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Assessing the Torsional Response of Elevated Water Tank with Amended Bracings

Sujina Sahib S
M tech Student [Structural Engineering]
Dept of Civil Engineering
Younus College of Engineering and Technology
Kollam, India

***Abstract*—Elevated tanks are important structures in storing vital products such as petroleum as well as water. Elevated storage tanks are commonly used to secure constant water supply from longer distance under the effect of gravitational force. They are constructed in such a way that it's greater portion of their weight is concentrated at an elevation. Torsional failure of elevated water tanks in past earthquakes has highlighted the importance of this problem.**

Modelling and analysis of elevated water tank should be done using ETAB Software. Seismic Response Spectrum, Equivalent Static Analysis and modal analysis were conducted. Different staging configurations consist of Staging with different altered longitudinal bracings are provided. Through this study an effective approach to reduce torsional effect must be formulated. Tank responses including Local Torsion, Global Torsion will also be calculated.

***Keywords*— Elevated tanks, bracings, Local Torsion, Global Torsion , ETAB Software**

I. INTRODUCTION

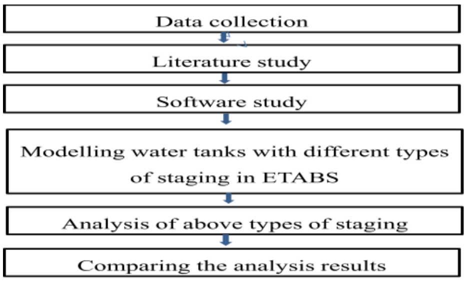
Water tanks are one of the most important lifeline structures. In most of the cities and rural areas, water tanks forms an integral part of water supply scheme. Types are underground water tanks, ground supporting water tanks and elevated storage water tanks. Elevated water tanks are mostly used .The elevated water tanks are also known as over head supply reservoir (OHSR) , elevated supply reservoir (ESR) etc. To secure constant water supply from longer distance under the effect of gravitational force, the elevated water tanks are necessary.

They have low ductility and energy absorbing capacity as compared to the conventional buildings. They get heavily damaged during earthquake due to the fluid-structure interactions. Presence of heavy roof top masses like water tanks increases the seismic forces in the members of a building. They constructed in such a way that a greater portion of their weight is concentrated at an elevation. So seismic safety of liquid storage tanks is of considerable importance. Damage to these structures during strong ground motions may lead to fire or other hazardous events. Reinforced concrete water tanks can be made economical, monolithic and watertight by their design and construction. Different types of bracings configurations can be provided to the staging for adequate resistance of seismic forces.

II. OBJECTIVE

To find out the torsional behavior of the elevated water tank by altering the longitudinal geometry of the braces.

III. METHODOLOGY



IV. MODELLING

TABLE I. DESIGN DATA OF WATERTANK (Patel et al, 2017)

SL.NO	COMPONENT	VALUES
1	Top slab	150 mm
2	Bottom slab	200 mm
3	230mmx230mm	150 mm
4	Height of staging	15 m
5	Height of container	5 m
6	Dimension of tank	6 x 6 m
7	Zone factor	0.36 (V)
8	Importance factor	1.5 for water tank
9	Reduction Factor	5 (SMRF)
10	Type of soil	Medium soil
11	Bracing type	X bracing
12	Beam	230mm x 300mm
13	Column	300mm x 300mm
14	Bracing	230mm x 230mm

TABLE II. WIND LOADS (IS 875 PART 3)

Type	Value	Source
Basic wind speed (Vb)	50 m/s	Clause 5.2
Probability factor or risk coefficient (k1)	1.06	Clause 5.2.1
Terrain, height and structure size factor (k2)	1.07	Clause 5.2.2
Topography factor (k3)	1.0	Clause 5.2.3
Structure class	B	Clause 5.3.2.2

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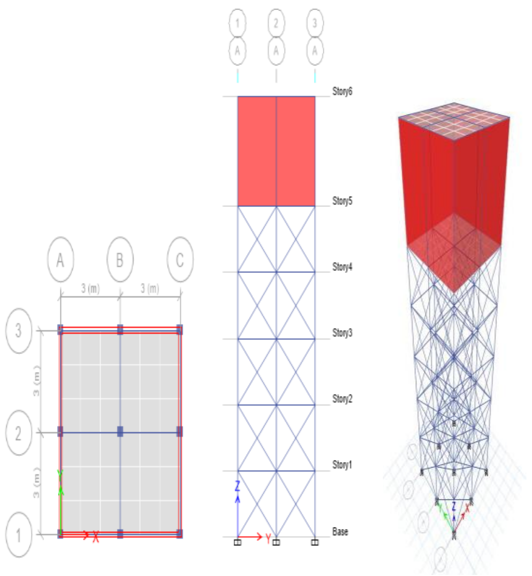
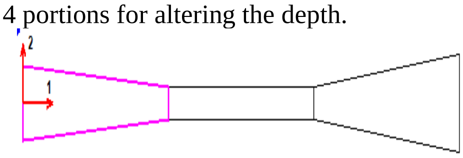


Fig.1. Plan, Elevation and 3d view of water tank

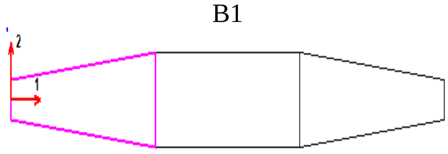
A. Modification of Bracing Geometry

In the present study modelling of 8 different types of altered longitudinal geometry of the braces. Only depth of the bracings are varying .Width remains the same. Length of bracings provided is 4.24m . Dimensions of large cross section provided is 230x230mm . Dimensions of small cross section provided is 230x76.67mm (That is 1/3 rd of the depth).

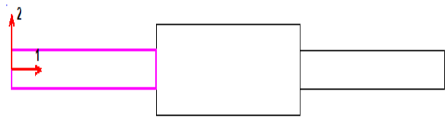
In the present study one normal bracing with 230x230 mm uniform cross section and 8 altered longitudinal geometrical bracings are modelled and analysed. From the 8 models ,All the models are symmetrical bracings .From this, 4 models (B1 to B4) are designed in such a way that it is divided equally into three portions for altering the depth and in case of B5to B8 bracings they divided in to 3 portions and the middle portion again divides equally,so total of 4 portions for altering the depth.



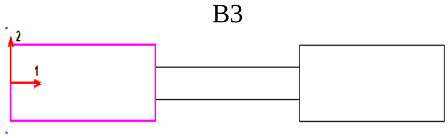
B1



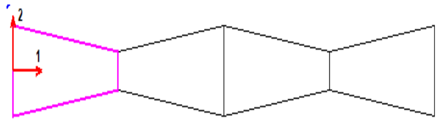
B2



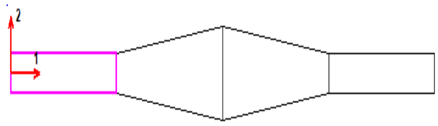
B3



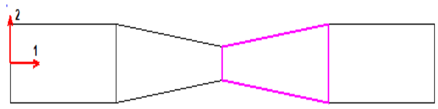
B4



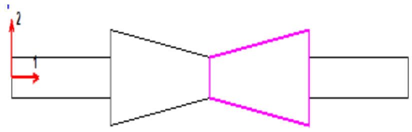
B5



B6



B7



B8

Fig. 2. Altered longitudinal geometry of the braces

V. ANALYSIS

A. Equivalent Static Analysis

The equivalent static lateral force method is a simplified technique to substitute the effect of dynamic loading of an expected earthquake by a static force distributed laterally on a structure for design purposes.

As per IS 1893:2002, Torsion should be considered when ratio of maximum story drift to average storey drift of the structure is more than 1.2

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TABLE III. DRIFT RATIO

Model Id	Max drift/Avg Drift
NB	1.332
B1	1.314
B2	1.324
B3	1.308
B4	1.319
B5	1.319
B6	1.308
B7	1.327
B8	1.308

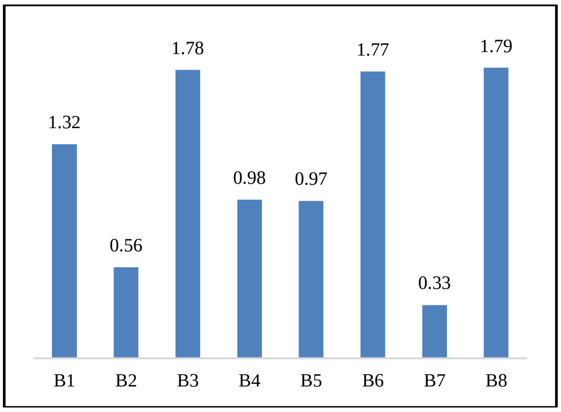

Fig.3.Percentage Reduction In Torsion w.r.t Normal Bracing

For all models the maximum story drift to average story drift is greater than 1.2. Model with normal bracing have maximum torsion. Model B3, B6 and B8 have the maximum reduction in torsion.

B. Modal Analysis

Modal analysis is used to determine the number of modes and corresponding mode shapes. Loads are applied as acceleration in X and Y direction. 12 number of modes are taken for analysis (At mode 12, mass participation ratio is approximately 100%). The effective mass participation factor represents the percentage of the system mass that participates in a particular mode. It provides a measure of the energy contained within each resonant mode.

Type : Eigen Vector Modal Analysis

No. of modes = 17 at 99% mass participation

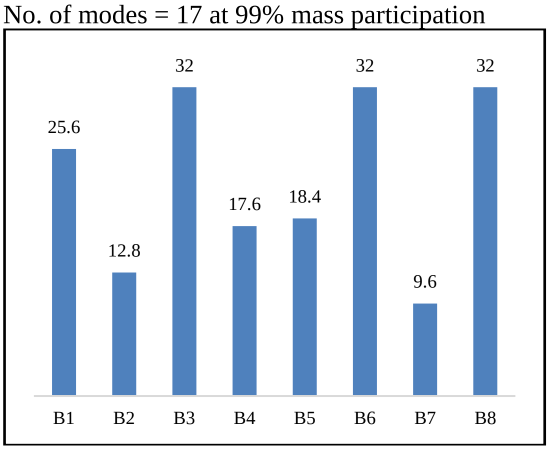

Fig 4. Percentage Reduction in torsion w.r.t Normal Bracing

The time period at torsional mode get reduced maximum for bracing B3, B6 and B8. Model with normal bracing have maximum torsion. The torsion is less for bracings with least cross sectional area near the supports. The torsion is highest for bracing with largest cross sectional area near the support.

C. Response Spectrum Analysis

Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essential elastic structure.

Seismic Zone Factor = 0.36

Soil Type = II

Damping Ratio = 50%

1. Global Torsion

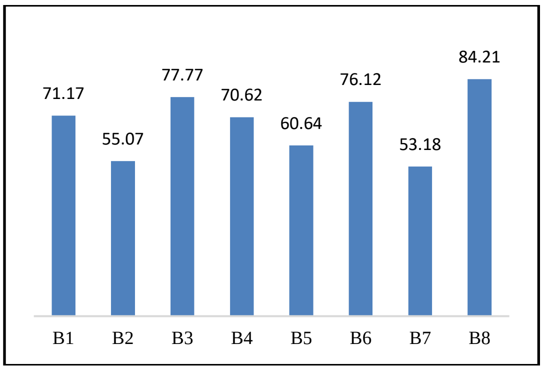

Fig.5.Percentage Reduction In Global Torsion w.r.t Normal Bracing

Global torsion refers to the torsion of the entire building.

The global torsion get reduced maximum for bracing B8. The torsion is less for bracings with least cross sectional area near the supports. The torsion is highest for bracing with largest cross sectional area near the support

2. Local Torsion

Local torsion refers to the torsion in each bracings.

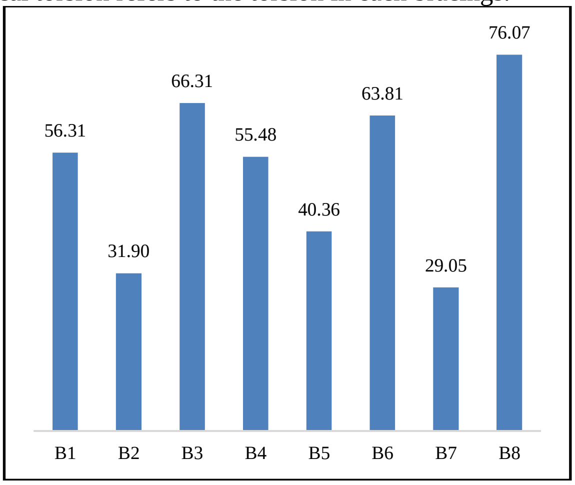

Fig.6.Percentage Reduction In Local Torsion w.r.t Normal Bracing

The local torsion get reduced maximum for bracing B8. Model with normal bracing have maximum torsion .The torsion is less for bracings with least cross sectional area near the supports. The torsion is highest for bracing with largest cross sectional area near the support.

3. Brace Reactions

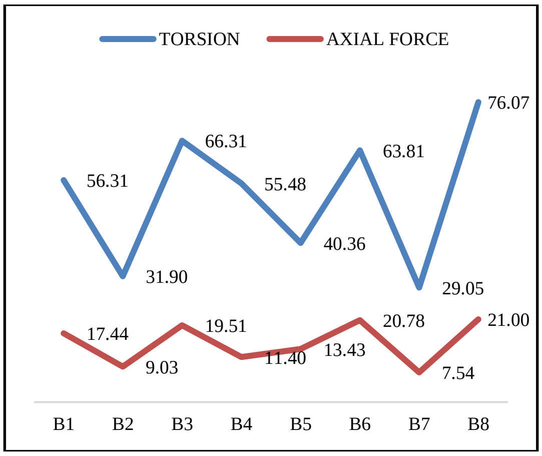

Fig.7.Percentage Decrease Of Axial force with respect To Normal Brace

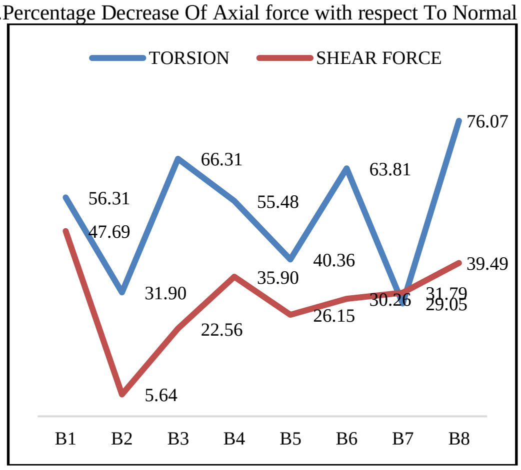

Fig.8.Percentage Decrease Of Shear force with respect To Normal Brace

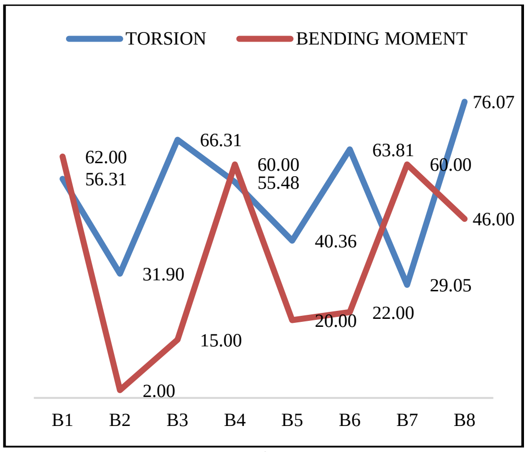

Fig.9.Percentage Decrease Of Bending moment with respect To Normal Brace

Brace Axial force and shear force are proportional to brace torsion. For braces with less cross sectional area near the supports, bending moment decreased by 15 to 46%.

VI. CONCLUSION

Staging with same cross-sectional area throughout the bracing have maximum torsion. The torsion is less for bracings with least cross-sectional area near the supports. Brace Axial force and shear force are proportional to brace torsion. For braces with less cross-sectional area near the supports, bending moment decreased by 15 to 46%. By reducing the cross-sectional area near the support, reinforcement and cost of the bracing can be reduced

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