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A Comparative Study of Circular Water Tank in Two Different Loading Conditions (Seismic and Wind Load Condition) using Staad-Pro

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Abstract: ***In this paper a comparison of the two loading combinations of a circular water tank i.e. seismic and wind load conditions have been made. The STAADPro software has been used to analyze the circular water tank structure and to compare both the loading combinations. Two similar models of a circular water tank were created, provided with the required attributes (i.e. loading conditions, zones etc.) and were analyzed in both, seismic load condition and wind load condition [1]. The comparison of results from both the analyses revealed that, due to lower seismic zones, the effect of earthquake is slightly less than the effect of wind. It was concluded that, wind load condition should be preferred over seismic load condition while designing, because the wind load condition gives safer design in the severe conditions. This can be used for the design of a circular water tank having similar attributes [2].***

Key-words: - Circular Water Tank, Seismic Load, Wind load, STAADPro.

I. INTRODUCTION

In India till 2009, Indian standard code IS code 3370:1965 has been adopted for the design of RCC water retaining structure. After introduction of new Indian standard code IS 3370:2009, the Limit State Method (LSM) has been adopted in all the designs. Design can be done utilizing the LSM, because it gives minimum area of reinforcement of steel but the check for crack width should be done. [Jindal, B.B. (2012)]. Pajgade & Meshram (2014) concluded in their paper that the size of member remain same for Working Stress Method (WSM) by both IS 3370(1965) or 3370(2009) and necessity of area of steel increased in IS: 3370(2009) as the allowable stresses in steel were lower. And the size of member or requirement of steel decreases for LSM by IS 3370:2009 as compare WSM by IS 3370:2009 or 3370:1965 [3]. Limit state design, is a semi-experimental methodology, is considered to be the best in the design of RCC structures over the versatile hypothesis of design where the level of stresses in concrete and steel are restricted so that stress-deformation are taken to be linear.

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Indian standard code (IS-3370:2009) adopts limit state method predominantly considering two perspectives. Initially, it restricts the burdens in steel so that concrete isn't over pushed and in second viewpoint, it limits the cracking width.[Prasad R.V.R.K.(2012)] STAADPro can be used for water tank design as it works on LSM. Singh (2016) concluded that seismic load gives more effects than wind load in 30 storey building [4].

As per Indian standard code IS 456:2000, while designing the structure the wind load condition and the seismic load condition both cannot be taken together. Only the condition which affects the structure severely has to be taken while designing the structure [5]. Therefore, for the selection of the suitable condition a comparison between both the conditions needs be carried out

In the present study for studying the loading conditions on RCC water retaining structure and identifying possible loading combinations, two water tank models are being created with same attributes but different loading conditions. The models were then analyzed and checked for errors using STAADPro and the results were compared for selecting the best suitable loading conditions [6].

II. OBJECTIVES OF THE STUDY

- To study loading conditions on a circular water tank.
- To identify possible loading combinations as per IS-Code.
- To create two water tank models with same attributes but different loading conditions.
- To analyze the created models using STAAD Pro and check for errors.
- To compare the results and decide the best loading condition for the design.

III. THEORY, METHODOLOGY and COMPARAISON OF RESULTS

The designing procedure of the circular water tank in STAADPro requires theoretical knowledge of the design of the structure as per IS codes [9] [10]. Considerations such as the quantity of water, the purpose of storage, the location of storage are to be taken, which further defines the dimensions of the storage tank [7].

After creating the geometry various types of loading combinations are calculated as per IS codes [8].

Loading combination:

1. For seismic load analysis of a structure the code gives following loading combination. (i) 1.5(DL + WP), (ii) 1.2(DL + WP ± EL), (iii) 1.5(DL ± EL), (iv) 0.9 DL ± 1.5 EL [IS 456:2000]

2. For wind load analysis of a structure the code gives following loading combination. (i) DL +WP, (ii) DL+WL, (iii) DL+0.8WP+0.8WL [IS 456:2000]

Both WL and EL are applied in X and Z direction. These loads are additionally applied further in adverse X and Z direction.

DL-Dead Load
WP-Water Pressure
EL-Earthquake Load
WL- Wind Load

IV. DESCRIPTION OF STRUCTURE

After understanding the procedure of working in STAADPro, two similar geometry of a circular water tank with two different load combinations were created. The 1st model was having combination of dead load, water load, & wind load and 2nd was having combination of dead load, water load & seismic load. The loading conditions are considered for the Bhopal city of Madhya Pradesh. This location falls under Seismic zone-II. Wind intensities have been calculated with respect to average wind speed of the location (Bhopal).

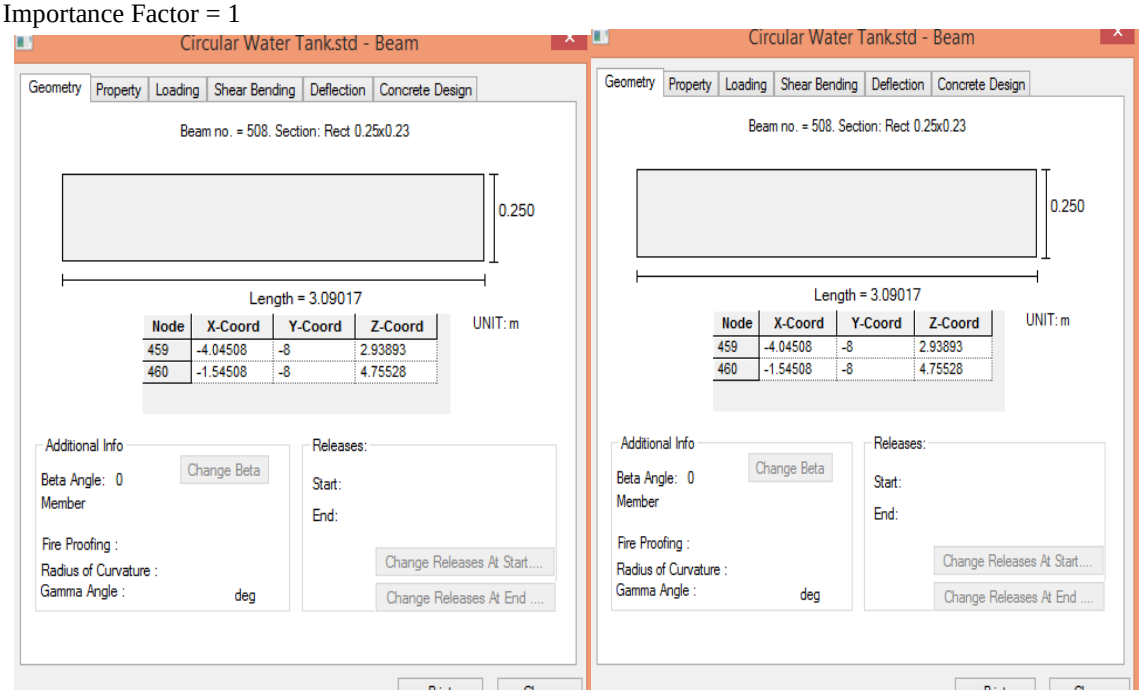
Data used:

- Type of structure- Space structure.
- Seismic Zone II (IS 1893-2002/2005)
- Zone factor=0.1
- Response Reduction Factor = 3
- Importance Factor = 1
- Rock and Soil site factor = 2
- Damping Ratio = 0.05
- Dimensions of tank
- Radius of tank = 5 m
- Depth of tank = 2.7 m
- Height of total structure = 12.7 m(10+2.7)
- Length of column = 2 m
- Size of column = ϕ 0.3 m
- No. of supports = 10
- Size of beam = 0.23 m * 0.25 m
- Ring beams = 1 top ring beam, 1 bottom ring beam, 4 ring beams connecting columns.
- Capacity of tank = 200 KL.
- Thickness of plate = 0.15 m
- Type = Dual Domed Circular Tank.
- Materials:
- Concrete = M30 grade
- Steel = Fe500 HYSD bars
- Specific weight of RCC 25 kN/m^3
- Water loads/Pressure
- Min. Water pressure = 2kN/m^2 (in negative global y-axis)
- Max. Water pressure = 25.5 kN/m^2 (in negative global y-axis)

V. COMPARISON OF RESULTS:

Above data was used to create the input file. After verifying and analyzing, following results were obtained in Post Processing Mode.

Comparison of Geometry in Beam no. 508



(In seismic load combination) (In wind load combination)

Fig.4.2 (a)

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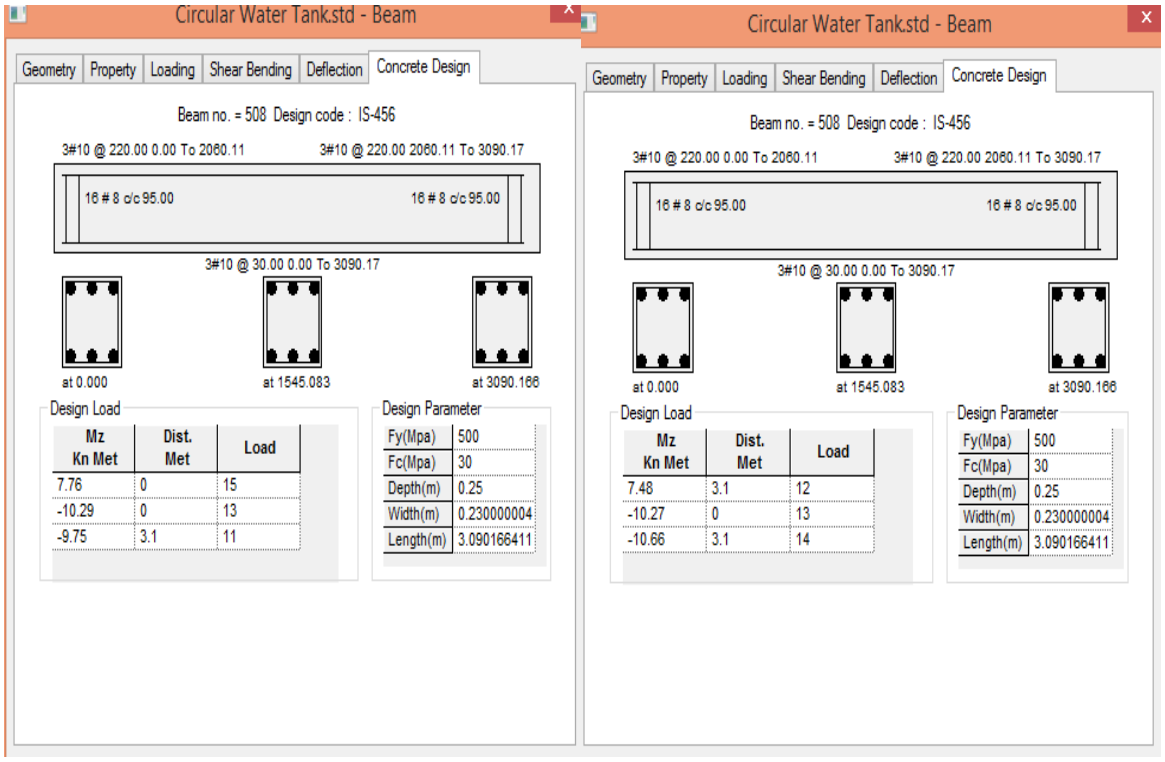
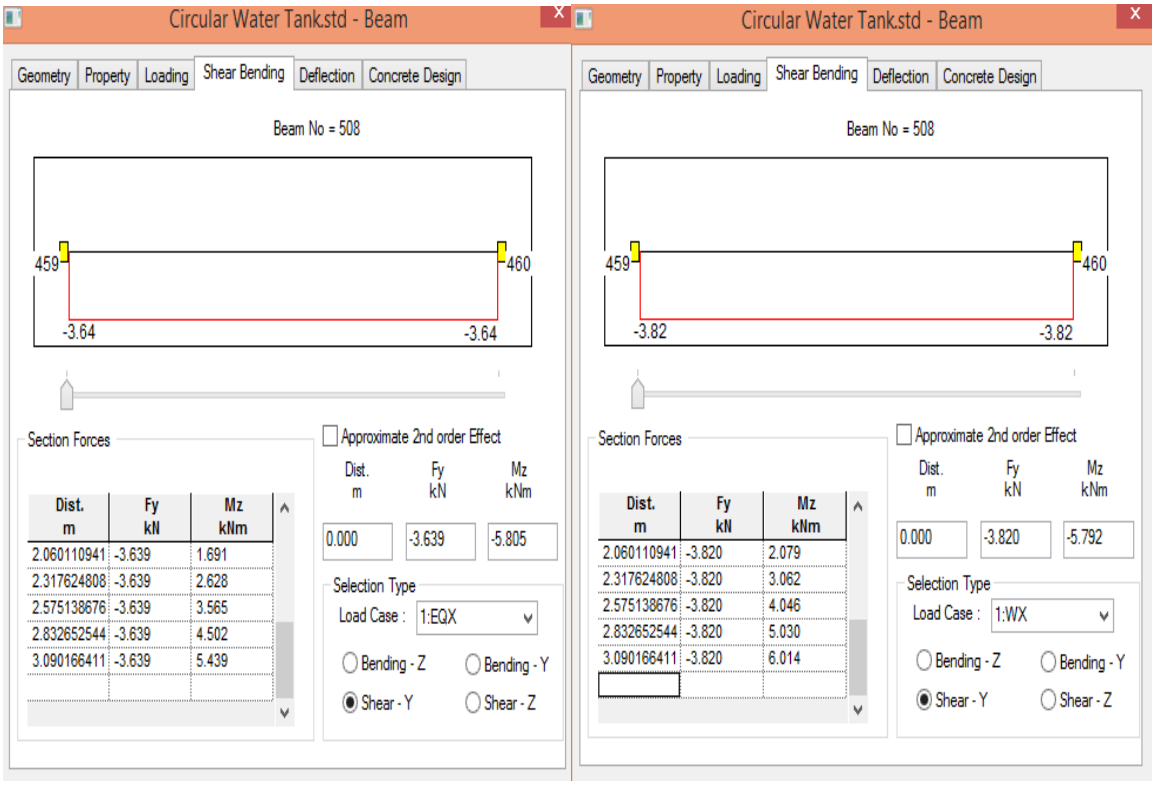
Comparison of Concrete Design in Beam no. 508



(In seismic load combination) (In wind load combination)

Fig.4.2 (b)

Comparison of Shear in Beam no. 508



(In seismic load combination) (In wind load combination)

Fig.4.2 (c)

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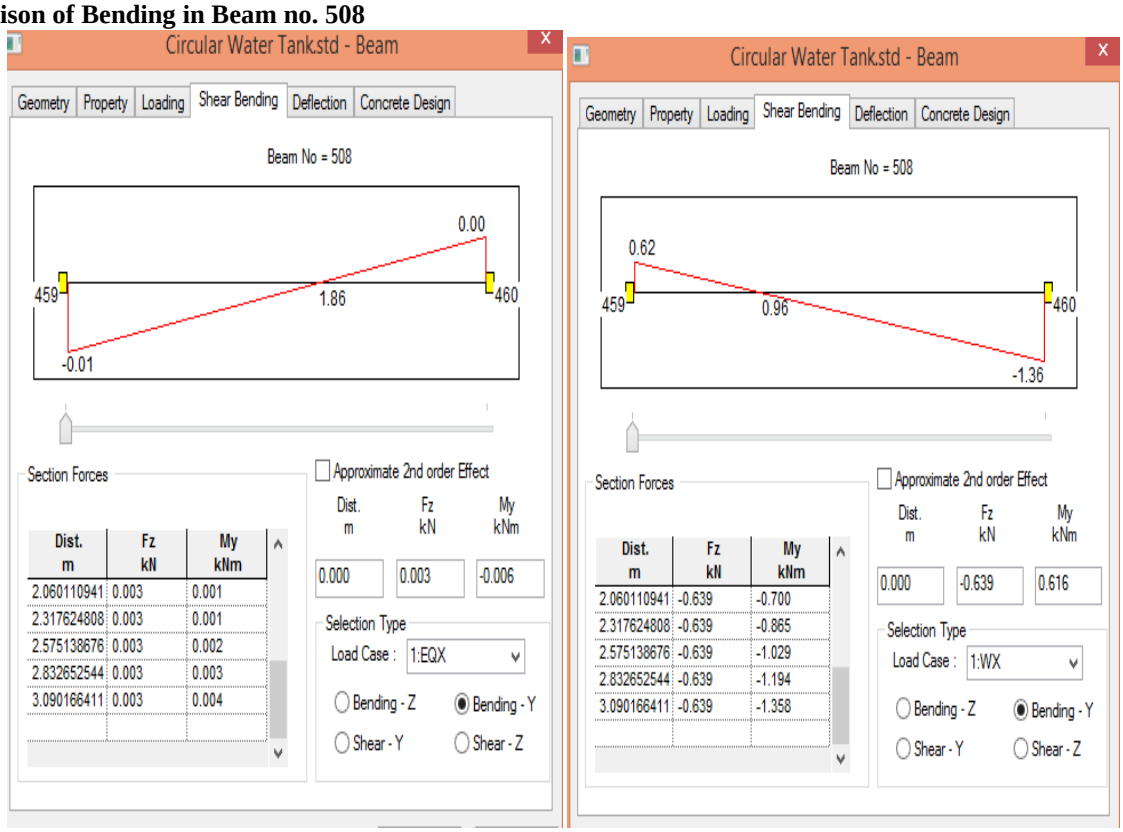
Comparison of Bending in Beam no. 508



(In seismic load combination) (In wind load combination)

Fig.4.2 (d)

Comparison of Deflection in Beam no. 508

(In seismic load combination) (In wind load combination)

Fig.4.2 (e)

VI. CONCLUSION

On the basis of the results obtained in this study, these can be concluded: In wind load condition, higher value of shear stress, bending stress and deflection was observed in comparison to seismic load condition for the beams having same geometry & concrete design and higher value of principle stress, corner stresses, centre stresses & displacement was observed in comparison to seismic load condition for the plates having same thickness and position in both the load combination. In wind load condition, higher value of reaction forces in direction X and Z was observed in comparison to seismic load condition at support whereas reaction forces in direction Y were more in seismic load combination in comparison to wind load combination. In seismic load condition, higher value of design load/moment was observed in comparison to wind load condition. Hence, wind load condition should be preferred over seismic load condition while designing the structure as the wind load condition indicates severe load effects, and if a structure is safe against severe load condition, it will definitely be safe against every load condition.

FUTURE SCOPE

This type of study can be used for bridge analysis.

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BIBLIOGRAPHY

[1]. STAADPRO. User Manual (Wikipedia).
[2]. FLUID MECHANICS in Civil Engineering (Made Easy)
[3]. RCC in Civil Engineering. (Made Easy)

REFERENCES

1. Singh, L. (2016). "3-D ANALYSIS OF BUILDING FRAME USING STAAD-PRO". JUIT, Solan.
2. Prasad, R.V.R.K. and Kamdi A.B. (2012), EFFECT OF REVISION OF IS: 3370 ON WATER STORAGE TANK. ijera Vol 2 pp, 664-666, ISSN: 2248-9622
3. Jindal, B.B. (2012), Comparative study of design of water tanks with reference to IS: 3370.
4. Meshram, N.K. and Pajgade, P.S. (2014), Comparative study of water tank using Limit State Method and Working Stress Method. IJRAT, Vol 2 No. 8, E-ISSN: 2321-9637
5. IS 3370 (Part–I, II) "Code of Practice for Concrete Structures for the Storage of Liquids", Bureau of Indian Standards, New Delhi, 2009
6. IS 3370 (Part–IV) Design table, "Code of Practice for Concrete Structures for the Storage of Liquids", Bureau of Indian Standards, New Delhi.1967.
7. IS 456, "Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards, New Delhi, 2000.
8. Lakhera, A. (2021), Finite Element and Equivalent Frame Analysis of Masonry Façade; Having an arched opening, International Journal of Emerging Technologies, Vol 12(2) ISSN 0975-8367.
9. Singhai, K. (2021), Seismic Strengthening of Existing RCC Structure by FRP Jacketing, International Journal of Innovative Technology and Exploring Engineering, Vol-10 Issue-8 ISSN 2278-3075.
10. Pal, A.(2021), Effects of Polypropylene Fibers on the Mechanical Performance of a 3D Printable Mix, International Journal of Innovative Technology and Exploring Engineering, Vol-10 Issue-8 ISSN 2278-3075.

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