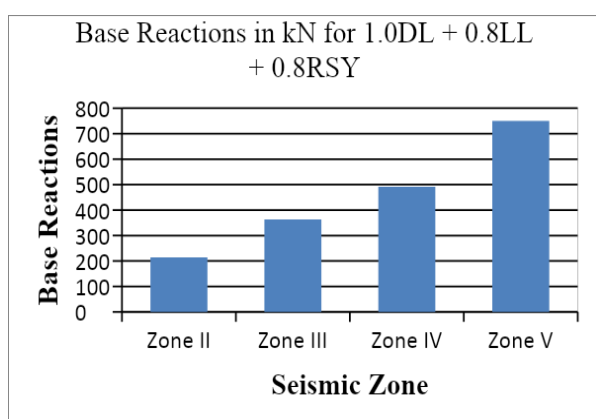
The modeling includes fixing the dimensions of components for the selected water tank and performing nonlinear dynamic analysis by: 1893- 2002 (Part 2) draft code. This work proposes to study Circular tanks of different zones with all type of soil condition. The analysis is carried out for tank with full tank and empty condition. Response spectrum analysis is used to model the elevated water tank using ETAB software.



IV. RESULTS AND DISCUSSION

1. BASE REACTION IN X DIRECITON

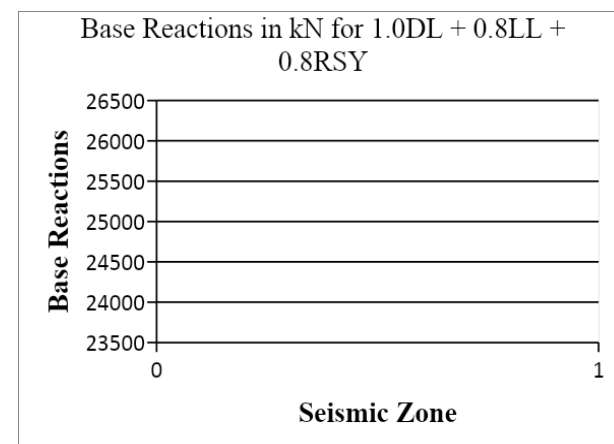
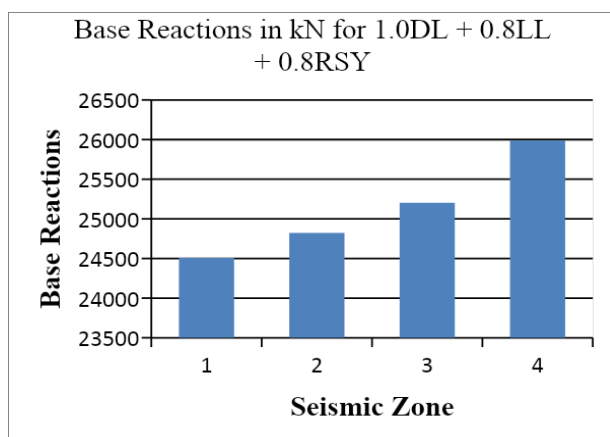
Base Reactions in KN for 1.0DL + 0.8LL + 0.8RSX			
Zone II	Zone III	Zone IV	Zone V
214.5503	363.229	491.7616	749.8549



Graph 4.1 Base Reaction in X direction

2. BASE REACTION IN Y DIRECTION

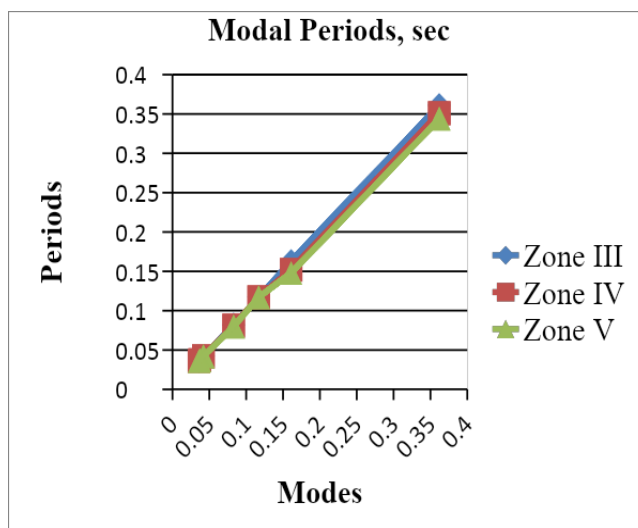
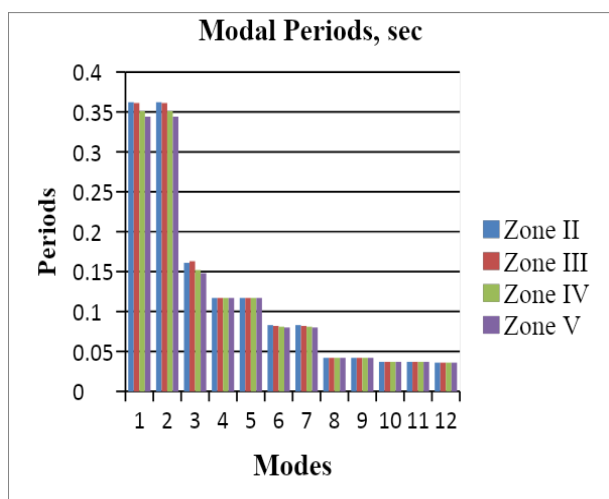
Base Reactions in KN for 1.0DL + 0.8LL + 0.8RSY			
Zone II	Zone III	Zone IV	Zone V
24508.4138	24824.08	25204.1191	25988.0857



Graph 4.2 Base Reaction in Y direction

3. MODAL PERIODS

Modal Periods, sec				
Mode	Zone II	Zone III	Zone IV	Zone V
1	0.362	0.361	0.351	0.344
2	0.362	0.361	0.351	0.344
3	0.161	0.163	0.152	0.148
4	0.117	0.117	0.117	0.117
5	0.117	0.117	0.117	0.117
6	0.083	0.082	0.081	0.08
7	0.083	0.082	0.081	0.08
8	0.042	0.042	0.042	0.042
9	0.042	0.042	0.042	0.042
10	0.037	0.037	0.037	0.037
11	0.037	0.037	0.037	0.037
12	0.036	0.036	0.036	0.036

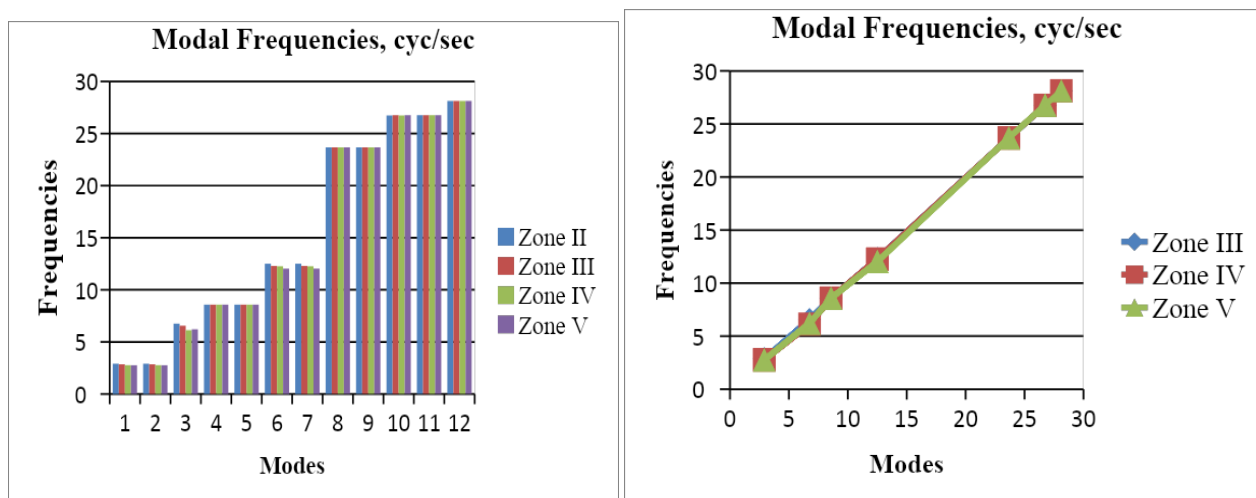


Graph 4.3 Model Periods

4. MODAL FREQUENCY

Modal Frequencies, cyc/sec				
Mode	Zone II	Zone III	Zone IV	Zone V
1	2.909	2.852	2.768	2.761
2	2.909	2.852	2.768	2.761
3	6.753	6.558	6.127	6.213
4	8.576	8.576	8.576	8.577
5	8.576	8.576	8.576	8.577
6	12.506	12.29	12.259	12.035
7	12.507	12.291	12.26	12.036

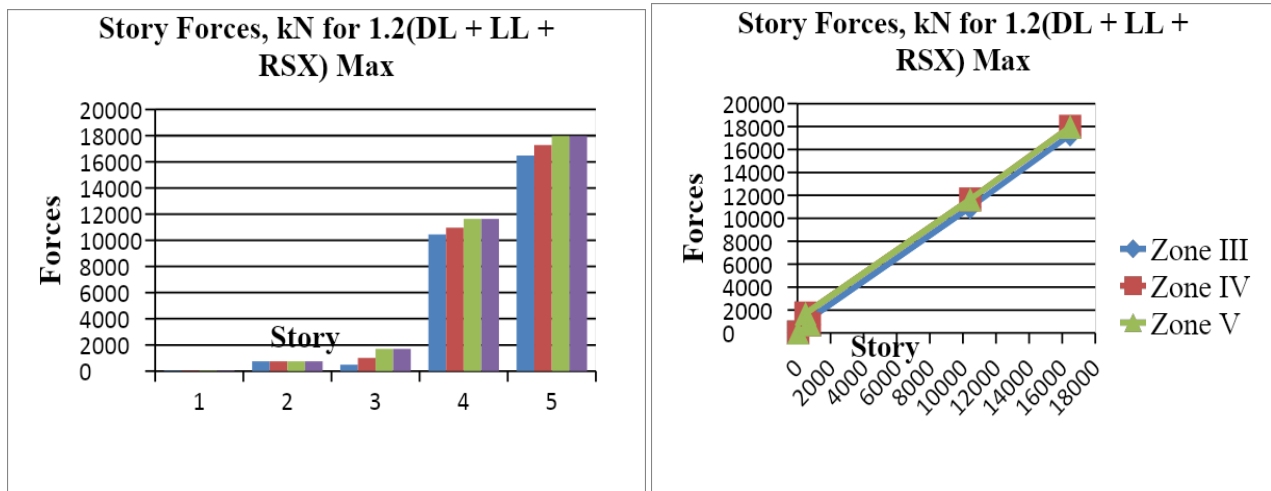
8	23.667	23.67	23.675	23.678
9	23.675	23.678	23.683	23.686
10	26.74	26.75	26.742	26.762
11	26.75	26.76	26.751	26.772
12	28.12	28.126	28.12	28.132



Graph 4.4 Model Frequencies

5. STORY FORCES

Story Forces, KN for 1.2(DL + LL + RSX) Max				
Story	Zone II	Zone III	Zone IV	Zone V
Story5	41.0913	41.0913	41.0913	41.0913
Story4	751.3489	751.3489	751.3489	751.3489
Story3	490.5894	1007.2006	1696.016	1696.016
Story2	10440.4	10957.0156	11645.83	11645.83
Story1	16480.24	17289.2277	17978.04	17978.04



Graph 4.5 Story Forces

V. CONCLUSION

1. Design a circular water tank is a time-consuming process. The entire structure was created by hand using M30 grade concrete.
2. In both seismic zones ii and v, the highest displacement occurs in a circular tank in compression with other tanks.
3. At filled tank condition the base shear and base moment of a ground supported rectangular tank exceed those of a ground supported circular tank by 6.89 percent and 6% respectively. So geometry of water tank can influence base shear. The ground supported circular tanks have less base reactions. Then it is better than ground supported rectangular tank.
4. The manual dynamic analysis and software dynamic analysis performed are found to be comparable.
5. Software results are superior to IS code calculations.
6. After performing response spectrum analysis of the circular water tank located overhead in 4 different earthquake zones and comparing the analysis results in ETABS our structure is safe.
7. Design of tank is safe from the software design with respect to loads applied.

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