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Performance Evaluation of Elevated Storage Reservoir with Hybrid Staging

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ABSTRACT
Elevated water tanks are essential Civil Engineering framework which are known as compulsory community services urban areas. A number of elevated water tanks suffered collapse and damage to their staging in deep earthquakes, consequently their safety performance is a crucial concern throughout effective earthquake. Because of storage of clean water, it is utilized for important needs such as drinking purpose and for other domestic purpose. Within the existing work, four support patterns viz. easy brace, cross brace, rectangular brace as well as radial brace connected with various staging heights (fifteen m, twenty m, and twenty-five m) are analysed for seismic zone II, III and IV for empty tank and loaded tank. Probably the most affordable as well as secure, Intze style tank of thousand kilolitre capacity considered. When it comes to the evaluation of Intze container, 72 designs are constructed with STAAD.ProV8i Software, by which 36 models are analysed for empty tank and additional 36 models are analysed for loaded tank. Each and every seismic zone has 12 models as well as every brace has three distinct staging rises. For the safety, stability and serviceability, different parameters are obtained for different brace pattern.

Key words : Intze container, Earthquake effect, Tank staging with brackets, STAAD.Pro. V8i.

1. INTRODUCTION

1.1 General

Water is an essential commodity for all living as well as non-living beings. Elevated water tanks are an overhead framework built with an adequate level to pressurize a normal water source process for division of water and it is utilized the place that the ground storage tanks can't be constructed because of not enough adequate natural elevation. Elevated water tanks are among the most crucial public utility constructions because they form an important aspect of the water distribution process.

Fig 1.1 Failure of braces because of earthquake

Beams and column of staging of water tanks provides the conception connection with frame structure of water tank. The mechanism of beams and column is extremely different with water tank staging model because of the large load of the container. As the failures of water tanks are always occurs within the staging system of elevated water tanks, it becomes necessary to develop an energetic fascination with checking out the powerful behaviour on the staging system.

1.2 Shape of Elevated Water Tank

The shape of the water tank plays a crucial economic role within the overall structure. The form of elevated water tank is frequently governed by the capacity of container. Capacity of container is the volume of water stores in water tank as per its design and style.

1.3 Dynamic Behaviour of Elevated Water Tank

The elevated water tank is top heavy structures and the structure can be assumed as an individual degree freedom program. The weight of staging (braces and column) might be sits in the C.G. on the tank, and also the whole load on the pot is transferred towards the floor on the tank and that plays a role in every column. The container is a huge rigid framework which is very tall and there is simply no distant relative motion involve in the components on the tank and also top of the frame. Thus, absolutely no dynamic forces are caused within the container because of the variation on the frame.

1.4 Layout of Elevated Water Tank

The affordable size and shape of an elevated water tank are depended on a few purposeful needs like as:

a) Tank capacity
b) The optimum level for water
c) Staging heights
d) Number of braces as well as their frame type
e) Allowable bearing capability of foundation
f) Seismic zone as well as Site conditions

1.5 Problem Statement

Elevated water tanks are visible from near as well as from long distances. They often become landmarks on the landscape due to their shape, form and support system. Therefore, it becomes important to receive attention from the point of aesthetics. Innovations in the shape and form should be encouraged when they improve the ambience and enhance the quality of the environment.

1.6 Scope of project

- To analyse an Intze water tank with different horizontal braces in staging using response spectrum analysis with the help of STAAD.ProV8i.
- To study the behaviour of Intze tank on the different rise of staging in seismic zones II, III and IV.
- Comparative study of various parameters of tank with different braced system at empty and filled condition in different seismic zones.
- To obtain most efficient, stable and durable horizontal brace system for Intze tank.

1.7 Objective

i. To develop models of ESR with conventional and hybrid staging systems.
ii. To check performance of ESR under seismic forces by using software.
iii. To suggest suitable hybrid staging system for ESR.
iv. To study the different shapes of ESR

1.8 Types of Staging System Used

In the present study four types of arrangements have been considered i.e normal, cross, radial and rectangular as shown in Figure

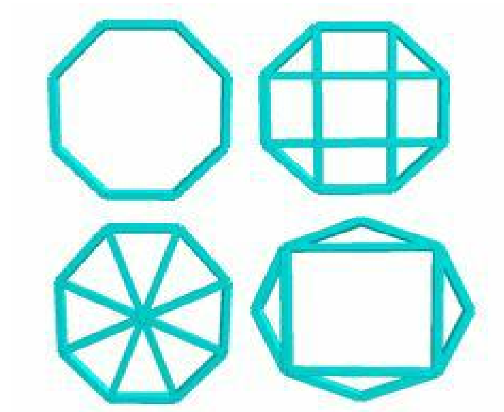

Fig. 1.2: Different types of staging arrangements

2. LITERATURE REVIEW

2.1 General

Elevated water tanks are an essential component of water supply layout within huge cities as well as within the countryside region. Of history years, a selection of elevated water tanks has collapsed in various places across the world because of the diverse dynamics of loadings. Failure of water tanks is definitely a huge loss of property and life. The seismic analysis is important but a lot of complex for strengthening the elevated tanks. This particular chapter deals having a short overview of recent and past research of seismic result on the balance of elevated water tanks.

2.2 Review of the Previous Study

Significant research information of elevated water tank is summarizing inside paragraphs. Each paper is discussed with the effective results of it's as well as things that impact the overall performance of elevated water tanks

A. H. Shrigondekar et.al (2017) (1) has studied and analysed the reinforced concrete elevated tank with linear dynamic method and seismic response such as base shear, tank displacement having different types of staging configuration by using finite element method software. Sonali M. Pole et. al (2017) (2) This paper presents seismic analysis of elevated water tank with different storage capacities having different staging patterns. They compared two different supporting systems like radial bracing and cross bracing with basic supporting system by considering various fluid level condition. By using STAAD Pro V8i software base shear, overturning moment ant displacement have been observed and then compared. Keyur Y. Prajapati et al. (2014) (3) This paper presents the analysis of hybrid staging of ESR by considering seismic loading and analysed with SAP 2000. It compared the frame type and shaft type staging systems of ESR. The main aim of this paper is to compare the cost of hybrid staging system of ESR. Mr. Santosh Rathod et. al (2018) (4) In this paper, reinforced cement concrete overhead water tank of capacity one lakh litre is considered for the analysis. Comparison is done with different staging height and base width. Analysis is carried out by STAAD Pro software. Tank level, seismic zone III considered for comparative study of bending moment, shear force and displacement. Kaviti Harsha et.al (2015) (5) has designed the Intze water tank as per IS: 3370-2009 and draft code1893-part 2, considering two mass modal method. Analysis is carried out by STAAD Pro for wind and seismic forces. Sneha Adhikari et al. (2016) (6) has compared the Intze tank with inclined bracing (single inclined bracing and cross inclined bracing) with alternate layers at staging and inclined bracing throughout height of staging. Overall analysis is carried out as per draft code of IS 1893 (part 2) by using STAAD Pro software. P. S. Nemade et al. (2016) (7) has analysed different bracing patterns in staging configuration of ESR by using STAAD Pro software. Analysis carried out by considering different seismic zones 3, 4 and 5 and also consider empty and full condition of tank for analysis. Manish N. Gandhi. et.al (2016) (8) has study the behaviour of different staging patterns of circular elevated tank for better performance during earthquake. It includes the different bracing types for the analysis using STAAD Pro software. Base shear and maximum displacement in X, Y and Z direction of circular tank is compared. Prashant A. Bansode et al. (2017) (9) has review the Seismic Analysis of Elevated Water Tank with as well as while not bracing with frame staging. The various forms of bracing are cross bracing as well as diagonal bracing with zone III by reaction spectrum strategy as per Is actually 1893 (Part II) 2014 as well as Seismic a lot are given as per Is actually: 1893:2002 (Part II) applying STAAD Pro V8i 2007 application. Ayazhussain M. Jabar et. al (2012) (10) In this paper two different systems are taken into consideration for the proposed work. Results from staging with basic pattern, staging with radial bracing and staging with cross bracing at various fluid level condition are compared here. To understand the seismic behaviour on elevated water tank they compared base shear, overturning moment, roof displacement at different staging type and different filled conditions of water tank.

3. RESEARCH METHODOLOGY

3.1 General

This particular project work includes the "Seismic Analysis of Intze Water Tank with different Bracing Configurations." To handle the analysis, different IS codes are used to evaluation of elevated water tank.

3.2 Categories of Loads

3.2.1 Dead Load

The fixed load for any structure is known as dead load. For overhead water tank, fixed elements like column, bracing, bottom ring beam, top ring beam, cylindrical walls, top dome, bottom dome weight that required on ground.

3.2.2 Imposed Load

When a load due to temporary objects and load other than dead load is known as imposed load. This particular load arises through the planned utilization of occupancy or structure of all of the structure. Various types of imposed loads coming on structure are given in IS: 875 (Part 2) - 1987. For overhead water tank, hydrostatic stress within cylindrical walls and bottom dome is a result of development of waves in the course of seismic outcome.

3.2.3 Wind Load

In almost any framework, load by the speed of wind and the density of it is known as wind load. In order to fight the result of breeze load, constructions are intended accordance IS: 875 (part 3) - 1987. Wind load is depend upon the velocity of wind and also design of any structure.

3.2.4 Seismic Forces

Seismic forces are one of the primary parts of force each time a system is examined as well as created. As seismic outcome leads to shacking of the ground, therefore the framework on the ground should be stable from its base.

3.2.5 Load Combination

Different load mixture of elevated water tanks is offered to protect the crucial condition during design and analysis. Is 1893 (part one): 2016 is utilized for load combinations, this particular code deals with effects of loads. In addition, it likewise consists of load combination guidelines. The next load combinations with a suitable factor of safety might be pushed based on Indian standard format.

- 1.2 (DL + IL + EL)
- 1.2 (DL + IL- EL)
- 1.5 (DL + EL)
- 1.5 (DL - EL)

- 0.9 DL + 1.5 EL
- 0.9 DL - 1.5 EL

Where,
DL = Dead Load
LL=Live Load
EL= Earthquake Load

3.3 Part of Intze Tank

A container is utilized to storage of water for a lot of uses (drinking clean water, sprinkler system farming, fire suppression etc.). Based on different code provisions we have been performed different element designs

3.4 Materials used for Elevated Water Tanks

In order to make a leak-proof container, well graded mix having low porosity and high tensile strength is suitable. As per IS: 3370, the minimum grade of concrete required for construction of water tank is M20 for plain concrete, M30 for reinforced cement concrete and M40 for prestressed cement concrete and as per IS: 1786-2008 Fe 415 have been used as reinforcement for water tanks.

3.5 Seismic Analysis Method

In India, almost all RCC structure components in various zones are seismically examined for a regular earthquake. It provides the estimation of reaction produced by the framework due to earthquake. System subjected to earthquake is examined by various approaches to seismic evaluation.

I. Response Spectrum Analysis.
II. Time History Analysis.

3.5.1 Factor Influencing Response Spectrum

- Energy releases mechanism.
- Soil condition of zone and type of soil.
- Damping in the structure system.
- Time period of the system.

3.6 Computation of Dynamic Quantity

The code IS: 1893 (Part 2) is used for evaluation of the heightened water tanks.

3.6.1 Horizontal Seismic Coefficient

The seismic coefficient Ah will probably be estimated by utilizing formula

$$A_h = \frac{Z}{2} \times \frac{S_a}{g} \times \frac{I}{R}$$

Where,

Z = Zone factor as per Table 2 of IS 1893 (Part 1)-2002

I = Importance factor as per Table 1 of IS 1893 (Part 2)-2002,

R = Response reduction factor as per Table 2 of IS 1893 (Part 2)-2002,

Sa/g = Average response acceleration coefficient as given by Fig.2 and table 3 of IS 1893 (Part 1)-2002 and subjected to clause 4.5.1 to 4.5.4 of standard.

3.6.2 Base Shear

The base shear for elevated tank on impulsive mode, just about the base of staging is given by Vi = (Ah)i (mi + ms)g

Where,

(Ah)i = horizontal seismic coefficient for impulsive mode,

mi = impulsive mass of liquid on container,

ms = mass of container one–third mass of staging,

g = acceleration due to gravity.

And in convective mode the base shear is given by

$$V_c = (A_h)_c\, m_c\, g$$

(Ah)c = horizontal seismic coefficient for convective mode,

mc = convective mass of liquid on container.

So the base shear will be obtained by combining the impulsive and convective mode base shear and is given as

$$V = \sqrt{V_i^2 + V_c^2}$$

Where

V = total base shear by elevated tank,

Vi = base shear in impulsive mode,

Vc = base shear in convective mode.

3.6.3 Base Moment

As per IS 1893 (part 2) -2002 clause 4.7,

Overturning moment at the base of staging for impulsive mode

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

And on convective mode is given by

$$M_c = (A_h)_c\, m_c\, (h_c + h_s)\, g$$

Where,

hs = structural height of staging, measured from top of footing of staging to the bottom of tank wall

hcg= height of center of gravity of empty container, measured from base of staging

Total base moment shell be obtained by square of sum of squares in both impulsive and convective modes given as follow

$$M = \sqrt{M_i^2 + M_c^2}$$

Where,

M = total overturning moment or base moment,

Mi = base moment in impulsive mode of tank at base,

Mc = base moment in convective mode of tank at base.

3.6.4 Time Period

As per IS 1893 (part 2) -2002, clause 4.3,

The period of impulsive mode of an elevated tank

$T_i = 2\pi \sqrt{} (m_i + m_s / K_s)$

Where,

mi = impulsive mass of liquid on container

ms = mass of container one–third mass of staging

Ks = lateral stiffness of staging

The period of convective mode

$T_c = 2\pi \sqrt{} (m_c / K_c)$

mc = convective mass of liquid on container

Kc = stiffness of convective mode

3.6.5 Hydrodynamic Pressure

The pressure exerted by the liquid in the tank as per IS 1893 (part 2)-2002 clause 4.9,

$$P = Q(y)\ (A_h)_i\ \rho\ g\ h \cos \phi$$

$$Q(y)= 0.866\ [\ 1 – (y/h)2\ ]\ \tanh [0.866\ (D / h)]$$

Where

P =hydrodynamic pressure on tank wall,

Q = of pressure on tank wall,

ρ = mass density of liquid,

ϕ = circumferential angle,

h = maximum depth of liquid,

y = vertical distance of a point on tank wall from bottom of tank wall.

3.6.6 Pressure due to Wall Inertia

As per IS 1893 (part 2)-2002 clause 4.9.5, Pressure on the tank wall due to its inertia is given by

$$P_{ww} = (A_h)_i\ t\ \rho_m\ g$$

Where,

ρ_m = mass density of tank wall,

t = thickness of wall.

Table 3.1 Intze tank version detail

Sr. No.	Name of parameter	Value of parameter
1.	Seismic zones	II, III, IV
2.	Seismic zone factor	1. II = 0.10 2. III = 0.16 3. IV = 0.24
3.	Types of bracing pattern	1. Simple bracing. 2. Cross bracing. 3. Radial bracing. 4. Rectangular bracing.
4.	Condition	1. Tank Full 2. Tank Empty
5.	Height of staging	15m, 20m, 25m
6.	Number of column	8
7.	Soil type	Medium soil
8.	Types of support	Fixed support
9.	Response reduction factor	2.5
10.	Importance factor (I)	1.5
11.	Damping ratio	5 %
12.	Capacity of tank (V) in kL	1000
13.	Diameter of cylindrical wall	15.57 m
14.	Rise of top dome	3.081 m
15.	Thickness of top dome	0.08 m
16.	Top ring beam	0.2 x 0.2 m2
17.	Thickness of cylindrical wall	0.17 m
18.	Height of cylindrical wall	4.622 m
19.	Middle ring beam length	1 m
20.	Middle ring beam height	0.25 m
21.	Height of conical wall	2.309 m
22.	Thickness of conical wall	0.38 m
23.	Diameter of bottom dome	11.40 m
24.	Rise of bottom dome	2.156
25.	Thickness of bottom dome	0.38 m
26.	Bottom ring beam	1.25 x 0.62 m2
27.	Brace size	0.6 x 0.4 m2
28.	Number of braces on tank	4
29.	Number of column on tank	8
30.	Angle of inclination of conical dome	45 0
31.	Semi central angle of bottom dome	44 0

3.7. Bracing Pattern on Intze Tank

Water tank without brace cannot avoid bent, rotations and twisting around its vertical axis. Therefore, the framework requires braces for supporting them in all of the circumstance. As stated by IS: 11682 – 1985, when the level of staging is more than 6m previously cosmetic foundation, the column shall require of horizontal bracing. Within this study we're planning to make use of 4 kinds of brace with staging process. Figures indicates 2 dimensional and 3 dimensional models of braces in STAAD.ProV8i. as uses.

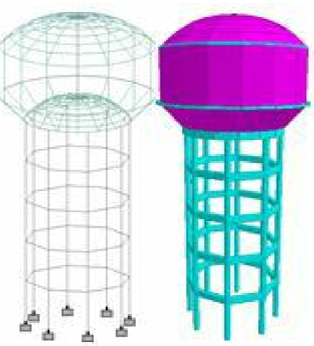

Fig. 3.1 2D and 3D simple type brace staging model

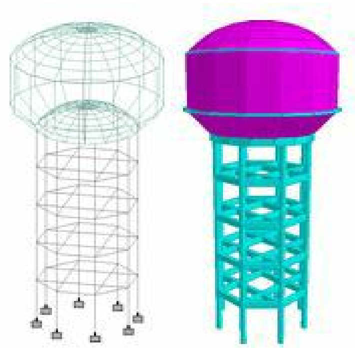

Fig 3.2 2D and 3D cross type brace staging model

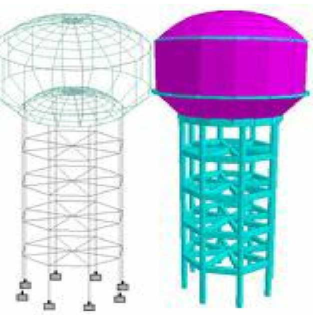

Fig 3.3 -2D and 3D radial type brace staging model

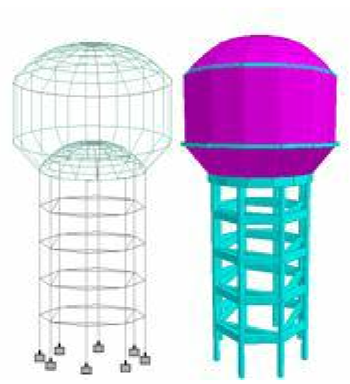

Fig 3.4 2D and 3D rectangular type brace staging model

4. RESULT AND DISCUSSION

4.1 General

The evaluation contains variables for simple, rectangular, radial and cross style braces connected with three distinct staging heights i.e. 15 m, 20 m as well as 25 m within seismic zones II, III and IV. Various tables & charts are indicating the different details as displacement, shear force, axial force, torsion, bending moment.

4.2 Results and Discussion

4.2.1 Displacement

Displacement within elevated water tanks indicates the movement of tank from its original position to the next position within the horizontal path. The specified final results present the maximum displacement values get as a result of the evaluation on the water tank which may occur at condition that is extreme. Outcomes are examined about the bases of most tank problems i.e. empty as well as loaded, with various kinds of braces in staging for several heights that evaluation for seismic zones II, III and IV.

Table 4.1 Displacement values during the empty state of tank in seismic zones II, III and IV

Braces on tank	Height of staging (m)	Maximum Displacement (mm)		
		Zone II	Zone III	Zone IV
Simple brace	15m	14.807	23.391	34.922
	20m	26.287	41.787	62.530
	25m	41.483	66.116	99.031
Rectangular brace	15m	13.891	21.879	32.625
	20m	24.744	39.750	58.550
	25m	38.595	61.449	92.007
Cross brace	15m	14.029	22.094	32.944
	20m	24.595	39.022	58.354
	25m	38.411	61.146	91.546
Radial brace	15m	14.062	22.145	33.018
	20m	24.592	39.015	58.341
	25m	38.327	61.007	91.336

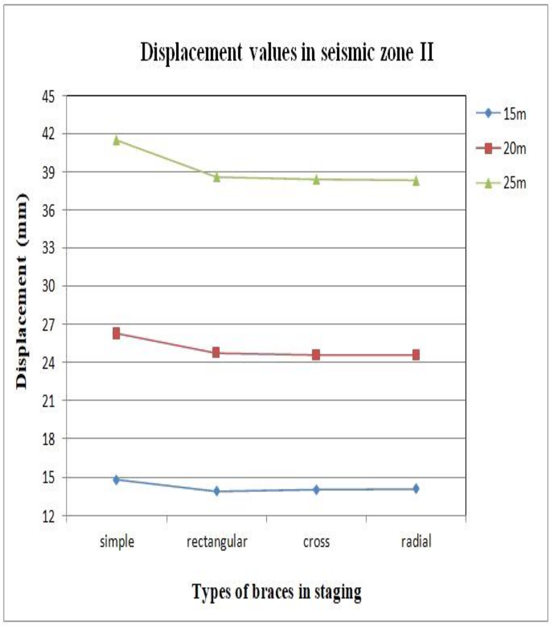

Fig. 4.1 Displacement graph for various kinds of braces in staging during the empty situation of tank in seismic zone II

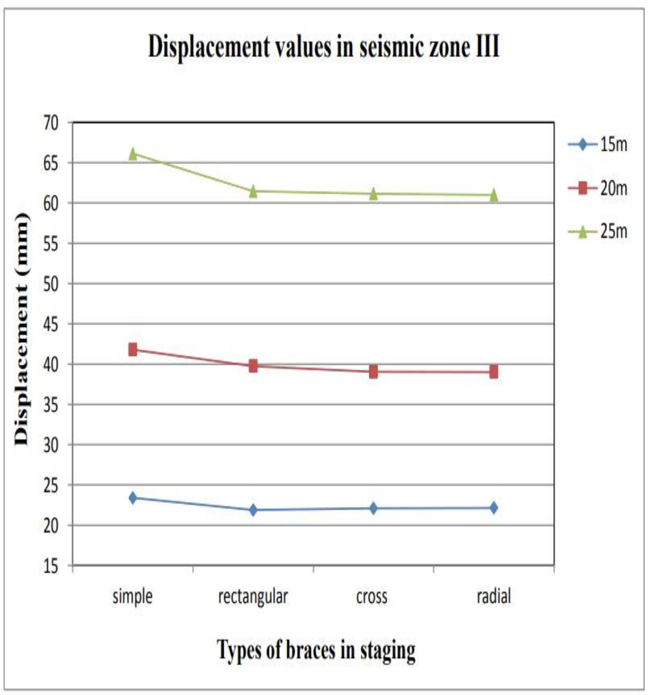

Fig. 4.2 Displacement graph for various kinds of braces in staging during the empty state of tank in seismic zone III

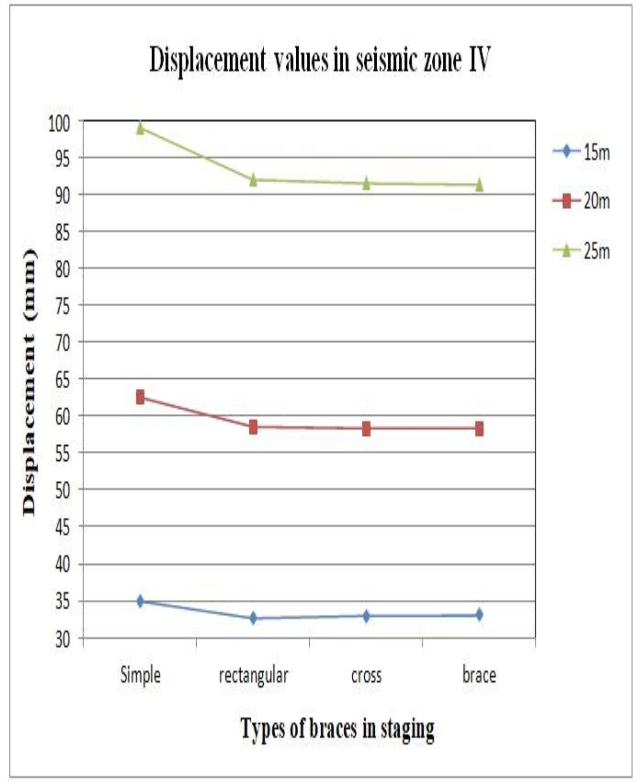

Fig. 4.3 Displacement graph for various kind of braces in staging during the empty situation of tank in seismic zone IV

Table 4.1 shows the horizontal displacement by tank staging on the time of empty state of tank. Fig. 4.1, 4.2 and 4.3 are plotted for displacement (mm) versus types of braces in staging for 15m, 20m, and 25m staging height in seismic zone II, III and IV respectively. Within seismic zones II, III and IV, the maximum horizontal displacement for 15 m staging height is shown by simple type brace staging and decreases for radial type brace staging and cross type brace staging and the minimum displacement is shown by rectangular type brace staging. For 20 m as well as 25 m staging heights, the optimum displacement is shown by simple type brace staging and it decreases for rectangular type brace staging as well as for cross type brace and minimum value of displacement is shown by radial brace staging within just about all seismic zones.

Table 4.2 Displacement values in the loaded condition of tank in seismic zones II, III and IV

Braces on tank	Height of staging (m)	Maximum Displacement (mm)		
		Zon e II	Zon e III	Zo ne IV
Simple brace	15m	20.1 38	29.4 72	42. 511

	20m	33.404	50.726	74.674
	25m	50.860	78.865	116.971
Rectangular brace	15m	19.059	27.520	39.423
	20m	31.237	47.002	68.919
	25m	47.208	72.739	107.628
Cross brace	15m	19.164	27.679	39.658
	20m	31.219	46.947	68.821
	25m	46.889	72.187	106.774
Radial brace	15m	19.186	27.708	39.669
	20m	31.192	46.893	68.733
	25m	46.758	71.960	106.423

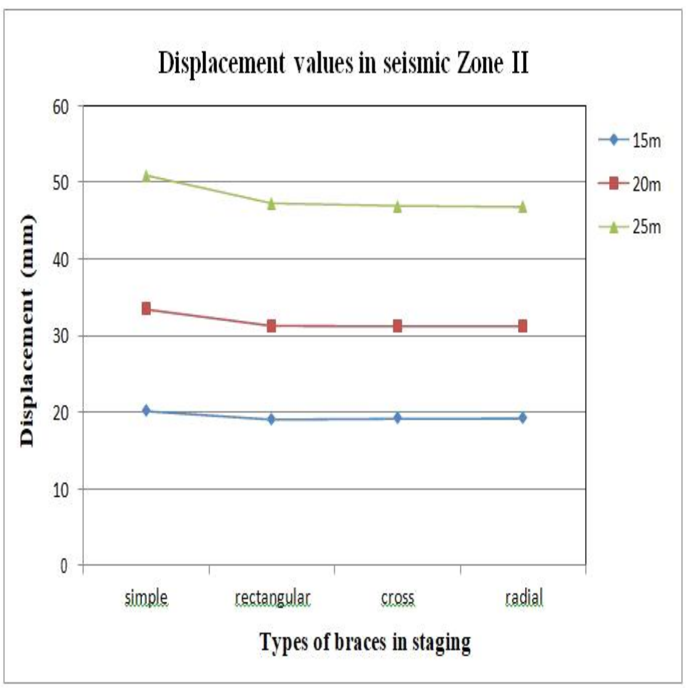

Fig. 4.4 Displacement graph for various kind of braces in staging in the loaded condition of tank in seismic zone II

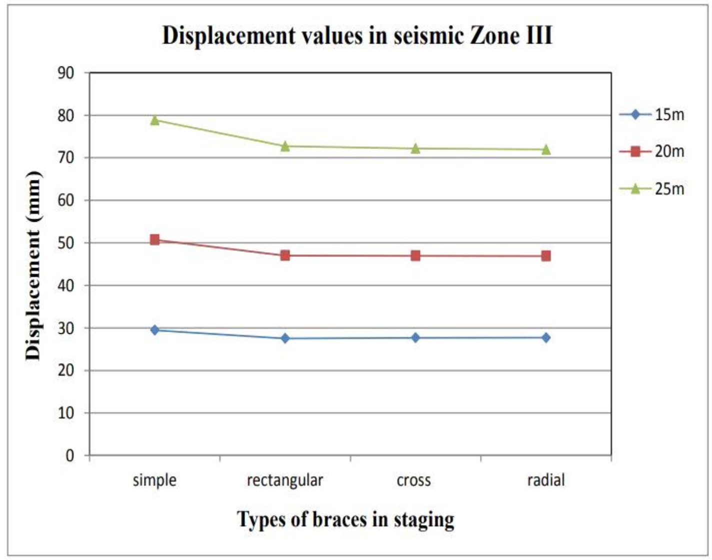

Fig. 4.5 Displacement graph for various kind of braces in staging in the loaded condition of tank in seismic zone III

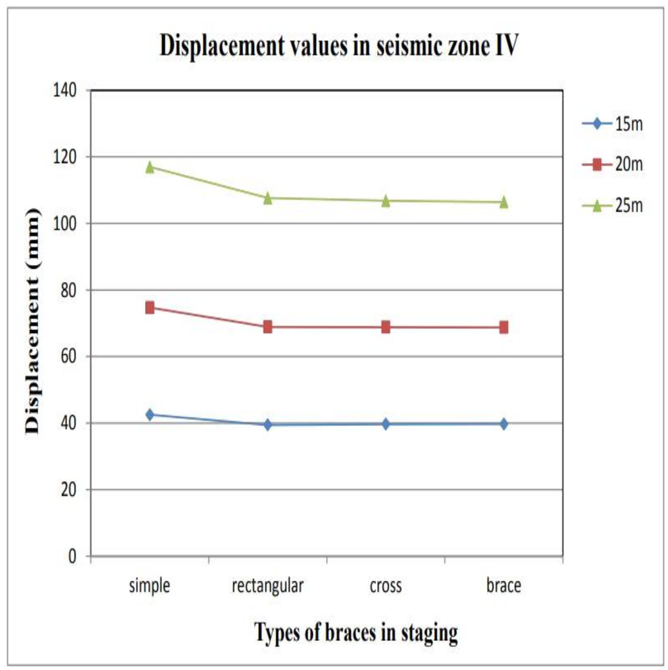

Fig. 4.6 Displacement graph for various kind of braces in staging in the loaded condition of tank in seismic zone IV

Table 4.2 shows the horizontal displacement by tank staging in the filled condition of tank. Fig. 4.4, 4.5 as well as 4.6 are plotted for displacement (mm) versus types of braces in staging for 15m, 20m, and 25m staging height in seismic zone II, III and IV respectively. The maximum horizontal displacement for 15 m staging level is shown by the simple type brace staging and decreases for radial type brace staging and cross type brace staging and the minimum displacement is shown by rectangular type brace staging. For 20 m as well as 25 m staging heights, the maximum displacement is shown by simple type brace staging and decreases for rectangular type brace staging and cross type brace and the minimum value of displacement is shown by radial type brace staging within seismic zones II, III and IV.

4.2.2 Axial Forces

The final results show the optimum importance of axial force for various kinds of braces in staging for seismic zones II, III and IV.

Table 4.3 Axial force during the empty state of tank in seismic zones II, III and IV

Braces on tank	Height of staging (m)	Axial force (kN)		
		Zone II	Zone III	Zone IV
Simple brace	15m	1288.766	1459.889	1688.054
	20m	1371.095	1567.632	1829.683
	25m	1447.735	1666.273	1957.660
Rectangular brace	15m	1468.825	1666.121	1929.184
	20m	1552.026	1777.033	2077.043
	25m	1627.990	1875.980	2206.634
Cross brace	15m	1441.496	1628.638	1878.160
	20m	1526.158	1740.113	2025.387
	25m	1603.845	1840.429	2155.875
Radial brace	15m	1453.965	1642.357	1893.546
	20m	1538.427	1753.514	2040.296
	25m	1615.739	1853.229	2169.884

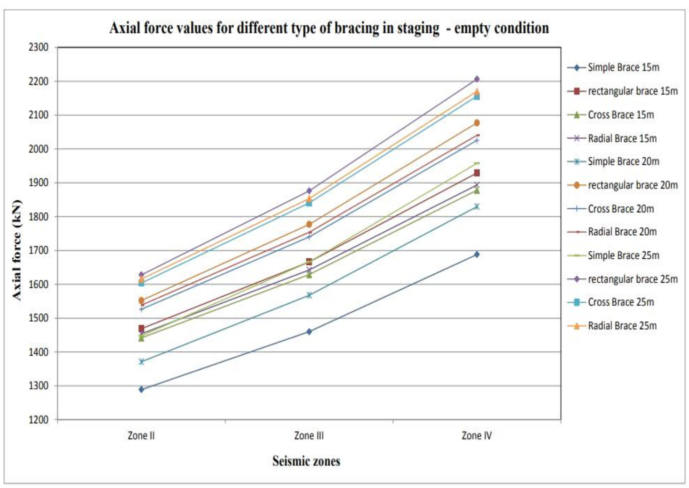

Fig.4.7. Axial force graph for various brace staging during the empty state of tank in seismic zones II,III and IV

Table 4.3 shows the axial force for various forms of brace staging for empty tank in seismic zones II, III and IV. Fig.4.7 are plotted for axial forces for simple, cross, radial and rectangular type support staging when connected with 15 m, 20 m as well as 25 m staging rise. The least axial force shown by simple type support staging in seismic zones II, III and IV and the maximum axial force values is shown by rectangular type brace staging for those zones.

Table 4.4 Axial pressure worth in the loaded condition of tank in seismic zones II, III and IV

Braces on tank	Height of staging (m)	Axial force (kN)		
		ZoneII	Zone III	ZoneIV
Simple brace	15m	3634.100	3837.130	4107.946
	20m	3722.055	3953.875	4262.969
	25m	3802.945	4059.312	4401.138
Rectangular brace	15m	3817.124	4048.079	4356.146
	20m	3906.069	4168.190	4517.687
	25m	3986.099	4273.633	4657.024
Cross brace	15m	3785.602	4003.912	4294.994
	20m	3875.775	4124.207	4455.450
	25m	3957.477	4230.943	4595.569
Radial brace	15m	3797.970	4017.471	4310.140
	20m	3887.867	4137.324	4469.934
	25m	3969.108	4243.323	4608.946

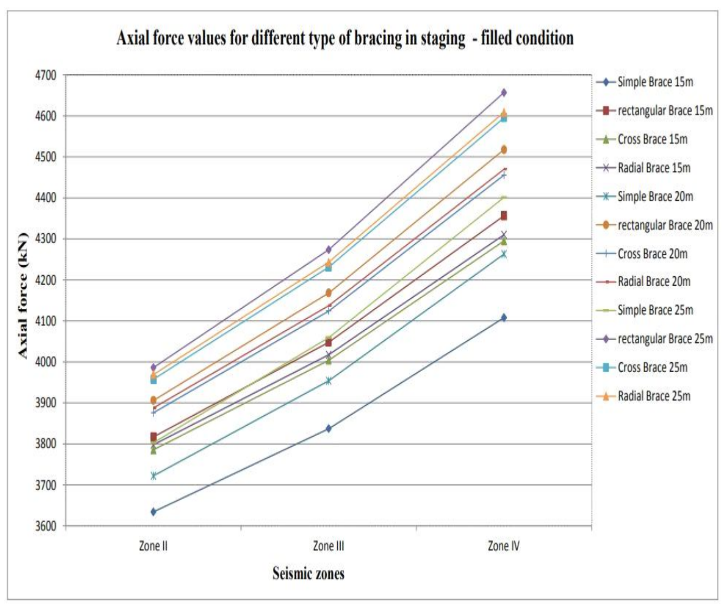

Fig. 4.8 Axial force graph for various support staging in the filled condition of tank in seismic zones II, III and IV

Table 4.4 shows the axial force for various forms of brace staging with the loaded tank in seismic zones II, III as well as IV. Fig.4.8 plotted for axial force during loaded condition of tank for simple, cross, radial and rectangular type brace staging when connected with 15 m, 20 m as well as 25 m staging rise. The least axial force shown by the simple type brace staging in seismic zones II, III and IV and the maximum axial force values are shown by rectangular type brace staging within seismic zones.

5. CONCLUSION

From the software analysis data for elevated water tank with different bracing types at different staging heights following conclusions are drawn:

1. As the level of staging increases, the variables viz. displacement, shear force, axial force, torsion as well as bending moment are increases for empty as well as loaded condition of the tank.
2. From table no. 4.1 and 4.2, maximum displacement is displayed by simple type brace staging and the least displacement is shown by radial type brace staging for staging heights 15m, 20m and 25m within seismic zones II, III and IV as shown in fig. 4.1,4.2 and 4.3 for empty tank and fig. 4.4,4.5 and 4.6 for loaded tank.
3. From table no. 4.3 and 4.4, axial force has least values at simple type brace staging and maximum for rectangular type brace staging for both empty and loaded tank in seismic zones II, III and IV as shown in fig. 4.7 and 4.8.
4. Tank with empty condition has less values for variables displacement, shear force, axial force, torsion as well as bending moment as compared to tank with loaded condition.
5. From the analysis of all structural models, rectangular type brace staging shows maximum value for torsion, shear force as well as bending moment and that is not risk-free within seismic zones II, III and IV.
6. Seismic analysis with radial type brace staging provide good balance as compared to other brace staging. Consequently, it is able to reduce the risks of collapse on the water container within seismic zones II, III and IV.

REFERENCES

7. A. H. Shrigondekar, G. D.Parulekar, V. R. Kasar **Behaviour of RC Overhead Water Tank Under Different Staging Patterns** International Journal of Engineering Researchand Technology, Vol. 6 Issue 04, PP538-541, April-2017.
8. Sonali M. Pole, Amey R. Khedikar **Seismic Investigation of RC Elevated Water Tank for Different Types of Staging Systems** International Journal of Innovative Research in Science, Engineering and Technology Vol. 6, Issue 7, PP 13793-13806, July 2017.
9. Keyur Y. Prajapati, Dr. H. S. Patel, Prof. A. R. Darji **Analysis of Hybrid Staging Systems for Elevated Storage Reservoir** Indian Journal of Research Volume: 3, Issue: 6, PP 71-76, June 2014.
10. Mr. Santosh Rathod, Prof. M. B. Ishwaragol **Analysis of Overhead Water Tank with Different Staging Height and Base Width** International Research journal of Engineering and Technology Volumn:05 Issue:06, PP 471-474, June-2018.
11. Kaviti Harsha, K. S. K Karthik Reddy & Kondepudi Sai Kala **Seismic Analysis and Design of INTZE Type Water Tank** International Journal of Science Technology & Engineering Vol. 2, Issue 03, PP 11-24, September 2015.
12. Sneha Adhikari, Imtiyaz A. Parvez, Kiran Kamath **Study of Tank with Inclined Braced Staging** International Journal of Innovative Research in Science, Engineering and Technology Vol. 5, Issue 9, PP 66-72, May 2016.
13. P. S. Nemade, Prof. D. G. Agarwal, Dr. A. M. Pande **Parametric Studies in Design of Staging Configuration for Elevated Service Reserviour for Seismic Consideration** International Journal of Science Technology & Engineering Vol. 2, Issue 10, PP 756-763, April 2016.
14. Manish N. Gandhi, Ancy Rajan **Earthquake Resistant Analysis of Circular Elevated Water Tank with Different Bracing in Staging** International Journal of Innovative Science, Engineering & Technology, Vol. 3, Issue 11, PP 255-259, November 2016.
15. Prashant A. Bansode, V. P. Datye, **Seismic Analysis of Elevated Water Tank with different Staging Configuration** Journal of Geotechnical Studies, vol.3, Issue 1, PP 1-5, October 2018.
16. Ayazhussain M. Jabar, H. S. Patel **Seismic Behavior of RC Elevated Water Tank Under Different Staging Pattern and Earthquake Characteristics** International Journal of Advanced Engineering Research and Studies , IJAERS/ Vol. I/ Issue III/PP 293-296, April-June,2012.
17. Lakade, G.D., Pise, C.P., Kadam, S.S., Pawar, Y.P., Mohite, D. and Deshmukh, C.M., 2015**.** **Performance of RC Building under Dynamic Forces and Suitability of Strengthening by FRP Jacketing.** International Journal of Civil Engineering and Technology, 6(9), p.2015.
18. Pise, C.P., Kadam, S.S., Pawar, Y.P., Mohite, D.D., Deshmukh, C.M. and Lakade, G.D., 2015. **Performance-Based Seismic Design of Structures**. International Journal of Scientific Research, 4, pp.475-478.
19. IS 1893-1 (2002): **Criteria for Earthquake Resistant Design of Structures**, Part 1: General Provisions and Buildings

20. Draft IS:1893 (Part 2, Liquid Retaining Tanks) **Criteria for Earthquake Resistant Design of Structures**, Bureau of Indian standards, New Delhi, India
21. IS: 11682 (1985): **Criteria for design of RCC staging for overhead water tank**, Bureau of Indian Standards