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# Performance of RC Elevated Water Tank Under Seismic Effect

**Shylaja N**
*Assistant Professor, School of Civil Engineering,*
*REVA University, Rukmini Knowledge Park,*
*Kattigenahalli, yelahanka, Bengaluru, Karnataka, India*

**Nanjunda K N**
*Assistant Professor, School of Civil Engineering,*
*REVA University, Rukmini Knowledge Park,*
*Kattigenahalli, yelahanka, Bengaluru, Karnataka, India*

**Avinash S Deshpande**
*Assistant Professor, School of Civil Engineering,*
*REVA University, Rukmini Knowledge Park,*
*Kattigenahalli, yelahanka, Bengaluru, Karnataka, India*

**Rudresh C H**
*PG Student, School of Civil Engineering,*
*REVA University, Rukmini Knowledge Park,*
*Kattigenahalli, yelahanka, Bengaluru, Karnataka, India.*

## Abstract
The present investigation centers around the reaction of the elevated circular water tanks to dynamic powers. Overhead water tanks comprise of enormous water mass at the highest point of a slender staging which are most critical consideration for the failure of the tank during earthquakes. Tanks of different frame staging with different numbers of columns is displayed utilizing SAP2000 programming. The examination is carried out for two cases to be specific, tank full and empty tank level condition thinking about the hydrostatic impact. The models were analysed with SAP2000 utilizing Response Spectrum Method (RSM) and results are displayed. It is watched that increasing in number of columns, does not guarantee the increment in the stability of the structural responses .The tanks withstood the acceleration with the displacements within the permissible limits. The peak displacement and base reactions got from the analysis were also compared. total 18 models were examined with SAP2000 utilizing Response Spectrum Method (RSM) and results are displayed.

**Keywords:** Elevated Circular Water Tank, Frame Staging, RSM, Different numbers of Columns.

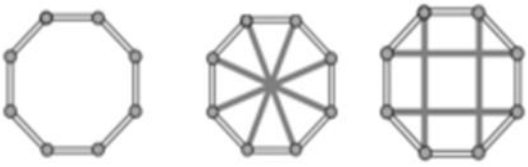
## Introduction
An elevated water tank is a large water storage container constructed for the purpose of holding water at certain height to pressurize the water distribution system. There are different ways for the storage of liquid such as underground, ground supported and elevated used extensively by municipalities and industries. Thus water tanks are very important for public utility and for industrial structure. Elevated water tanks consist of huge water mass at the top of a slender staging which is most critical consideration for the failure of the tank during earthquakes. Elevated water tanks are critical and strategic structures; and damage of these structures during earthquakes may endanger drinking water supply,fail in preventing large fires and may cause substantial economic loss. Due to the lack of knowledge of supporting systems, many of the water tanks were collapsed or heavily damaged. In comparison with shaft staging, the reinforced concrete elevated water tanks with frame staging have shown better seismic resistance against lateral loads, because of having more degree of determinacy and seismic energy absorption capacity through the non-linear behaviour. There are also various modes of failures such as buckling, sloshing damage to roof, inlet/outlet pipe breaks and impulsion due to rapid loss of contents. So we should focus on seismic safety of lifeline structure with respect to alternate supporting system. The present work is an effort to study the structural responses of circular elevated water tank using Response spectrum Method (RSM) considering different staging arrangements, staging levels and different sizes of columns, using SAP2000. For modelling, impulsive and convective water mass is considered. After study of structural responses optimization of diameter and number of columns is done. Considering cost parameter; the best suitable number of columns required for the structurally adequate staging arrangement and staging levels were found out..

## Literature review

From the literature study it is discover that, basic execution of water tanks depends a considerable measure of components which incorporates, fluid structure interaction , soil structure collaboration, types of support ,types of bracings, wall flexibility , nearness of dampers, arrangement of columns, staging height, water fill conditions and so on. Failure of water tanks are caused by different reasons. The principle issue is water tanks are very little safe under various loading conditions because of absence of its quality and ability to withstand the most exceedingly bad conditions. Henceforth plan a water tank which gives much wellbeing and quality is a testing assignment for the designers. For this, it is essential to know the tank reaction under different loading conditions, and its failure patterns.

## Numerical simulation of the tank

The frame type staging is the most commonly used supporting in practice. The main components of frame type of staging are columns and braces. In frame staging, columns are arranged on the periphery and it is connected internally by bracing at various levels. The staging is acting like scaffolding between container and foundation for the transfer of loads acting on the tank. In elevated water tanks, head requirement for distribution of water is satisfied by adjusting the height of the staging portion. A reinforced elevated circular water tank having different staging arrangements, column sizes and staging levels has been considered for the present investigation. Total 18 models are studied for tank full and tank empty condition. The storage capacity of water tank is 500 m3. The organizing of staging is the arrangements of columns and bracings in specific pattern. In the present study, three frame types of staging arrangements –ordinary, radial and cross have been considered as shown in Figure 1. Finite element model of tank is is set up in SAP2000.



Ordinary Radial Cross

**Figure 1:** Different types of staging arrangement.

**Table -1:** Design data

| | |
|---|---|
| Capacity | 500m$^3$ |
| Staging height | 18m |
| Unit weight of concrete | 25 KN/M$^3$ |
| Grade of steel | Fe500 |
| Grade of concrete | 25 |
| Earthquake zone | lV |
| Type of soil | Medium |
| Staging levels | 4 , 5 , 6 |

**Table -2:** Estimated size of components

| | |
|---|---|
| Roof slab | 300mm |
| Wall | 350mm |
| Floor slab | 350mm |
| Floor beams | 400x600mm |
| Braces | 300x500mm |
| Columns | Lll |
| Inner diameter | Medium |
| Outer diameter | 4 , 5 , 6 |
| Height | 5m |

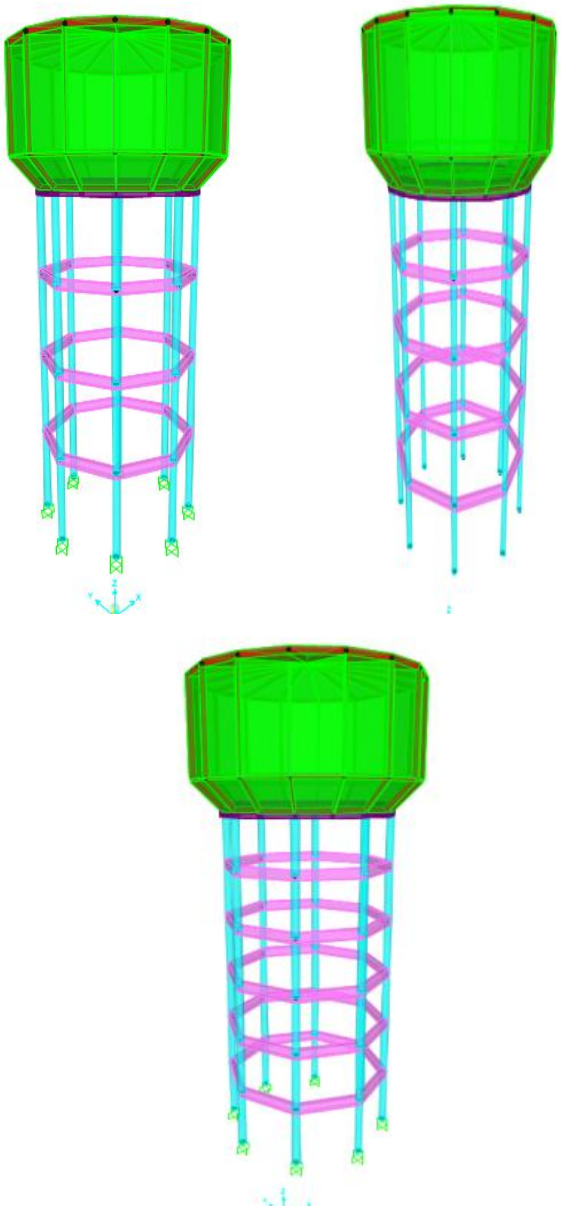


**Figure 2:** 3D modeling of elevated water tank with different staging height in SAP2000

## Results

**Stiffness version of Different Staging arrangements .**

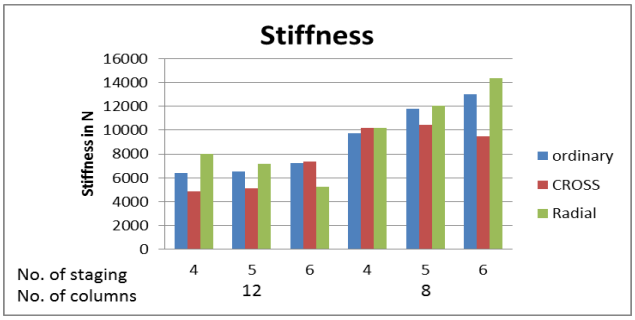



**Figure 3 -** Stiffness variation of staging arrangement

From the above figure it is observed that as the number of columns increases, the over all stiffness of staging arrangement reduces . As increasing the staging level the overall stiffness increases. This is due to the fact that total cross section area of columns required to resist the vertical load is calculated by considering the parameters axial load for short column in working stress method. since cross sectional area required is constant , the diameter decreases with increasing in number of columns this also reduces the moment of inertia of the column the stiffness of Staging is directly proportional to the moment of inertia.

**Optimizations of columns considered using radial arrangement, six staging levels and full tank condition:**
It is noticed that for bracing width below 300mm, design is inadequate and so 300mm is optimized value for bracings. Six, eight ten and twelve numbers of columns is optimized considering radial arrangement for six staging level for full tank condition. For this column diameter are decreased with increasing ratio of 0.15 till the design is adequate using SAP2000 V16 software.

**Table 3 –** Optimized diameter of columns

| Sl.N0 | Number of columns | optimized diameter of column(mm) |
|---|---|---|
| 1 | Six | 520 |
| 2 | | 450 (ratio 1:15) |
| 3 | | 390 (ratio 1:30) |
| 4 | | 350 ( ratio 1:45 |
| 5 | Eight | 450 |
| 6 | | 390 (ratio 1:15) |
| 7 | | 350 ( ratio 1:30) |
| 8 | | 350 (ratio 1:45) |
| 9 | Ten | 350 |
| 10 | | 300 (ratio 1:15) |
| 11 | Twelve | 300 |

(Ratio determines the proposition by which the diameter decreased)

For over study we have considered only the two types of columns ie; 12 numbers and 8 numbers

(12 number - 300mm dia, 8 number - 350mm dia ).

**Comparison of Different models for Roof displacement, Base Reaction and Base shear.**

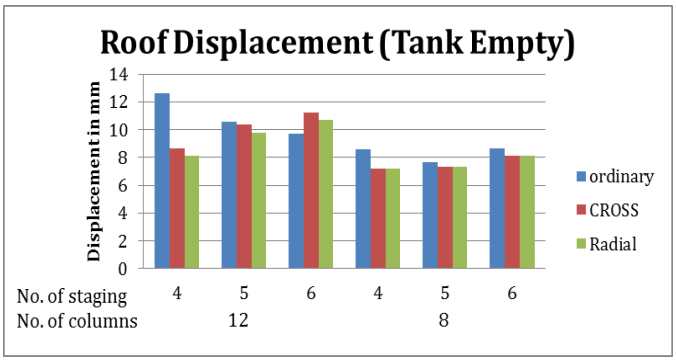



**Figure 4**: Roof Displacement for Tank Empty condition.

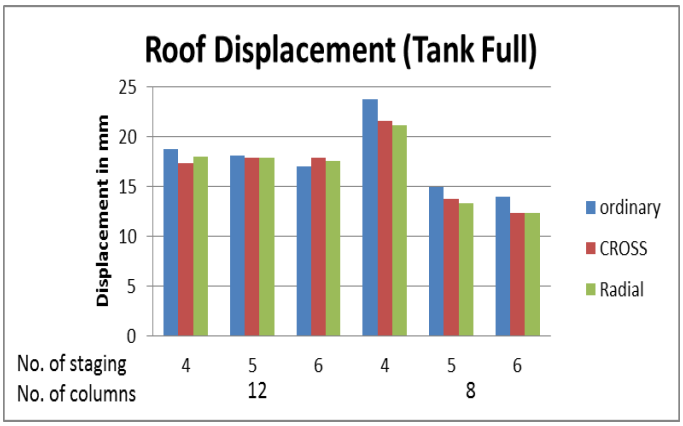



**Figure 5:** Roof Displacement for Tank Full condition.

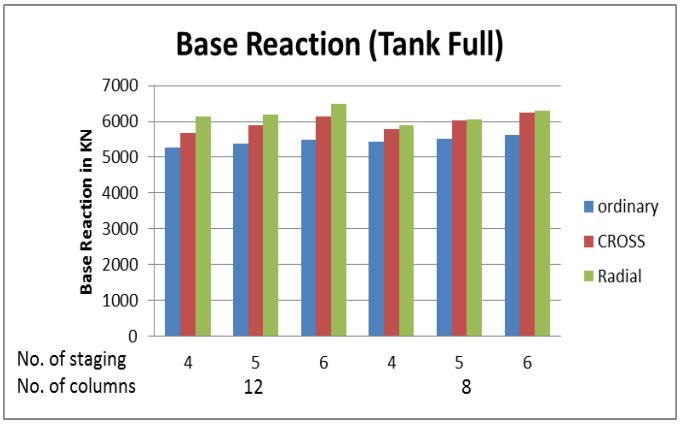



**Figure 6:** Base Reaction variation for Tank Full condition.

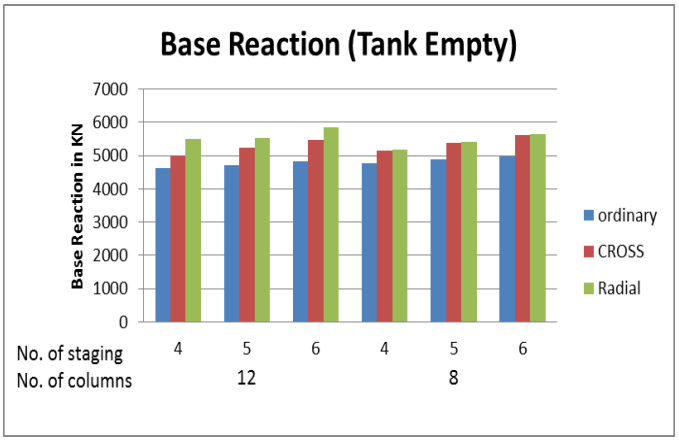



**Figure 7:** Base Reaction variation for Tank Empty condition.

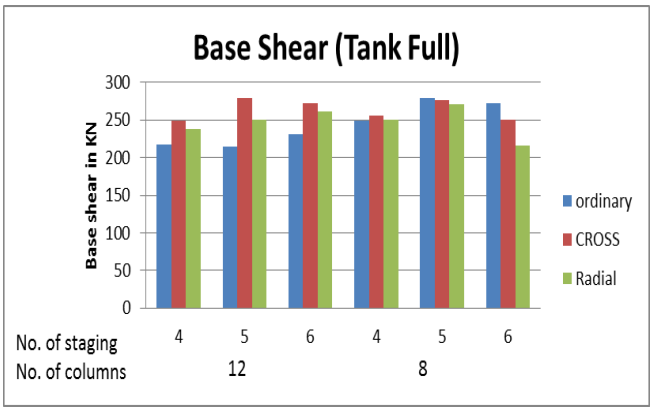



**Figure 8:** Base Shear variation for Tank Full condition.

## Conclusion

- In Radial arrangement with six staging level is best suitable for eight and twelve numbers of columns followed by cross and ordinary. Full tank condition shoes critical response then empty tank condition. but we cannot neglect the empty tank condition
- Normal type of arrangement has more deflection then the cross and minimum for radial and vice versa in stiffness
- For the tank full and tank empty condition as staging level increases Base reaction increasers and roof displacement decrease
- For tank full and tank empty condition base shear and base reaction is more for radial arrangement then cross and minimum for ordinary type of arrangement
- Tank empty condition has less base shear and base reaction than the full tank condition
- For roof displacement it is vice versa
- It can be said that instead of increasing the number of column for the stiffness of structure it is better to optimize after assuring proper structural response.

## References

[1] D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[2] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.Furquan Elahi Shaikh, "Performance Study of Elevated Water Tanks under Seismic Forces," .

[3] Ankush N. AsatI , "**S**eismic Analysis and Optimization of RC Elevated Water Tank Using Various Staging Patterns," published.

[4] B. Batiha, M.S.M. Noorani, I. Hashim, Numerical simulation of the generalized Huxley equation by He"s variational iteration method, Applied Mathematics and Computation 186 (2007) 1322-1325.