Study of Intze Tank with Different Horizontal Bracing Patterns

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Abstract- Water tank and especially elevated RC tank are important public utility and industrial structure in day to day life. This paper presents comparative study of elevated water tank subjected to dynamic loading with different horizontal bracing pattern and placed in different seismic zones. A sample of RC elevated water tank ie. Intze tank with 250m^3 have been studied and analyzed by Response Spectrum Method and seismic response such as tank displacement, base shear, base moment at the base of columns under tank empty condition and tank full condition for different bracing pattern in different seismic zones II, III, IV and V have been calculated and then results have been compared. The main aim of this study is to understand the behavior of supporting system which is more effective in different seismic zones under Response Spectrum Method.

Keywords- Elevated Water Tank, Staging, Bracing, Tank empty condition, Tank full condition.

I. INTRODUCTION

Most of the basic needs of people are fulfill by water so water is the important part of human life. Huge water mass in elevated water tanks lies at the top of slender staging which is most critical part for the failure of tank during earthquake excitations. Some of the water tanks were collapsed or heavily damaged due to lack of knowledge of supporting system of elevated water tanks. When the tank is in full condition, earthquake forces are more or less govern the lateral force design criteria in the zone of high seismic activity because of heavy mass.

Circular tanks are found to be more economical in case of large capacity storage overhead tanks. There is the need of beams to reduce their span because top and bottom slabs of such tanks become thick. So intze tank is the way to solve this problem by providing dome in place of level slab.

Intze tank can divided into two parts based on support systems.

a) Column rested water tank
b) Shaft rested water tank

Column rested water tanks are more preferred because of loading condition is easily calculated. Staging system in case of column rested water tank consist of columns and braces. Columns of tanks transfer the entire load of the tank to the foundation. If the staging height above foundation is greater than 6m, columns shall be connected by horizontal bracing at suitable interval which is not greater then 6m according to IS:11682-1985. Without braces, elevated water tower would have inherent stability against force applied in every direction (all three axis-forward and backward, left-right, up-down). Hence Elevated tanks need braces for supporting in all condition.

Simple Brace Cross Brace Radial Brace

Figure 1. Different Pattern of Bracing

II. METHODS OF ANALYSIS

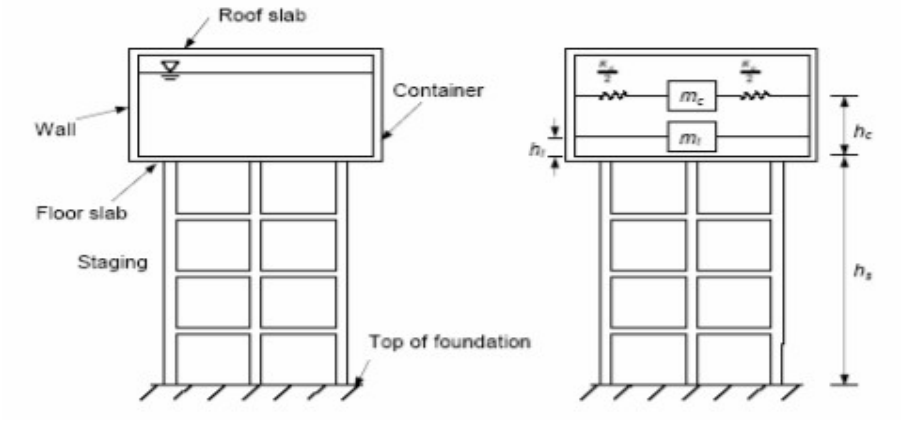
2.1 Dynamic analysis method- Response Spectrum Method

In this analysis method, superposition of modal response represents the response of Multi-degree of freedom (MDOF) system, spectral analysis of single degree of freedom (SDOF) system is used to determined each modal response which is then combined to compute the total response. Curve plotted between maximum response of single degree of freedom (SDOF) system subjected to earthquake and its frequency.

2.2 Code Based Procedure

Seismic method of analysis based on Indian Standard Code IS 1892(Part 2):2016 given below

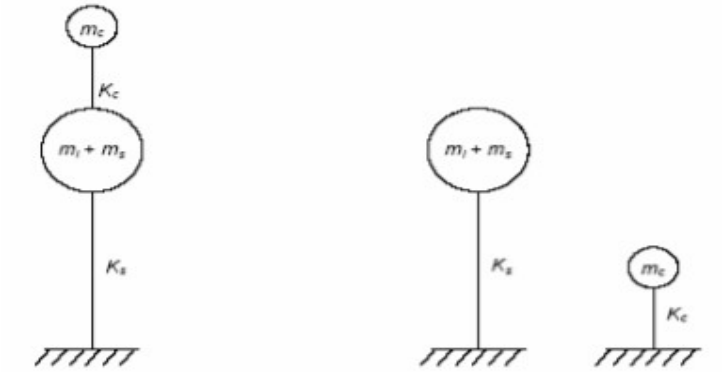
a) Lumped Mass Model Method



Elevated Tank Spring Mass Model

Figure2. Lumped Mass Model Method

b) *Two Mass Model Method*



Two mass idealization of elevated tankEquivalent uncoupled system

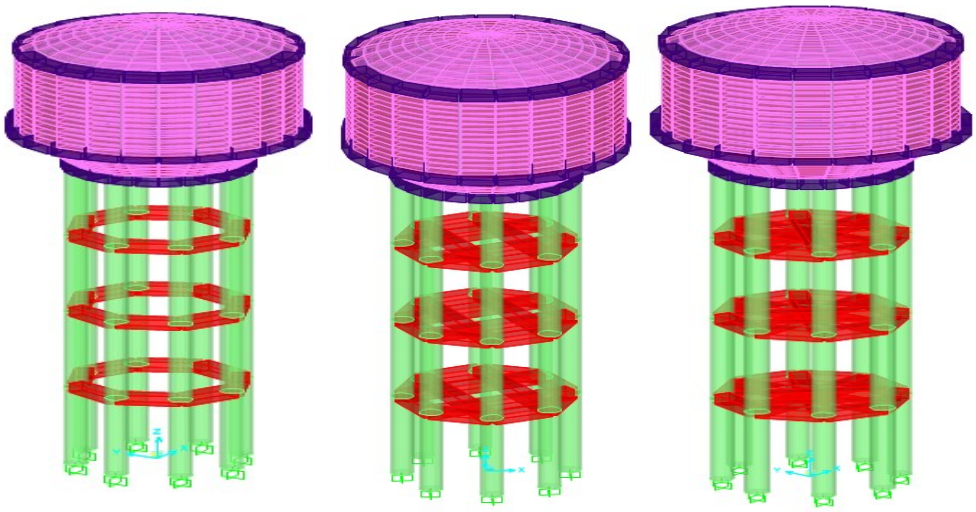
Figure3. Two Mass Model Method

Dynamic analysis of intze tank supported on RC frame staging of different bracing patterns are performed as per IS 1893 (Part 2):2016 for hard soil condition and zone II, III,IV, V. Reinforced concrete intze type elevated water tanks with fixed base connection and different bracing patterns is considered for present study. In frame staging, columns are arranged on periphery and it is connected internally by bracing at various level not more then 6m spacing between braces. FEM structural software SAP2000 is used to model water tank.Grade of concrete and steel are M30 and Fe415 respectively.

Table- 1 Data for Frame Type Staging

Particulars	Data Values
Capacity of Tank	250m^3
Cylindrical Portion Diameter	8.10m
Lower Ring Beam Diameter	5.06m
Rise of Top Dome	1.2m
Cylindrical Portion Height	4.05m
Conical Dome Height	1.52m
Rise of Top Dome	1.01m
Radius of Top Spherical Dome	7.43m
Radius of Bottom Spherical Dome	3.67m
Top Dome	100mm
Top Ring Beam	500mm×400mm
Cylindrical Wall	400mm
Middle Ring Beam	1000mm×600mm
Conical Dome	500mm
Bottom Dome	250mm
Bottom Ring Beam	750mm×1200mm
Columns	700mm
No.of Columns	8
Bracing	500mm×500mm
Bracing Level	3
Height of Staging	16m
Type of Support	Fixed support
Unit weight of Concrete	30kN/m^3
Grade of Steel	Fe415
Seismic Zones	II, III, IV, V
Soil Type	Hard Soil
Importance Factor	1.5
Response Reduction Factor	2.5

Intze water tank with different bracing patterns used in study are



Simple Brace Cross Brace Radial Brace

Figure 4. Finite Element Model in SAP 2000 v21

III. ANALYSIS AND COMPARISON OF RESULTS

Models of 250m^3 capacity with different bracing pattern such as simple brace, cross brace, radial brace have been prepared and analyzed in SAP2000 v21 software by "Response Spectrum Method" to get following results which is shown in table and graph form given below.

Table -2 Base Shear(kN) at Empty Condition

Zones	Simple Bracing	Cross Bracing	Radial Bracing
Zone II	188.763	215.43	217.016
Zone III	302.021	345.029	347.225
Zone IV	453.032	517.543	520.838
Zone V	679.548	776.315	781.257

Table -3 Base Moment(kNm) at Empty Condition

Zones	Simple Bracing	Cross Bracing	Radial Bracing
Zone II	3182.4385	3558.1186	3574.6106
Zone III	5091.9016	5692.9898	5719.377
Zone IV	7637.852	8539.4846	8579.065
Zone V	11456.778	12809.227	12868.598

Table- 4 Storey Displacement(mm) for Empty Condition at 16m height from Base

Zones	Simple Bracing	Cross Bracing	Radial Bracing
Zone II	5.489	5.365	5.38
Zone III	8.783	8.584	8.608
Zone IV	13.175	12.876	12.913
Zone V	19.762	19.314	19.369

Table -5 Base Shear(kN) at Fill Condition

Zones	Simple Bracing	Cross Bracing	Radial Bracing
Zone II	304.14	345.762	347.671
Zone III	486.624	553.219	556.273
Zone IV	729.935	829.828	834.904
Zone V	1094.903	1244.742	1251.614

Table- 6Base Moment(kNm) at Fill Condition

Zones	Simple Bracing	Cross Bracing	Radial Bracing
Zone II	5091.7627	5674.6513	5697.0471
Zone III	8146.8204	9079.442	9115.2753
Zone IV	12220.23	13619.163	13672.913
Zone V	18330.345	20428.74	20509.369

Table- 7 Storey Displacement(mm) for Fill Condition at 16m height from Base

Zones	Simple Bracing	Cross Bracing	Radial Bracing
Zone II	10.084	9.976	8.702
Zone III	16.135	15.962	13.924
Zone IV	24.203	23.943	23.99
Zone V	36.304	35.915	31.329

Base shear, Overturning moment, Storey Displacement values in case of filled condition is more than empty condition because of weight of water in filled condition also included in calculations. So filled condition is preferred over empty condition.

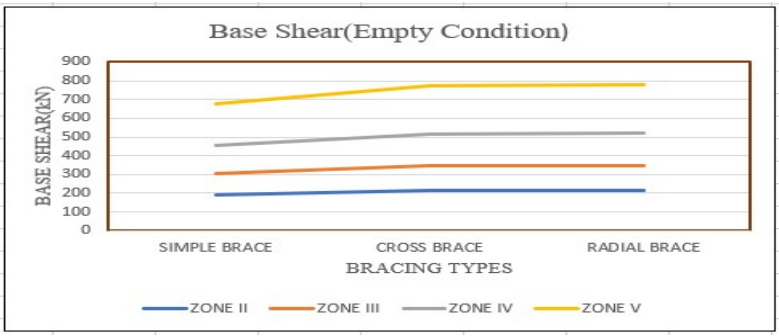


Figure 5. Base Shear for empty Condition

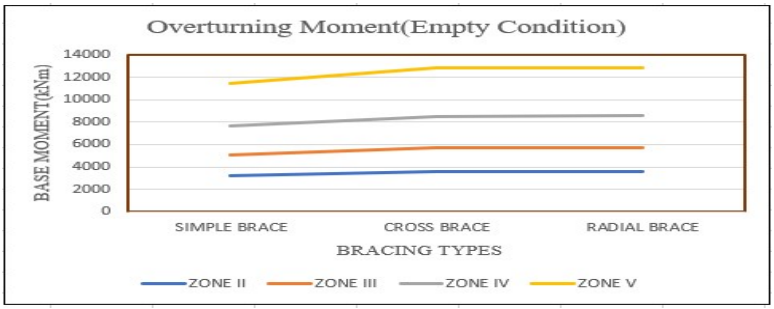


Figure 6.Base Moment for empty Condition

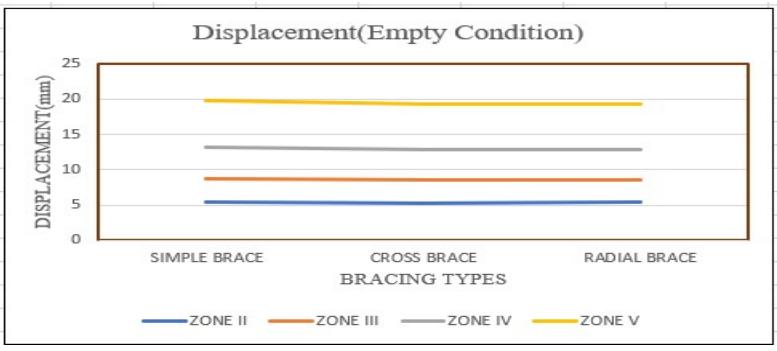


Figure 7.Storey Displacement(mm) for Empty Condition at 16m height from Base

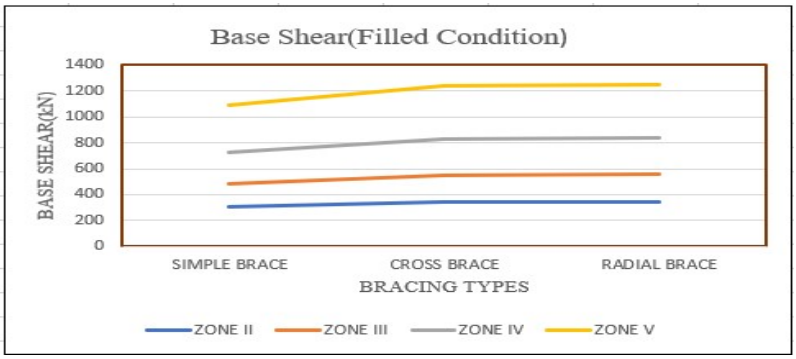


Figure8. Base Shear for filled Condition

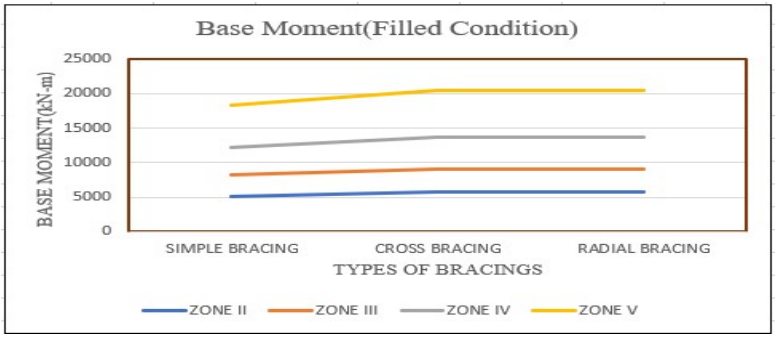


Figure9. Base Moment for Filled Condition

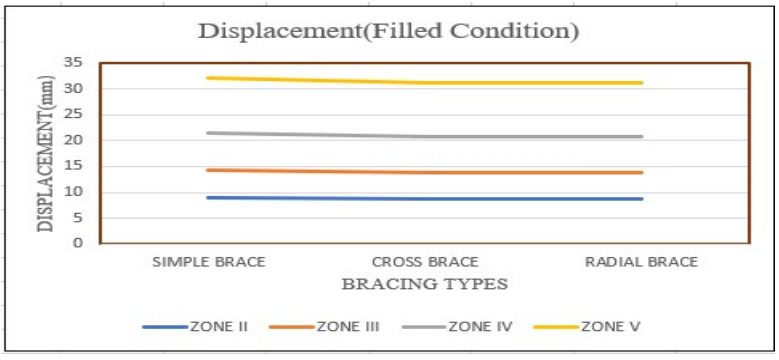


Figure10. Storey Displacement(mm) for Fill Condition at 16m height from Base

IV. CONCLUSIONS

Seismic analysis on RC elevated intze water tank has been presented for frame type of staging pattern with different bracing types in this study.Response Spectrum analysis is used for the structure under seismic zones II, III, IV, V.After performing analysis by Response Spectrum Method using SAP2000 v21 software and comparisons, following conclusions are obtained :

1. It is observed that base shear, base moment and displacement obtained from full condition is greater than empty condition.
2. As seismic zone going up, base shear and base moment are also getting rise for all bracing types.
3. In seismic zone V, there is sudden rise of base shear and base moment from simple brace then cross brace but there is somewhat small increase from cross then radial brace.
4. For lower seismic intensity zone, all three types of bracing show almost similar behavior in base shear and base moment.

5. As seismic zones increase from zone II to Zone V, base shear and base moment values for simple brace are less then cross brace and radial brace.
6. Base shear and base moment values in seismic zone V are less for simple brace.
7. Storey displacement values of simple brace is higher for all seismic zones.
8. There is not significant difference in simple brace, cross brace and radial brace in lower seismic zones (II & III).

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