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RESEARCH ARTICLE OPEN ACCESS

Comparative Study of Elastic Analysis and P-Δ Effect in Elevated Water Tank for Seismic Loads

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Abstract
In this project an attempt is made to compare seismic analysis of water tanks using elastic analysis and p-delta effect. The Circular and Intz type Water Tank are analyzed for critical load combination considering severe zone (V zone only). The analysis is to be carried out for Axial Force, Shear Force and Moments with p-delta and without p-delta conditions. In overall study of seismic analysis, critical load combination is found out. For these critical load combinations for different height like 16M, 20M, 24M various parameters are calculated. Important part of this project is to find out height wise variation in column displacement and column moment for same capacity of tank at different height of staging by taking same dimensions of bracing and column and significant co-relationship between these parameters are established.

Keywords- Elastic analysis, P-Δ analysis, STAAD-PRO Water Tank Model, Design of Water Tanks, seismic analysis results

I. INTRODUCTION

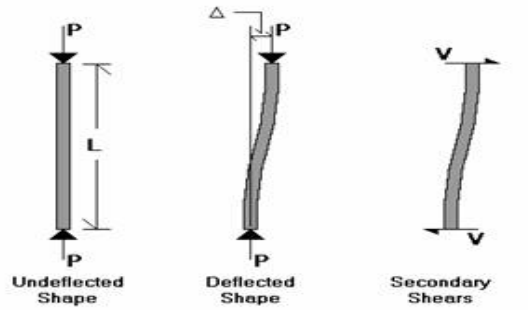
In India, elevated tanks are commonly used in the public water distribution systems. These elevated tanks are generally of reinforced cement concrete (RCC).Since these elevated tanks are integral parts of lifeline systems, their seismic safety is of considerable importance. [4] During seismic response, lateral deformation increases very sharply causing p-Δ effect to play a very crucial role in the structures like elevated water tank, which has large mass concentration at the top and supported by a relative slender supporting system, seismic analysis of elevated tank needs special considerations.

A. Elastic Analysis

In the elastic range all steel elements and even the complete steel structure can be assumed to follow Hooke's law and recover completely to their original state upon removal of load. The maximum elastic load capacity is determined when any point in any member section reaches the yield stress or elastic critical buckling stress where stability is a problem. Under a particular loading combination, the forces and moments throughout all or part of the structure may be determined by an analysis that assumes that individual members behave elastically.

B. P-Delta Analysis

[5] When a model is loaded, it deflects. The deflections in the members of the model may induce secondary moments due to the fact that the ends of the member may no longer be vertical in the deflected position. These secondary effects for members can be accurately approximated through the use of P-Delta analysis. This type of analysis is called "P-Delta analysis" because the magnitude of the secondary moment is equal to "P", the axial force in the member, times "Delta", the distance one end of the member is offset from the other end.



$$P * \Delta = V * L$$

Figure 1

II. ANALYSIS AND DESIGN OF STRUCTURES

In this project Analysis and Design of Circular and Intz type of Tank of capacity 500m3 for different heights of staging like 16M, 20M and 24M for Critical Load combination 1.5DL + 1.5EL for zone V is done.

Table 1

Seismic zone	**I**	**II**	**III**	**IV**
Seismic intensity	Low	Moderate	Severe	Very Severe
z	0.1	0.16	0.24	0.36

A. *[1] Design Of Circular Water Tank and Intz Water Tank*

Design of Water Tank container of capacity 500m3

By Conventional Method

2.1.1 *[3]* The Dimensions of the container of Circular Water Tank provided are
Diameter of Tank - 13.5m
Height of Tank - 3.8m
Top Dome – 100mm thickness
Bottom slab – 550mm depth
Cylindrical Wall – 300mm thickness
Top ring beam – 350mm x 350mm
Bottom ring beam – 500mm x 800mm

The Dimensions of the container of Intz Water Tank provided are
Diameter of Tank – 10m
Top dome – 100mm thickness
Top ring beam - 250mm x 250mm
Circular side wall – 200mm thickness
Bottom ring beam - 600mm x 600mm
Conical dome – 600mm thickness
Bottom spherical dome – 300mm thickness
Bottom circular ring beam – 550mm depth

B. Design Of Supporting system using STAAD-PRO. IS 1893 (part 1): 2002

for seismic parameter in staad-pro command
For 16m Height Of Column
1st Trial: Size of bracing: 0.3x0.3M
Size of column: 0.3M diameter
2nd Trial: Size of bracing: 0.3x0.3M
Size of column: 0.6M diameter
3rd Trial: Size of bracing: 0.3x0.3M
Size of column: 0.55M diameter
4th Trial: Size of bracing: 0.3x0.3M
Size of column: 0.4M diameter

Final dimensions For 16m , 20m, 24m Height Of Columns And Size Of Bracings : The following size of bracings and size of columns, the difference in axial force, shear force, moment for without p-delta and with p-delta condition for 16M height of staging in both case of Tanks is found. Hence for design and analysis purpose 20M and 24M height of staging of same dimensions of bracings and columns are carried out.

4th Trial: Size of bracing : 0.3x0.3M
Size of column: 0.4M dia The following Figure shows Circular Water Tank and Intz Water Tank

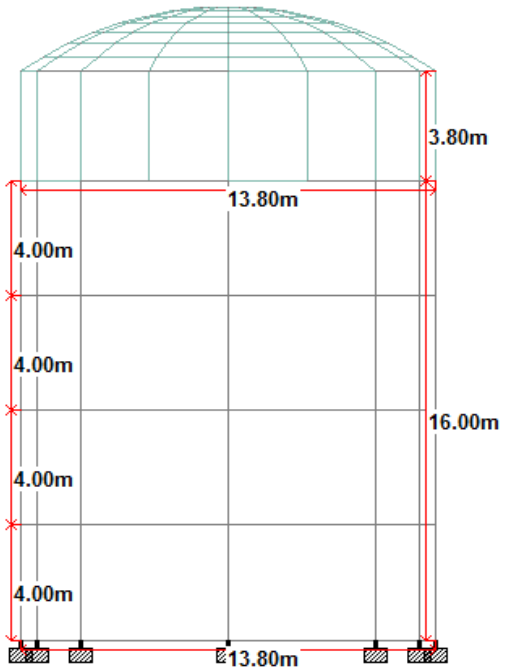


Figure 2 Column Height 16M

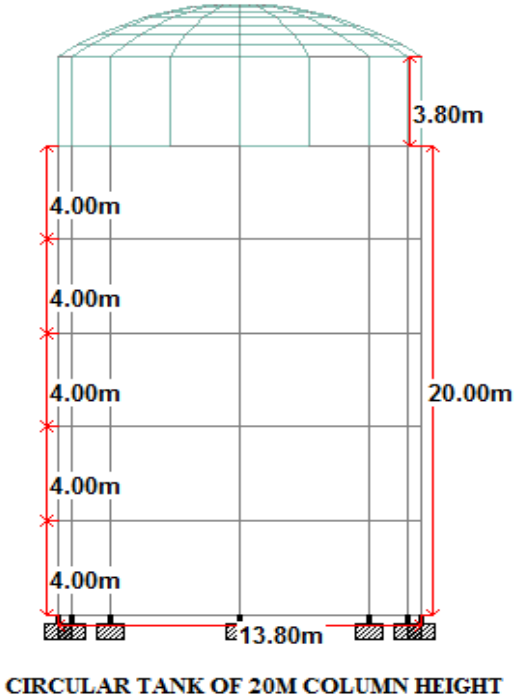


Figure3 Column Height 20M

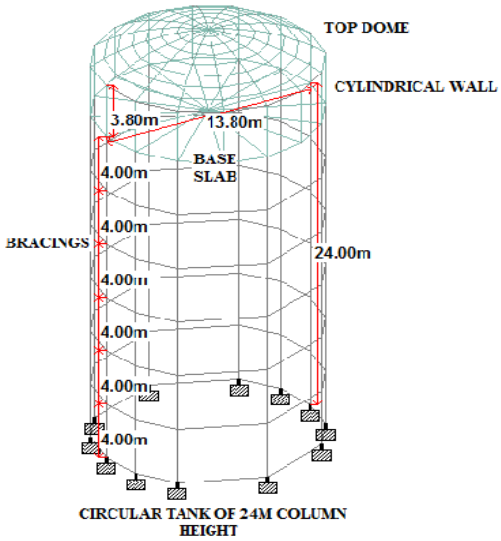


Figure 4 Column Height 24M

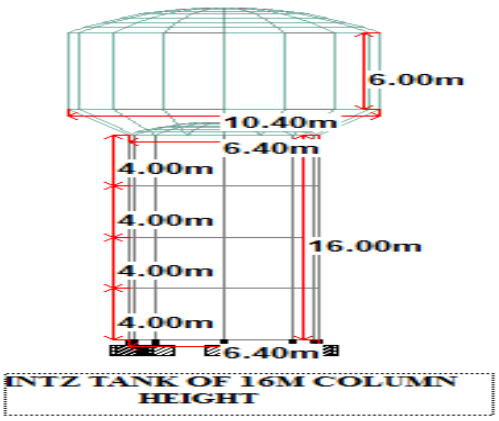


Figure 5 Column Height 16M

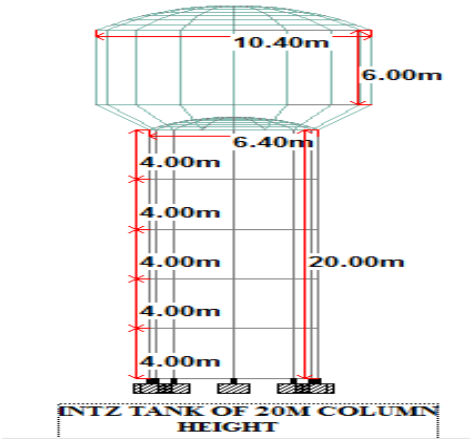


Figure 6 Column Height 20M

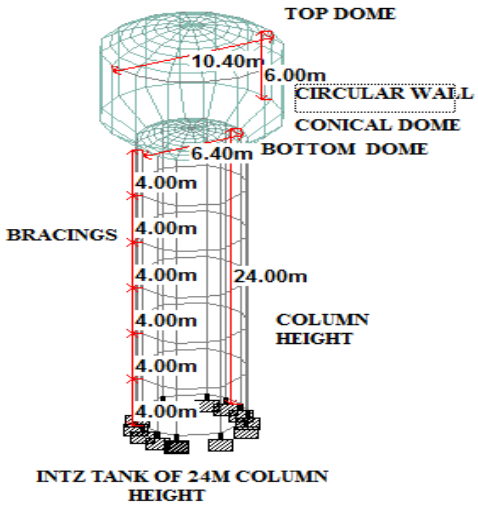


Figure 7 Column Height 24M

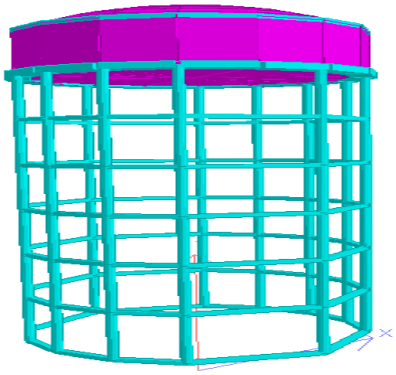


Figure 8- Circular Water Tank

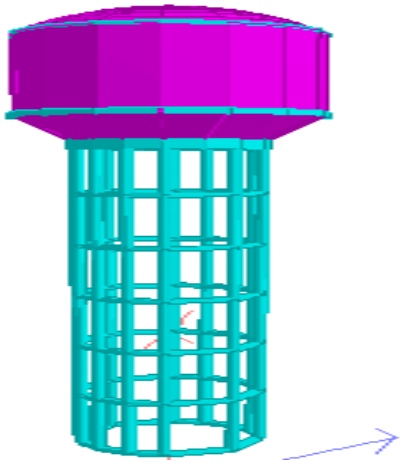


Figure 9 – Intz Water Tank

C Seismic Analysis

[2] Seismic analysis of Water Tanks are carried out in STAAD-PRO software "Table 2,3,4,5"

III. RESULTS AND DISCUSSIONS

Column Displacement and Column Moment for Circular Tanks

Height Wise Variation In Column Displacement At Node No.583 "Fig. 10"

Table 2

Type of Tank	Column Displacement (mm) At ground level	
Column height	Without P-Δ	With P-Δ
16 m	76.498	141.321
20 m	109.7	195.744
24 m	145.367	275.487

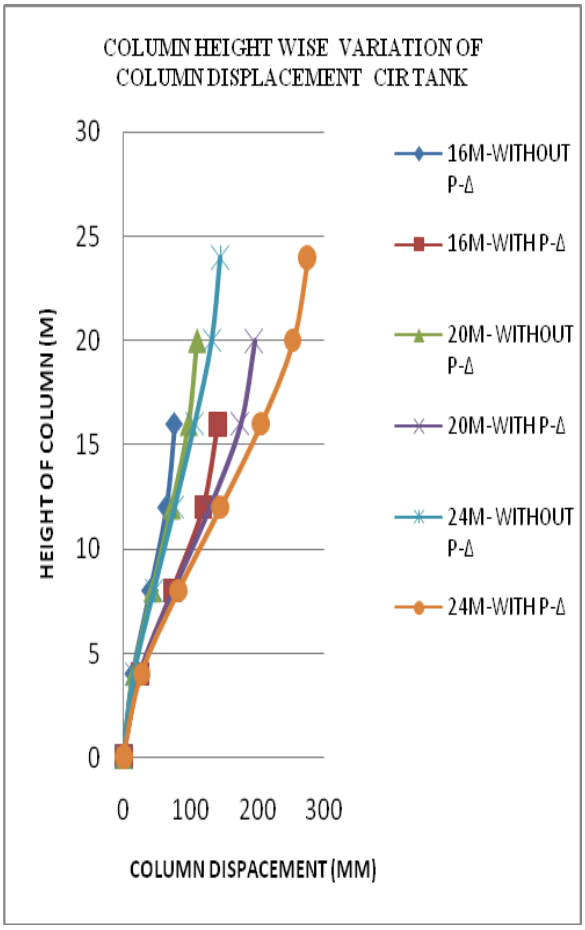


Figure 10 Column Displacements for Circular Tanks

Height Wise Variation In Column Moment At Node No.583 "fig. 11"

Table 3

Type of Tank	Column moment (kn-m) At ground level	
Column height	Without P-Δ	With P-Δ
16 m	103.726	169.851
20 m	110.501	170.615
24 m	116.965	184.8

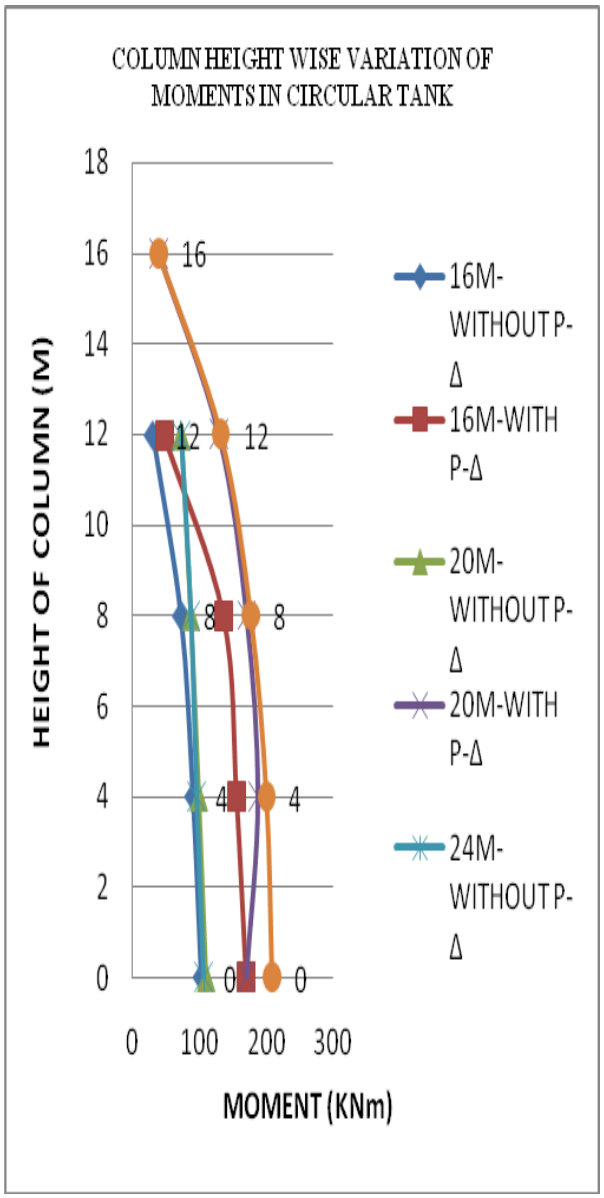


Figure 11 Column moment for Circular Tanks

Column Displacement and Column Moment for Intz Tanks

Height Wise Variation In Column Displacement At Node No.586 "fig. 12"

Table 4

Type of Tank	Column Displacement (mm) At ground level	
Column height	Without P-Δ	With P-Δ
16 m	54.9	81.48
20 m	81.09	159.498
24 m	110.779	241.215

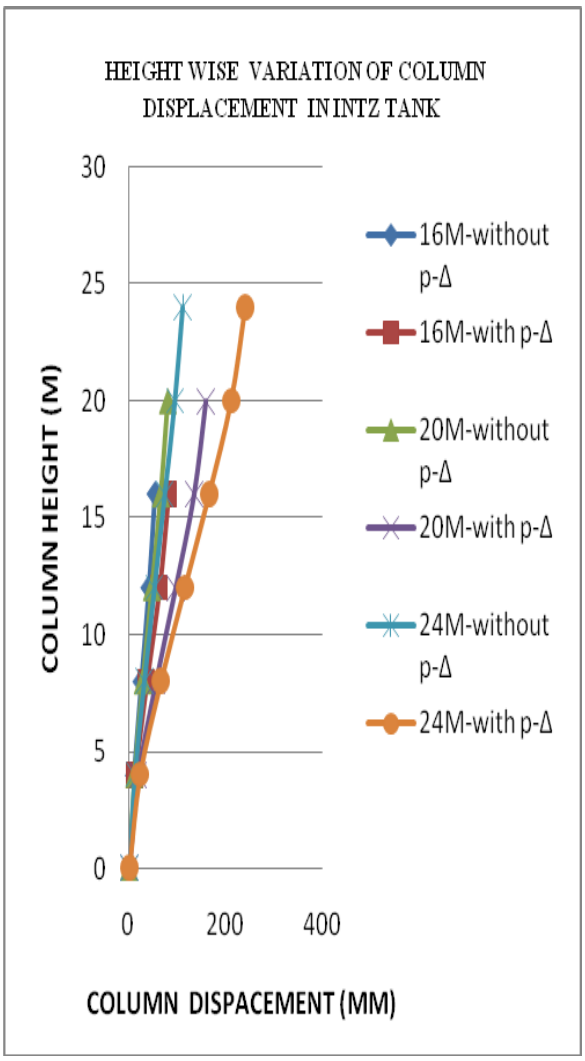


Figure 12 Column Displacement for Intz Tanks

Height Wise Variation In Column moment At Node No.586 "fig. 13"

Table 5

Type of Tank	Column moment (kn-m) At ground level	
Column height	Without P-Δ	With P-Δ
16 m	59.466	90.697
20 m	61.23	111.786
24 m	65.925	130.819

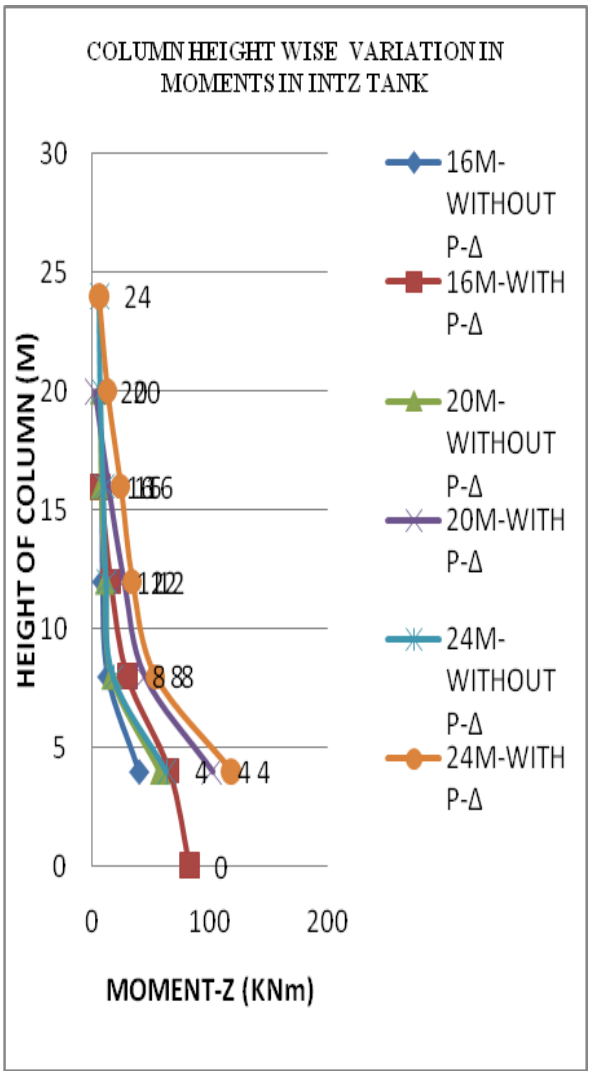


Figure 13 Column Moment for Intz Tanks

IV. CONCLUSION

After considering p-delta effect it is observed that the end forces in bracing and columns are increased very marginally. The axial load is not equally distributed among the columns but it varies with its distance from the central axis. The sizes of column play an important role in redistributing the load carried by various columns. Maximum forces are carried by bracing provided at top panel. After application of earthquake force on tank and transferring it to staging, the forces in horizontal members are not increased. On other hand they are decreased in magnitude. As we increase the height of tank, p-delta effect is found to be more in 20M, 24M height of supporting system. Hence for this project study we can say that p-delta effect is directly proportional to height. Among the all two types of water tanks , intz tank is complicated in design and casting. But without p-delta and with p-delta for these both conditions, effect on Intz type of Tank as

compare to circular tank is less. Hence it is aesthetically good than circular

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