"SEISMIC ANALYASIS AND DESIGN OF PROPOSED ELEVATED INTZ TYPE WATER TANK AT SBPCOE INDAPUR"

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ABSTRACT

Elevated water tanks are one of the most important lifeline structures in earthquake prone regions. The major cities and also in rural areas. The elevated water tank is an integral part of water supply scheme, these structure has large mass concentrated at the top of slender supporting structures are especially vulnerable to horizontal forces due to earthquake. All over the world, the elevated water tanks were collapsed or heavily damaged during the earthquake because of unsuitable design of supporting system or wrong selection of supporting system underestimated demand or strength. So it is very important to select proper supporting system and also need to study the response of elevated Intz water tank to dynamic forces by both equivalent static or dynamic method and to find out the design parameters for seismic analysis. It is also necessary to consider the sloshing effect on container roof slab. This sloshing of water considerably different the parametric value used in design and economical in construction. This paper present the study of seismic performance of the elevated water tank for various seismic zones of India for various heights and capacity of elevated water tanks for different soil condition on earthquake forces.

KEY WORDS: Elevated water tanks, Earthquake effect, seismic analysis, design code, impulsive mass and Convective mass.

INTRODUCTION

Water supply is a life line facility that must remain functional following disaster. Most municipalities in India have water supply system which depends on elevated tanks for storage. Elevated water tank is a large elevated water storage container constructed for the purpose of holding a water supply at a height sufficient to pressurize a water distribution system. In major cities the main supply scheme is augmented by individual supply systems of institutions and industrial estates for which elevated tanks are an integral part. 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. According to seismic code IS:1893(Part I):2002, more than 60% of India is prone to earthquakes. After an earthquake, property loss can be recovered to some extent however, the life loss cannot. The main reason for life loss is collapse of structures. It is said that earthquake itself never kills people; it is badly constructed structures that kill. Hence it is important to analyze the structure properly for earthquake effects. 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 detail. 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.

The present study is an effort to identify the behaviour of elevated water tank under consideration and modelling of impulsive and convective water masses inside the container for different fluid conditions, types of bracings and bracing levels using structural software.

MODELING AND ANALYSIS OF ELEVATED INTZ WATER TANK FOR EARTHQUAKE:

Overhead or elevated water tanks

A wide variety of elevated water tank can be seen in the skylines at the industrial and residential complexes. The shape of a tank it is height above the ground, the type of surrounding structures etc, is dedicated by functional, structural, aesthetical and economical consideration. In all above the cases the Intz type water is most suitable because of the tank having conical and bottom and spherical domes provide and economical situation. In such cases, dome cover is provided at top with cylindrical conical wall at bottom. A ring will be required to support the dome roof, A ring beam is also provided at the junction of the cylindrical and conical walls. The conical wall and the tank floor are supported on ring girder which is supported on a number column. The domed floor is provided as result of which the ring girder supported on the columns will be relieved from the horizontal thrust as the horizontal thrust of the conical wall and the domed floor act in opposite direction. Sometimes a vertical hollow shaft may be provided which may supported on the domed floor and the help to reduce the motion of wave that is slashing motion.

MODEL PROVISION

Two mass models for elevated tank was proposed by G.W. Housner (1963) after the Chileane earthquake 1960, which is more appropriate and is being commonly used in most of the international codes. The pressure generated within the fluid due to the dynamic motion of the tank can be separated into impulsive and convective parts.

Impulsive liquid mass-When a tank containing liquid with a free surface is subjected to horizontal earthquake ground motion, tank wall and liquid are subjected to horizontal acceleration. The liquid in the lower region of tank behaves like a mass that is rigidly connected to tank wall. This mass is termed as impulsive liquid mass which accelerates along with the wall and induces impulsive hydrodynamic pressure on tank wall and similarly on base.

Convective liquid mass- Liquid mass in the upper region of tank undergoes sloshing motion. This is termed as convective liquid mass and it exerts convective hydrodynamic pressure on tank wall and base. Thus, total liquid mass of elevated water tank shown in Fig. (a) gets divided into two parts, i.e., impulsive mass and convective mass. In spring mass model system, these two liquid masses are to be suitably represented as shown in Fig. (b)

Structural mass ms, includes mass of container and one-third mass of staging. Mass of container comprises of mass of roof slab, container wall, gallery, floor slab, and floor beams. Staging acts like a lateral spring and one-third mass of staging is considered based on classical result on effect of spring mass on natural frequency of single degree of freedom system. Most elevated tanks are never completely filled with liquid. Hence a two-mass idealization of the tank shown in Fig. (c) is more appropriate as compared to a one mass idealization, which was used in IS 1893: 1984. The response of the two-degree of freedom system can be obtained by elementary structural dynamics. However, for most elevated tanks it is observed that the two periods are well separated. Hence, the system may be considered as

two uncoupled single degree of freedom systems as shown in Figure (d). This method will be satisfactory for design purpose, if the ratio of the period of the two uncoupled systems exceeds 2.5. If impulsive and convective time periods are not well separated, then coupled 2-DOF system will have to be solved using elementary structural dynamics. There are two cases for seismic analysis namely tank empty condition and tank full condition. For tank empty condition, tank will be considered as single degree of freedom system and empty tank will not have convective mode of vibration whereas tank full condition is considered as two degree of freedom system.
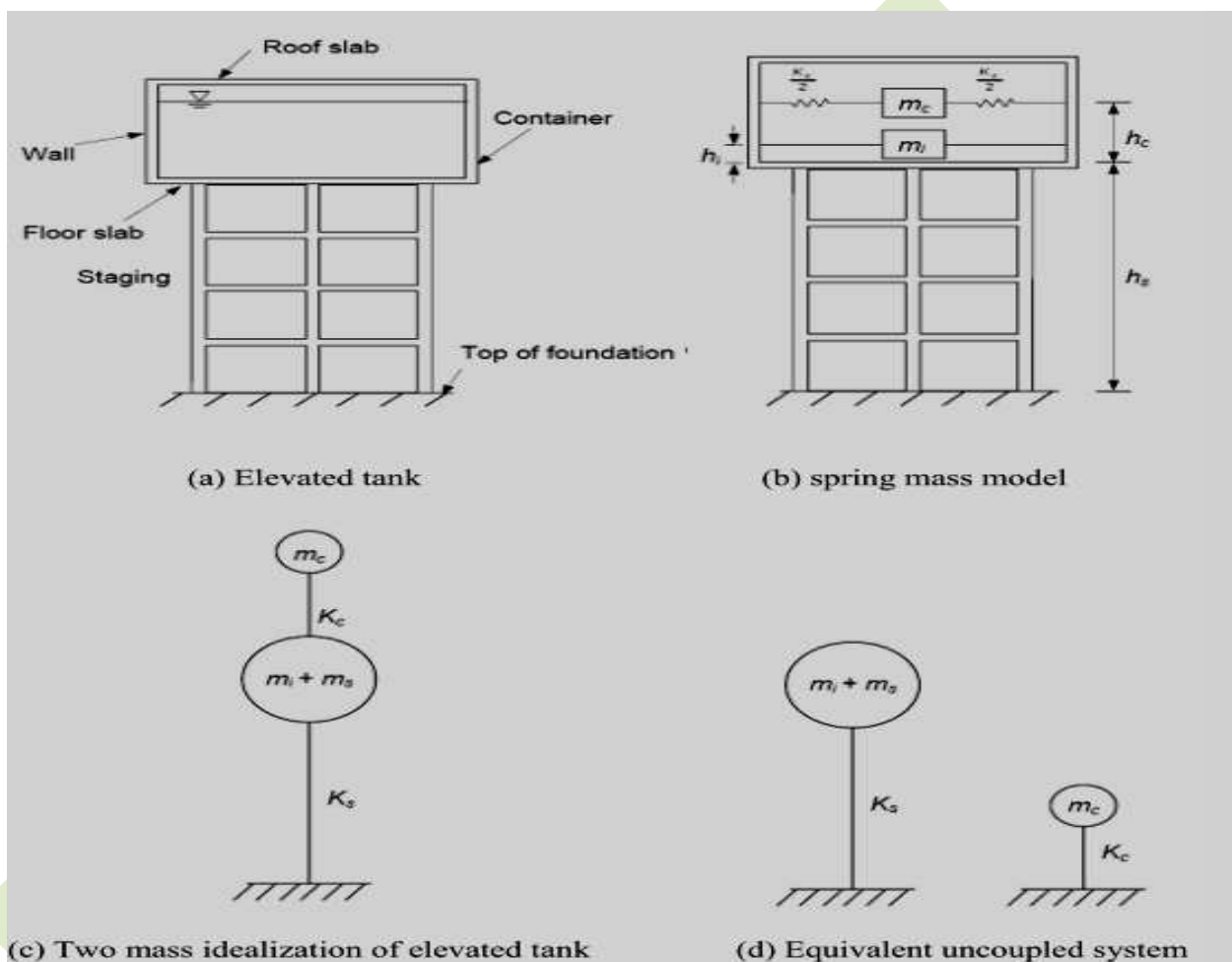

Fig. 1: Two mass idealization of elevated tank [IITK- GSDMA, 2005]

The important factors that affect the magnitude of earthquake forces are-

(a) Seismic zone factor, Z

India has been divided into four seismic zones as per IS 1893 (Part 1): 2002 for the Maximum Considered Earthquake (MCE) and service life of the structure in a zone. Different zone have different zone factor. Fig. shows seismic zone map of India. India is divided into four seismic zones. There are three types of soil considered by IS 1893 (Part 1): 2002 i.e. soft medium and hard soil.

(b) Importance factor, I

Importance factor depends upon the functional use of the structures, characterized by .hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance. Elevated water tanks are used for storing potable water and intended for emergency services such as fire fighting services and are of post earthquake importance. So importance factor is 1.5 for elevated water tank.

(c) Response reduction factor, R

Response reduction factor depends on the perceived seismic damage performance of the structure, characterized by ductile or brittle deformations. R values of tanks are less than building since tanks are generally less ductile and have low redundancy as compared to building. For frame confirming to ductile detailing i.e. special moment resisting frame (SMRF), R value is 2.5.

(d) Structural response factor, (Sa/g)

It is a factor denoting acceleration response spectrum of the structure subjected to earthquake ground vibrations, and depends on natural period of vibration and damping of the structure.
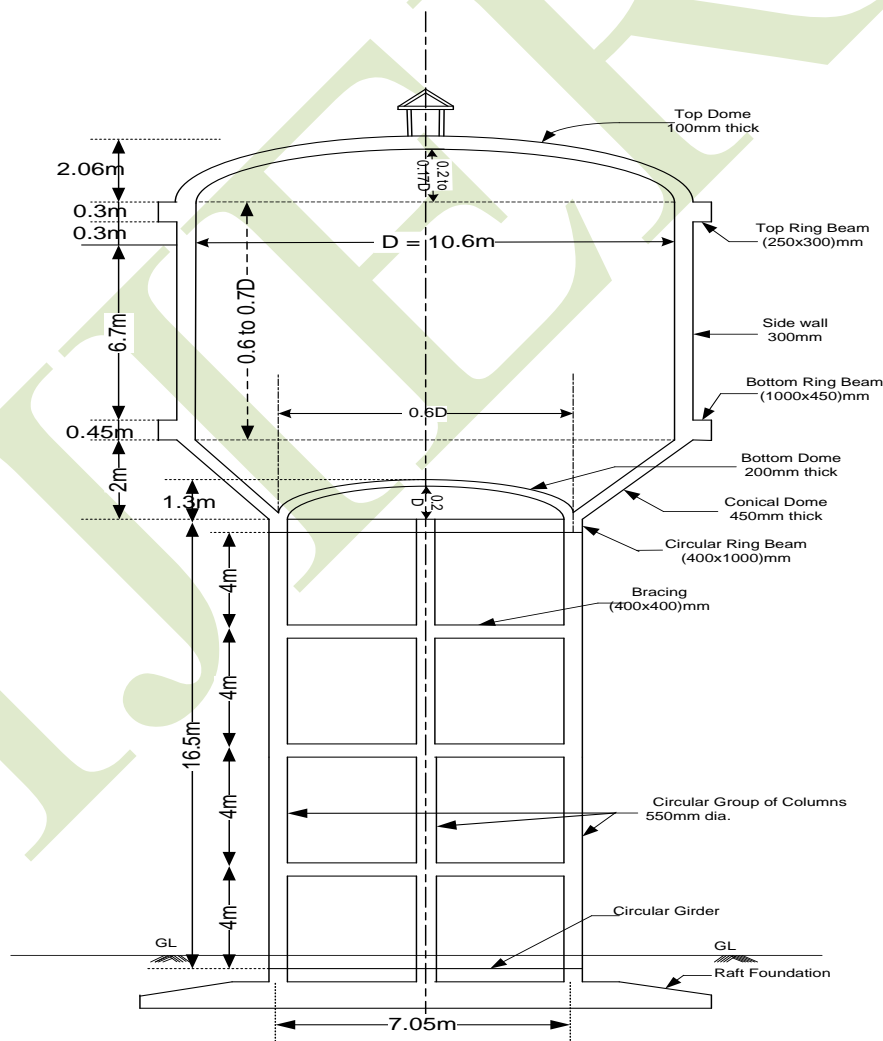
WATER TANK DESIGN

Fig. detailing of structural element of Intz tank

In this study, a Intz elevated RC water tank having diameter 10.6m, with eight column staging has been considered as a Numerical problem for understanding the seismic behaviour under the influence of various parameter discussed in table.

Capacity of tank = 700m^3

Height of Staging = 16m

Material properties

The grade of concrete and grade of steel required for the analysis of water tank is defined is this section. Grade of concrete is M$_{25}$ & grade of steel is taken as Fe415.

Table 1.1 Sizes of various components

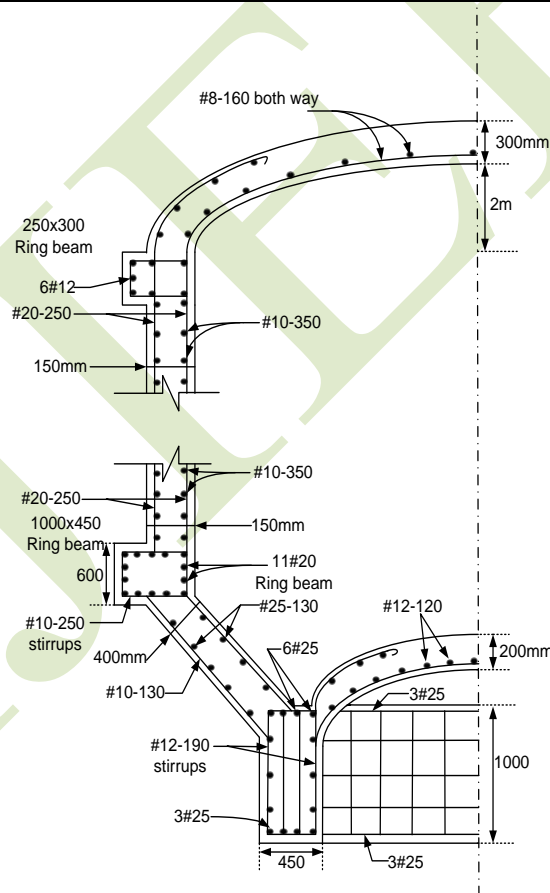| Component	Sizes
Top Dome	100mm thick
Top Ring Beam	250x300mm
Cylindrical Wall	300mm thick
Bottom Ring Beam	1000x450mm
Circular Ring Beam	400x1000mm
Bottom Dome	200mm thick
Conical Dome	450mm thick
Braces	400x400mm
Columns	550mm dia.

Fig. Detail reinforcement of Intz water tank

Simple Procedure for Seismic Analysis

The procedure presented here is based on certain modifications that make the procedure simple and more generally applicable. Specifically, these modifications include

− representing the tank-liquid system by the first impulsive and first convective modes only

− combining the higher impulsive modal mass with the first impulsive mode and the higher convective modal mass with the first convective mode

− adjusting the impulsive and convective heights to account for the overturning effect of the higher modes

− generalising the impulsive period formula so that it can be applied to steel as well as concrete tanks of various wall thicknesses.

The impulsive and convective responses are combined by taking their numerical sum rather than their root mean-square value.

Tank must be analysed for tank full and empty conditions:

Time Period

Time period of impulsive mode,

$T_i = 2\pi \{(m_i+m_s)/Ks\}^{0.5}$

Time period of convective mode,

$T_c = C_c (D/g)^{0.5}$

Design of Horizontal Seismic Coefficient

Design horizontal seismic coefficient for impulsive convective mode,

$$(A_h)_i = \frac{Z}{2} \frac{I}{R} \frac{S_a}{g}$$

Base Shear

For Impulsive mode, $V_i = (A_h)_i (m_i+m_s)g$

For Convective mode, $V_c = (A_h)_c (m_c)g$

Base Moment

Overturning moment at the base of staging in impulsive mode,

$M_i^* = (A_h)_i [m_i(h_i^* +h_s) + m_s h_{cg}] g$

Overturning moment at the base of staging convective mode,

$M_c^* = (A_h)_c m_c(h_i^* +h_s) g$

Elevated Intz Tank Supported on 8 Column RC Staging

1) Wt. of empty container = 3869.82KN
2) Wt. of staging = 924.18KN
3) Wt. of full container =10606.34KN

Table 1.2 Seismic responses

Factor	Full condition		Empty condition
	Impulsive	Convective	Impulsive
Time Period	0.76sec	3.10sec	0.56sec
Horizontal seismic Coefficient	0.074	0.032	0.06
Base Shear	265KN	272KN	205KN
Base Moment	5310KN-m	5398KN-m	3985KN-m

CONCLUSION

Analysis & design of elevated water tanks against earthquake effect is of considerable importance. These structures must remain functional even after an earthquake. Elevated water tanks, which typically consist of a large mass supported on the top of a slender staging, are particularly susceptible to earthquake damage. Thus, analysis & design of such structures against the earthquake effect is of considerable importance.

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