SEISMIC ANALYSIS OF CIRCULAR ELEVATED TANK

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Abstract:*Liquid storage tanks are used in industries for storing chemicals. Petroleum products & for storing water in public water distribution system. In this study seismic behavior of cylindrical liquid storage tanks was carried out by performing dynamic response spectrum analysis using FEM base software (ETABS) as per IS 1893: 2002.Analysis was carried out for elevated circular RC tank for empty & full tank condition under different soil conditions & different zones. The responses include base shear & base moments in all soil conditions have been compared.*

Key Word: Sloshing, Circular water tank, Soil condition, Seismic zones, Base shear, Base moment, ETABS 9.7.1.

INTRODUCTION-An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to provide sufficient pressure in the water distribution system. Liquid storage tanks are used extensively by municipalities and industries for storing water, inflammable liquids and other chemicals. Industrial liquid tanks may contain highly toxic and inflammable liquids and these tanks should not lose their contents during the earthquake. These tanks have various types of support structures like RC braced frame, steel frame, RC shaft, and even masonry pedestal. The frame type is the most commonly used staging in practice. The main components of the frame type of staging are columns and braces. The staging acts like a bridge between container and foundation for the transfer of loads acting on the tank. Thus Water tanks are very important for public utility and for industrial structure.

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 the 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 hence; seismic behavior of them has to be investigated in detail. Due to the lack of knowledge of supporting system some of the water tanks were collapsed or heavily damaged. So there is need to focus on seismic safety of lifeline structure with respect to alternate supporting system which are safe during earthquake and also to withstand more design forces. The frame support of elevated water tank should have adequate strength to resist axial loads, moment and shear force due to lateral loads. These forces depend upon total weight of the structure, which varies with the amount of water present in the tank container. An analysis of the dynamic behavior of such tanks must take into account the motion of the water relative to the tank as well as the motion of the tank relative to the ground. The aim of the present work is to compare the seismic performance of elevated water tank considering different zones and different soil condition.

METHODOLOGY

The methodology 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. Finite Element Model (FEM) is used to model the elevated water tank using ETAB software.

MODEL DESCRIPTION

Capacity of tank:	250m^3
Top slab thickness:	250mm
Bottom slab thickness:	100mm
Cylindrical wall:	200mm
Circular ring beam:	500*1000mm
Braces:	300*500mm
Column:	500mm diameter

No of columns: 6

Column height: 16m

Height of tank: 7.8m

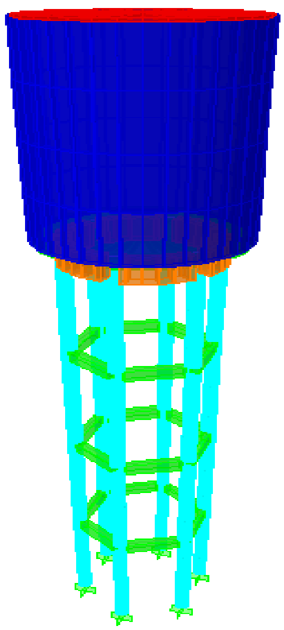

Fig no 1. Elevation of water tank

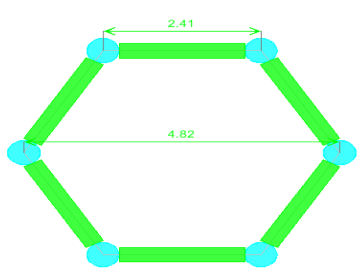

Fig no 2. Plan at staging

ANALYSIS

Seismic data used for analysis

Zones: II. III. IV. V.

Zone factor: 0.1, 0.16, 0.24, 0.36.

Reduction factor: 2.5

Soil type: Soft. Medium. Hard

Importance factor: 1.5

Equivalent static analysis considering hydrodynamic effect and response spectra analysis was carried out on the above selected models. For calculating the seismic weight of tank weight of empty container plus 2/3 weight of staging is considered. Hydrodynamic forces were calculated considering spring mass model suggested by IS 1893:2002 part II. Tank is model in finite element software package ETABS. The walls are modeled as shell element with six degrees of freedom at each node. Beams and columns are modeled as frame element. The lateral forces considering impulsive and convective masses due to earthquake is lumped at mass centre of tank along both the principal directions. A rigid link is assumed from top of staging up to the mass centre of tank and lateral earthquake forces are lumped on rigid link in both the principal directions. For the present study CG of tank is taken as CG of empty container. Finally parameters such as base shear and base moments for the above model are presented.

RESULTS AND DISCUSSION

Table 1: For hard soil condition

Zone	Tank empty condition		Tank full condition	
	Base shear (kN)	Base moment (kN-m)	Base shear (kN)	Base moment (kN-m)
II	49.76	1131.79	63.54	1445.08
III	79.61	1810.43	101.66	2311.86
IV	119.41	2715.65	152.48	3467.78
V	179.12	4073.47	228.74	5201.6

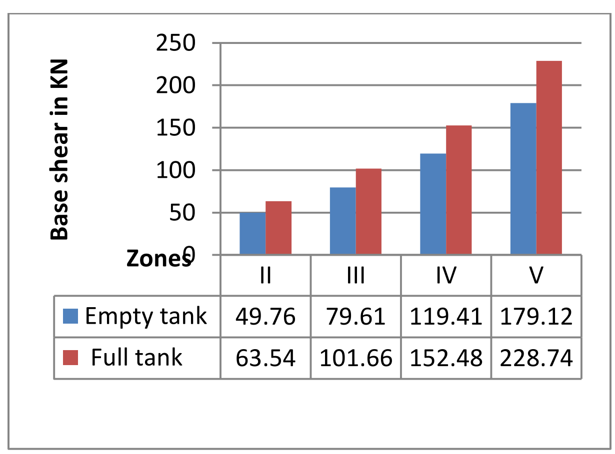

Fig No 3. Base shear in hard soil condition

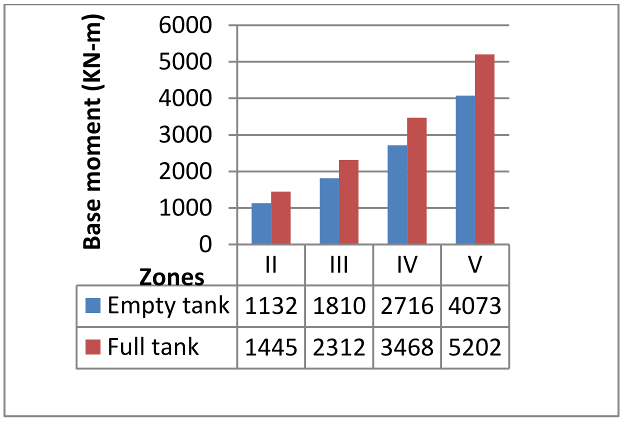

Fig No 4.Base moment in hard soil condition

Table 2: For medium soil condition

Zone	Tank full condition		Tank empty condition	
	Base shear (kN)	Base moment (kN-m)	Base shear (kN)	Base moment (kN-m)
II	67.67	1538.87	86.4	1965
III	108.27	2467.19	138.26	3144.12
IV	162.47	3693.28	207.38	4716.18
V	243.6	5539.93	311.08	7074.28

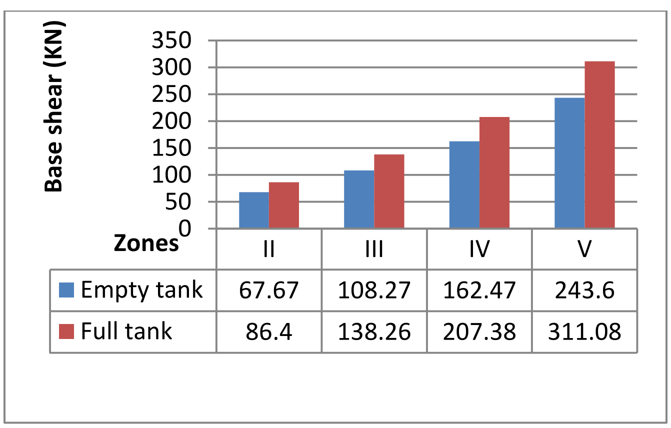

Fig No 5. Base shear in medium soil condition

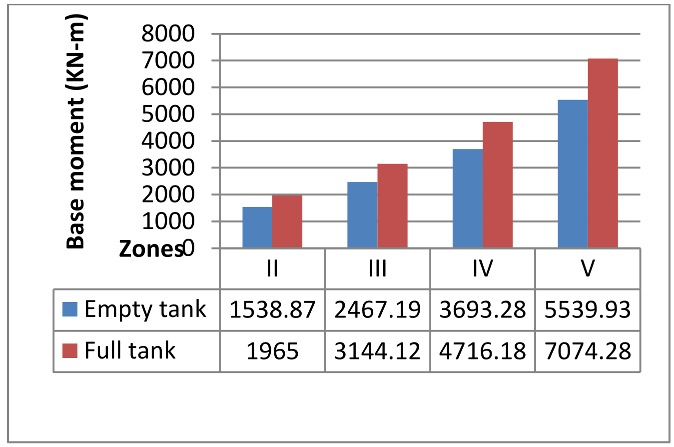

Fig No 6. Base moment in medium soil condition

Table 3: For soft soil condition

Zone	Empty tank		Full condition	
	Base shear (kN)	Base moment (kN-m)	Base shear (kN)	Base moment (kN-m)
II	83.09	1889.64	106.1	2413
III	132.95	3023.42	168.27	3860.8
IV	199.42	4535.19	254.6	5791.2
V	299.13	6802.7	381.98	8686

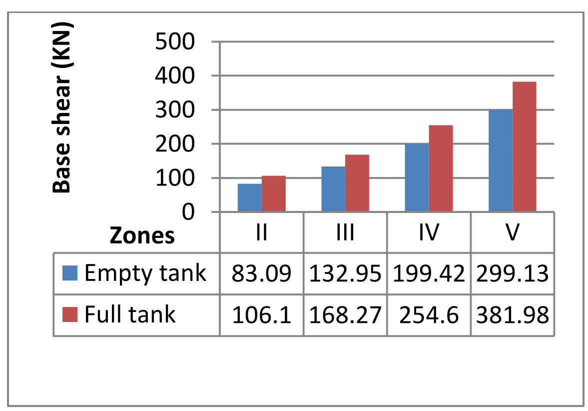

Fig No 7.Base shear in soft soil condition

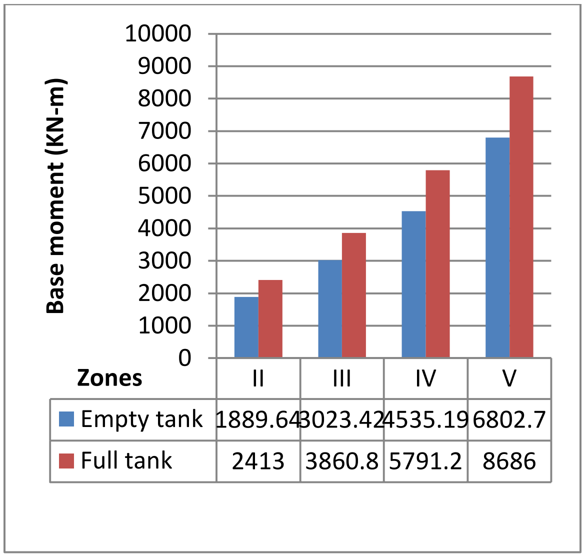

Fig No 8. Base moment in soft soil condition

Table 4: For zone II

Soil condition	Empty tank		Full tank	
	Base shear (kN)	Base moment (kN-m)	Base shear (kN)	Base moment(kN-m)
Hard soil	49.76	1131.78	63.54	1444.9
Medium soil	67.67	1538.87	86.4	1965
Soft soil	83.09	1889.64	106.1	2413

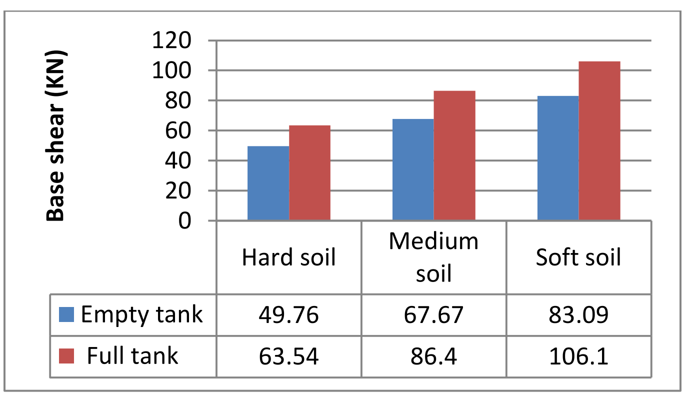

Fig No 9.Base shear for different soils

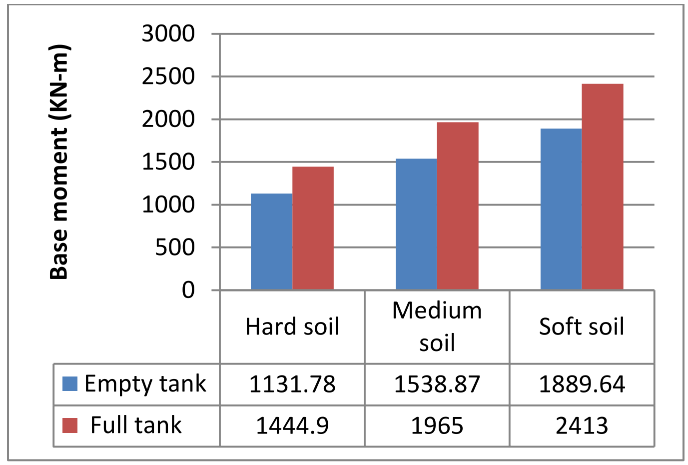

Fig No 10.Base moment for different soils

Following are the conclusions are observed form above figures

1. From figure 3. 5 &7 is observed that for tank full condition the base shear is more.
2. Form figure 4.6 & 8 is observed that the base moments is higher for full tank condition as compare to empty tank condition.
3. If the water tank is located in higher seismic zone corresponding base shear and base moments would also increase.
4. Form figure 9 & 10 is observed that the base shear &Base moment changes with soil medium.

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3. **IS: 3370 (part II-IV)-1965** Code of practice for concrete structures for the storage of liquids, in this code general requirement and stress for design of liquid storage tank is illustrated.
4. **IS: 3370 (Part II) – 1965** code of practice for concrete structures for the storage of liquids
5. **IS: 11682-1985** Criteria for design of RCC staging for overhead water tanks, in this code analysis and design for both type of staging frame staging and shaft staging has illustrate.
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