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"INFLUENCE OF VERTICAL STEEL BRACING AT STAGING OF R.C.C. ELEVATED WATER TANK"

Brajesh kumar[1], Prof. Rashmi Sakalle[2], Prof. Ankita Choubey[3]

[1]PG student Department of civil Engineering, Truba Institute of Engineering and Information Technology, Bhopal (M.P)
[2]Assistant Professor in Department of civil Engineering, Truba Institute of Engineering and Information Technology, Bhopal (M.P)
[3]Assistant Professor in Department of civil Engineering, Truba Institute of Engineering and Information Technology, Bhopal (M.P)

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Abstract - In this study, use of steel vertical bracing at each staging level has been discussed. Steel bracings can improve the seismic behaviour of structure compared to conventional design of elevated water tank, also use of steel bracing can result in decrease in the quantity of reinforcement required for design of elevated water tank, which lead to decrease the cost of construction of structure.

In this study, influence of vertical steel bracing on nodal displacement, moment, forces and reinforcement quantity without effecting base shear of structure has been shown. Steel bracing has proven to make more stable design for elevated water tank in high seismic zone as steel section improves the ductility and flexibility of structure. Steel bracing can be provided in many different sections of steel as I section, W section, rolled tube section and channel section etc. In present study, use of double channel section back to back has been discussed for vertical bracing. In this study, first conventional design of elevated water tank without vertical bracing has been modelled and analysed for each seismic zone of India, followed by the modelling and analysis of same structural frame with vertical steel bracing at staging. Modelling, Designing, and Analysis of each design of elevated water tank has been done through STAAD-Pro. Post processing results obtained from STAAD-Pro has been compared to derive the conclusion and benefits of using steel bracing at staging.

1. INTRODUCTION

A water tank is a container for storage of water for applications like, drinking, irrigation agriculture, farming, both for plants and livelihood, chemical manufacturing, food preparation as well as many other uses. Water tank construction include the general design of the tank, and choice of construction materials, linings. Various materials are used for making a water tank: plastics, fiberglass, concrete, stone. Water tanks are most effective way to help developing countries to store clean water.

Reinforced Concrete Water tank is designed on the basis of IS 3370: 2009 (Parts I – IV). The design rely on the location of tanks, i.e. overhead, on ground or underground water tanks. The tanks can be constructed in different shapes, circular and rectangular shapes are mostly used. The tanks have been built with R.C.C. and Steel.

1.1 Circular Water Tank

The common form of water tank is circular tank. The circular tank requires less amount of material as compare to other types. Also because of the circular shape it has no corner and can hold water tight easily. It is very cheap for smaller storage of water up to 20000000 liters. And the side walls are designed in accordance for hoop tension and bendingmoments.

1.2 User Interface

Beams. Standard linear, curved and physical beams, compression/tension only, with databases of sections from around the world

- Plates. 3- or 4-noded 2D plates and surface objects with holes
- Solid. Solid 3D bricks from 4- to 8-noded
- Supports. Foundation and multi-linear springs
- Loads. Full range of loads for static and dynamic analysis that can be defined explicitly or calculated using the wide range of load generators

1.3 Aim

As far as current approaches, R.C.C. overhead water tanks are braced with concrete bracing at staging to improve the seismic stability of structure and to improve the ductility & stiffness of frame of water tank. These concrete bracing may increase the base shear of structure but also increases the overall dead load and cost of construction by really highnumbers.

The aim of this study is to maintain & improve the seismic behaviour of structure without compromising the base shear force and to reduce the displacement of structure during seismic activities. To fulfil this aim steel bracings may result very effective at stagings of water tank as they reduce the reinforcement requirement for structural members which led to reduction in cost and also these steel bracing are highly effective in reducing the displacement and overturning moment of structure.

1.3 Objective

a) To study variation in base shear of water tank using different type of bracing and different location patterns.

b) To obtain the nodal displacement, reinforcement quantity, beam end forces and moments of differently braced water tanks for each seismic zone with the help of STAAD-Pro.

c) To make comparison of cost for reinforcement of conventional design with braced design of water tank.

2. Literature review

A. Sahebi and M R Maheri (1996), Study shows that the degree of effectiveness of different diagonal bracing arrangements to increase the in-plane shear strength of the concrete frame and to observe the relative behavior of tension and compression braces. The study indicates that considerable increase in the in-plane strength of the frame due to steel bracing

M. Barron and Mary Beth D. Hueste (2004), analysed under seismic loading, floor and roof systems in reinforced concrete (RC) buildings act as diaphragms to transfer lateral earthquake loads to the vertical lateral force-resisting system (LFRS). In current practice, horizontal diaphragms are typically assumed to be rigid, thus neglecting the effect of their in-plane movement relative to the vertical LFRS. The objective of this study is to evaluate the impact on inplane diaphragm deformation on the structural.

Viswanath K.G, et. al. (2010), study shows that the concept of using steel bracing is one of the advantageous concepts which can be used to strengthen or retrofit the existing structures. Steel bracings can be used as an alternative to the other strengthening or retro fitting techniques available as the total weight on the existing building will not change significantly.

Manish Kumar (2016), This study concludes reinforced cement concrete is getting extensively used for construction of different type of structures for the last one century. It is essential to maintain those structures in functional condition. Since deterioration in RCC Structures is a common and natural phenomenon it is required to have a detailed plan, methodology for structural repair and rehabilitation shall be in place for dealing such issues.

3. Methodology

For the current study, circular elevated R.C.C. water tank has been modelled for each seismic zone of India through STAAD-Pro. Structural features of model tanks has been shown in the table 3.1

Table -1: Sample Table format

S. No.	Parameter	Value
1	Capacity of tank	33.94 lack litre
2	Unit weight of concrete	25 Kn/m^3
3	Thickness of top dome	150 mm
4	Size of top ring beam	20 mm*25 mm
5	Rise of top dome	2.96 m
6	Diameter of tank	26 m
7	Height of cylindrical wall	6 m
8	Thickness of cylindrical wall	200 mm
9	Size of bottom ring beam	30 mm*25 mm
10	Rise of conical dome	3 m
11	Thickness of conical dome	250 mm
12	Rise of bottom dome	2.08 m
13	Thickness of bottom dome	300 mm
14	Size of circular ring beam	50 mm*75 mm
15	No of columns	10
16	Diameter of column	1.5 m
17	No of bracing[H] levels	3
18	Height of staging	12 m
19	Size of bracing[H] beams	40 mm*65 mm
20	Support type	Fixed
21	Importance factor	1.5
22	Type of soil	Hard
23	Response reduction factor	5
24	Zone factor for zone II	.1
25	Zone factor for zone III	.16
26	Zone factor for zone IV	.24
27	Zone factor for zone V	.36

3.1 Types and Pattern of Bracing

For better comparative study, four different types of bracing i.e. W, K, V and X have been used at staging of water tank vertically. Also these four bracing have been placed in two different location patterns, one has been on each horizontal concrete bracing beam.

Table 3.2: Dimensions, Mass and Sectional Properties ISMC Channel Section

S.No.	Property	Value
1	Mass	13.1 kg/m
2	Sectional area	16.7 cm^2
3	D	125 mm
4	B	65 mm
5	t	5.3 mm
6	T	8.1 mm
7	R_1	9.5 mm
8	R_2	5.0 mm
9	C_y	2.14 mm
10	I_x	321 cm^4
11	I_y	69.8 cm^4
12	r_x	4.39 cm
13	r_y	2.04 cm
14	Z_x	51.4 cm^3
15	Z_y	16.1 cm^3

3.2 Modelling Through STAAD-Pro

Elevated water tank of capacity has been modelled through STAAD-Pro. Approach for comparative modelling of water tank has been discussed below

Modelling and designing of conventional elevated water tank with M40 [Tank] and M35 [Staging] grade of concrete, reinforcement of 415 grade with structural elements and factors as per table 3.2 for each seismic zone.

Modelling and designing of elevated water tank with vertical W steel bracing continuously at staging with

M40 [Tank] and M35 [Staging] grade of concrete, reinforcement of 415 grade with structural elements and factors as per table 3.2 for each seismic zone.

Modelling and designing of elevated water tank with vertical K and inverted K steel bracing continuously at staging with M40 [Tank] and M35 [Staging] grade of concrete, reinforcement of 415 grade with structural elements and factors as per table 3.2 for III & VI seismic zone.

a. Modelling and designing of elevated water tank with vertical inverted V steel bracing continuously at staging with M40 [Tank] and M35 [Staging] grade of concrete, reinforcement of 415 grade with structural elements and factors as per table 3.2 for III & VI seismic zone.

b. Modelling and designing of elevated water tank with vertical X steel bracing continuously at staging with M40 [Tank] and M35 [Staging] grade of concrete, reinforcement of 415 grade with structural elements and factors as per table 3.2 for III & VI seismic zone.

c.

4.1. Results And Discussion

Nine designs of elevated water tank for each seismic zone have been modelled and analysed through STAAD-Pro, this chapter summaries the influence of steel bracings on seismic behaviour, beam forces, displacement and reinforcement quantity of elevated water tanks with the output received from STAAD-Pro in post processing model.

4.2. Nodal displacement :- Resultant nodal displacement of each design of elevated water tank i.e. conventional and eight braced designs, for seismic Zone II and Zone III have been obtained from post processing part of analysis of STAAD-Pro and variations of result for each design have been displayed in Table 4.1 and Figure 4.1

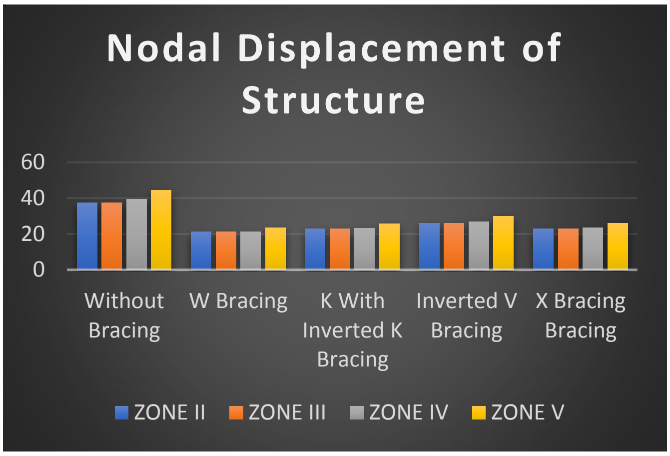

Fig. 5.1: Nodal Displacement of Structure (mm)

4.3. Nodal displacement zone wise compression:-

Resultant nodal displacement of each design of elevated water tank i.e. conventional and eight braced designs, for seismic Zone II and Zone III have been obtained from post processing part of analysis of STAAD-Pro and variations of result for each design have been displayed in Fig.: 4.2 and Figure 4.3

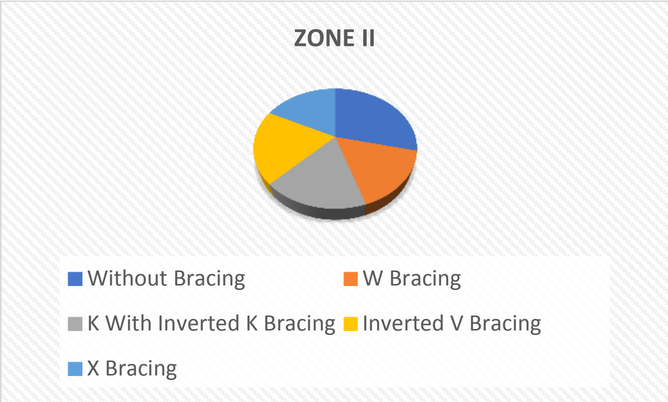

Fig.4.2: Nodal Displacement of Structure in Zone II(mm)

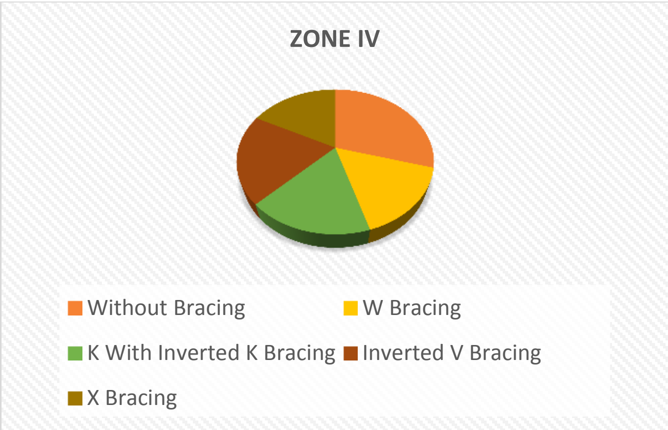

Fig. 4.3: Nodal Displacement of Structure in Zone IV(mm)

4.4. Moment at Supports of Elevated Tank:-

Resultant moment [M_x] at supports of each design of elevated water tank i.e. conventional and eight braced designs, for seismic Zone II, Zone III and Zone IV have been obtained from post processing part of analysis of STAAD-Pro and variations of result for each design have been displayed in Figure 4.7

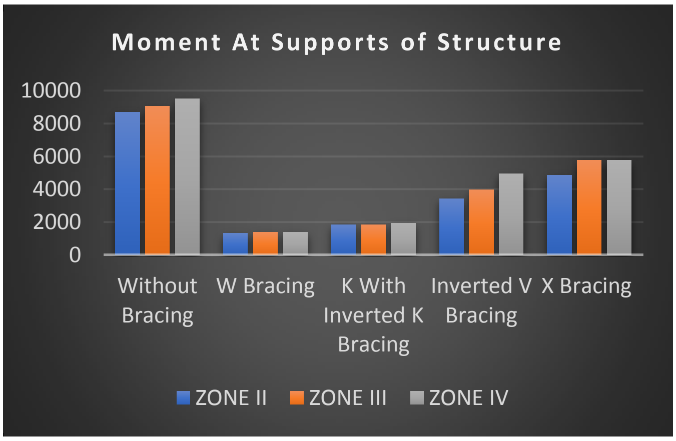

Fig. 4.5. Moment at Supports of Structure

4.5. Moment at Supports of Elevated Tank:-

Resultant moment [M_x] at supports of each design of elevated water tank i.e. conventional and eight braced designs, for seismic Zone II, Zone III and Zone IV have been obtained from post processing part of analysis of STAAD-Pro and variations of result for each design have been displayed in Figure 4.5

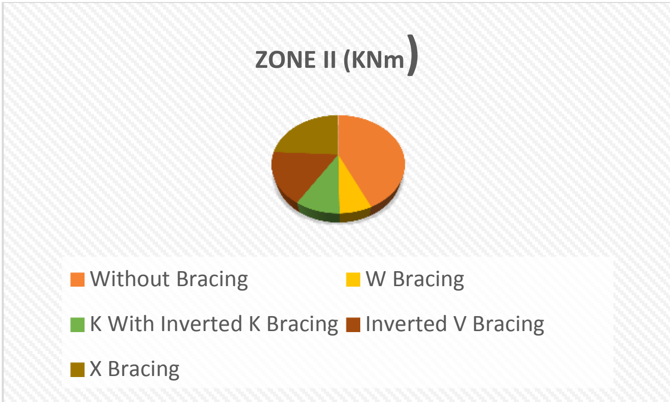

Fig.4.5: Moment at Supports of Structure

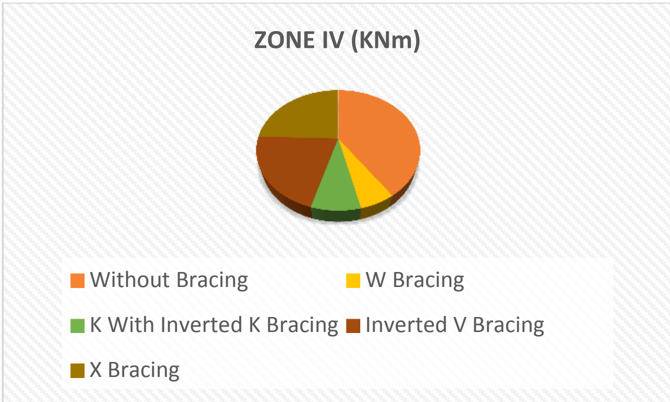

Fig.4.6: Moment at Supports of Structure

4.6. End Moment of Elevated Tank:-

Maximum beam end forces [M_z] of each design of elevated water tank i.e. conventional and eight braced designs, for seismic Zone II, Zone III and Zone IV have been obtained from post processing part of analysis of STAAD-Pro and variations of result for each design have been displayed in Table 5.4 and Figure 5.10

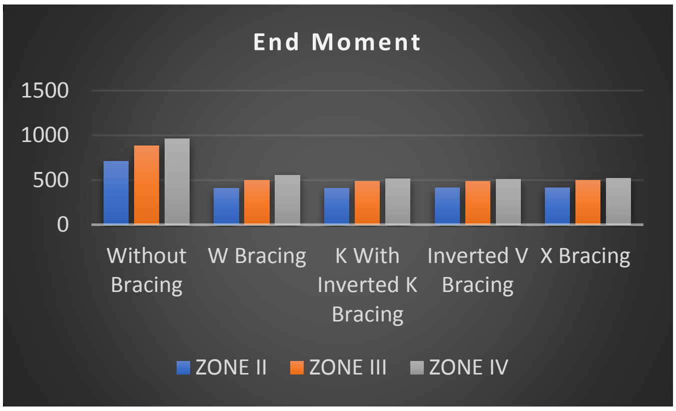

Fig. 4.7: Beam End Moment of Structure

4.7: End Moment of Elevated Tank Zone wise compression:-

Maximum beam end forces [M_z] of each design of elevated water tank i.e. conventional and eight braced designs, for seismic Zone II, Zone III and Zone IV have been obtained from post processing part of analysis of STAAD-Pro and variations of result for each design have been displayed in Fig. 4.8 and Figure 4.9

Fig. 4.8: Beam End Moment of Structure

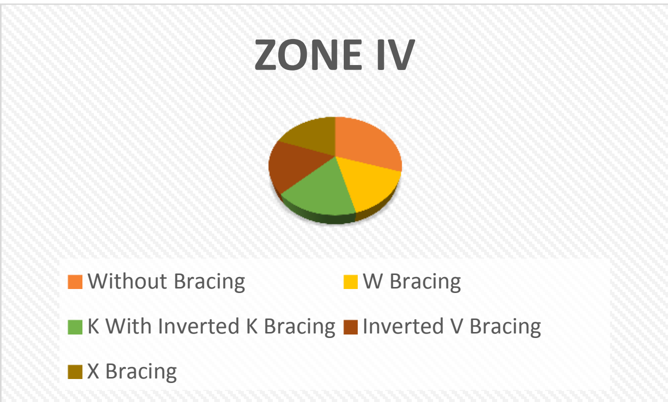

Fig. 4.9: Beam End Moment of Structure

5.1 Conclusion

This report reflects the modelling and analysis of vertically steel braced elevated R.C.C. overhead water tank for unfilled as well as for filled condition to reduce the nodal displacement, bending moment, forces, reinforcement quantity without compromising the base shear forceof structure. To achieve this, four different types of bracing i.e. W, K, V and X of steel channel section ISMC 125 [double section back to back] have been designed as brace beam vertically to staging of elevated water tank in two patterns i.e. continuously and alternately. Also one conventional design of elevated water tank has been modelled and analysed to compare the outcomes. The process of modelling and analysing has been done through STAAD-Pro. Following conclusions have been drawn from this dissertation work.

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