# Perfomance Of 50 Kl water Tank Under Is -1893 Response Spectra

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***Abstract***

In this research article, an analytical investigation of 50 kL water tank under the action of IS 1893 response spectra has been analyzed. The tank modelled with three types of bracing system i.e. Basic staging, cross staging, radial staging with varying height from 5m,15m,30m,35m is used. A response spectrum analysis is carried, it is observed that basic staging pattern with varying staging height behaves satisfactory ascompared to radial and cross staging pattern.The response obtained for convective mass is less with increasing height of staging but in all over position the response increases with increase in height of staging.

**Keywords**: -50 kl elevated water tank, IS 1893 response spectra, Response spectrum analysis.

## Introduction

Concrete liquid containing structures as part of environmental engineering structures are considered as essential facilities during earthquakes[4]. While the leakage of tanks containing hazardous materials is essential to be controlled in water tanks, the contents are important for firefighting operations as well as for meeting the public demands. Reinforced concrete tanks are widely used in environmental engineering applications in the form of rectangular or circular configuration. It is necessary to have a good understanding of the seismic behavior of these structures to meet safety objectives while containing construction and maintenance costs[3]. Loading conditions of liquid storage tanks subjected to earthquakes are very complex. Beside the inertial force due to the weight of the tank walls, the hydrodynamic pressures are also applied on the tank walls. As the nonlinear hydrodynamic pressure loads are strongly dependent on the input of ground motion, in this study, circular 50 kl reinforced concrete tanks are subjected to seismic ground motions of different staging pattern with varying height is used. The results of this study will provide useful information on the response of concrete tanks subjected to seismic ground motions.

Hydrodynamic Pressure[2]

Fig. 1(a) shows a 3-D circular tank. It is assumed that the liquid storage tank is fixed to the rigid foundation and a Cartesian coordinate system (x, y, z) is used. The fluid filled in the circular tank is of height, Hl above the base. The fluid is considered to be ideal, which is incompressible, invicid, and with a mass density ρ. Two mass model for elevated tank was proposed by Housner (1963) which is more appropriate and is being commonly used in most of the international codes including Draft code for I S 1893 (Part-II) [3]. The pressure generated within the fluid due to the dynamic motion of the tank can be separated into impulsive and convective parts. The liquid in the lower region of tank behaves like a mass that is rigidly connected to tank wall. This mass is termed as impulsive liquid mass which accelerates along with the wall and induces impulsive hydrodynamic pressure on tank wall and similarly on base Liquid mass in the upper region of tank undergoes sloshing motion. This mass is termed as convective liquid mass and it exerts convective hydrodynamic pressure on tank wall and base. For representing these two masses and in order to include the effect of their hydrodynamic pressure in analysis, spring mass model is adopted for ground-supported tanks and two-mass model for elevated tanks. Figure 1.Two mass model for elevated tank. In spring mass model convective mass ($m_c$) is attached to the tank wall by the spring having stiffness ($k_c$), where an impulsive mass ($m_i$) is rigidly attached to tank wall.

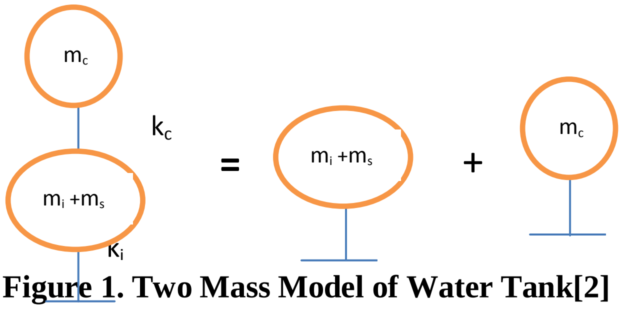



**Figure 1. Two Mass Model of Water Tank[2]**

Shallow and Slender Tanks [2]

For a cylindrical storage tank of radius R, containing an incompressible liquid of mass density (ρw) of the liquid. Filled to a depth H, the total mass of liquid is given by.

m = πR2H ρw (1.4) Shallow tank

A shallow tank is one with height to the radius ratio of less or equal to 1.5. The lumped mass model for this case is as shown in Fig. 2 It consists of a mass, mi, moving with the rigid tank wall producing the impulsive force and a mass mc, producing the convective force.

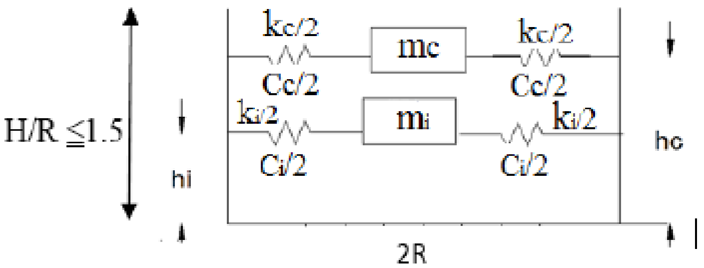



**Figure 2. Shallow Tank- Lumped mass approach for H/R ≤1.5 using Housner's method [2]**

The heights of these masses were located on the basis of producing the correct moment about the base. These heights are designated by the letters hi and hc as shown in Fig. 2. The heights hi and hc are used to calculate the bending moments about the base of the structure. The bending moment just above the base is resisted by the shell[2].

$$h_{i=}\frac{3}{8}H \quad (1.1)$$

$$h_{i=}H\left[1-\frac{cosh\left(\frac{1.84H}{R}\right)-1}{\frac{1.84H}{R}.Sinh\left(\frac{1.84H}{R}\right)}\right] \quad (1.2)$$

$$\frac{m_i}{m}=\frac{\tanh\left(0.866\frac{D}{h}\right)}{0.866\frac{D}{h}} \quad (1.3)$$

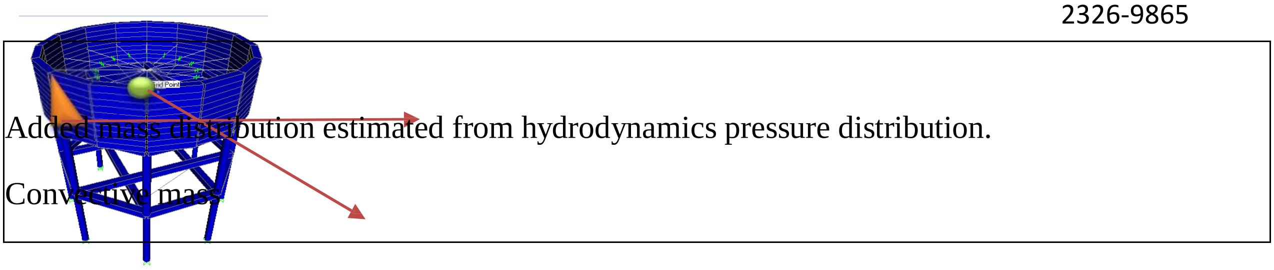
$$\frac{m_c}{m}=0.23\frac{\tanh\left(3.68\frac{h}{D}\right)}{\frac{h}{D}} \quad (1.4)$$

**AnalyticalInvestigation**

Finite element model (FEM) considered for the elevated tank-fluid system in this study as given in fig.1 degree of freedom at base models were fixed and other left free. Columns and beams were modelled with frame element, wall modelled with shell element. Added mass approach is used in this study. In this approach, two masses which are obtained in different height from the ground level of tank are determined. Impulsive mass added finite element of tank wall in accordance with height level calculated for the impulsive mass. The convective massplaced in the center of tank at the level of calculated height. This mass connected to the finite element of wall with spring having stiffness of 30653(kg/m) along the axis symmetrical direction.

**Table 1. Details of various parameters of tank**

| Wall thickness (m) | Bottom slab thickness (m) | Column size (m) | Nos. Of column | Beam size (m x m) | Impulsive masses (kg) | Stiffness of convective mass (kg/m) | Distribution of convective mass along all eight direction (kg) | Height of application of mass along height (m) from base of tank |
|---|---|---|---|---|---|---|---|---|
| 0.2 | 0.2 | 0.23 Diam. | 8 Nos. | 0.23 x 0.23 | 17183 | 30653 | 1915 | 0.91 |
| | | | | | | | | |




2. Responseof 50 kL Water Tank Under IS 1893 Response Spectra[3]

The behavior of the tank to seismic forces was studied under three conditions namely, basic staging pattern, radial staging pattern, cross staging pattern with varying height of staging from 5m,15m,30m,35m. Time period for various conditions are shown in Table 4

| Staging Height | StagingPattern | TimePeriod |
|---|---|---|
| 5m | Basicstaging | 0.492541 |
| | Radialstaging | 0.485484 |
| | Crossstaging | 0.485779 |
| 15m | Basicstaging | 1.077472 |
| | Radialstaging | 1.073297 |
| | Crossstaging | 1.072085 |
| 30m | Basicstaging | 1.823094 |
| | Radialstaging | 1.891466 |
| | Crossstaging | 1.888059 |
| 35m | Basicstaging | 2.063844 |
| | Radialstaging | 2.181467 |
| | Crossstaging | 2.174315 |

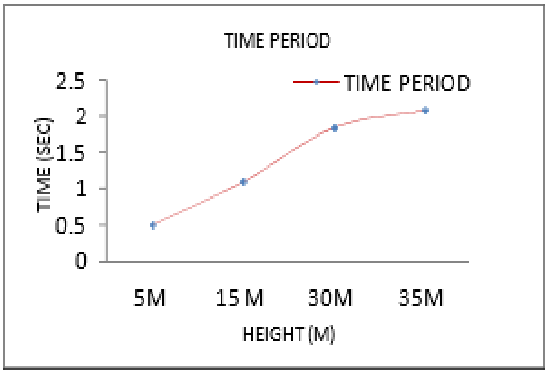
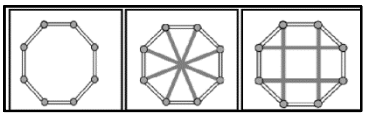
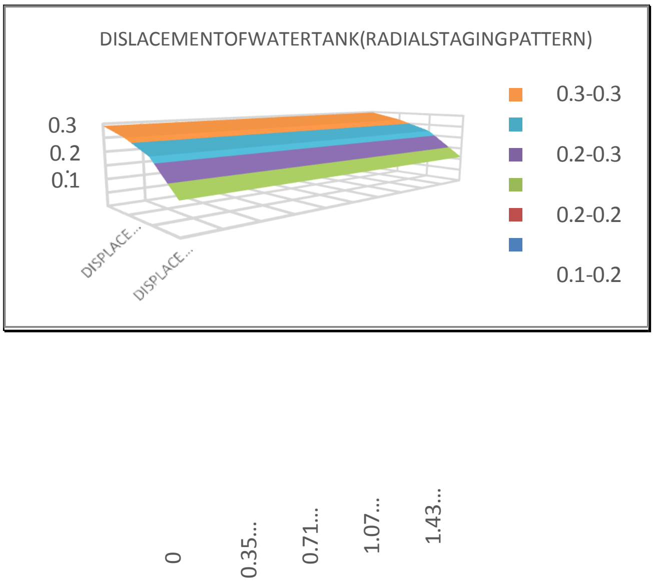



**Figure No.3 Time period of water tank with Different Bracing pattern**



1.Basic 2. Radial 3. Cross -Figure No.4 Different Staging pattern

3. Responseoftankwall under is1893responsespectra



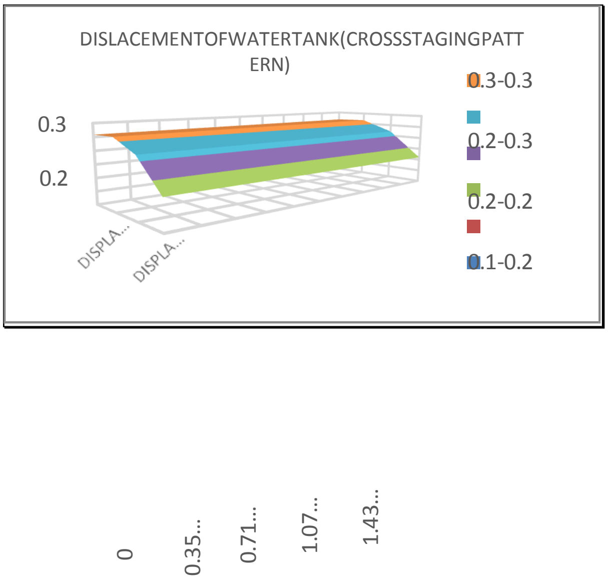




fig.5 fig.6

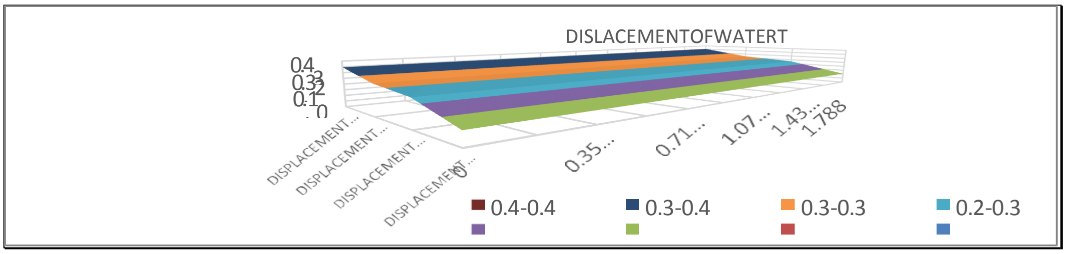
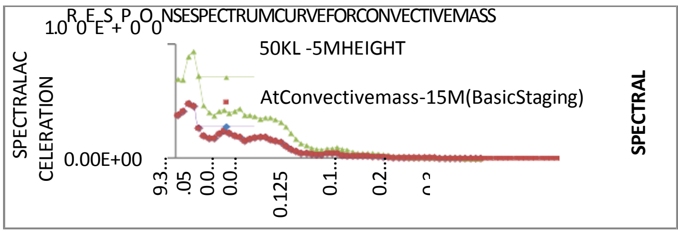
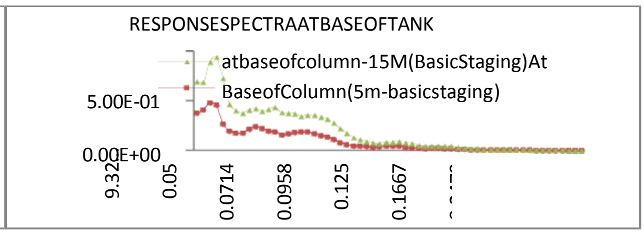



**Figure No.5 Displacement of Water Tank with Different Bracing Pattern**

The variation of maximum displacement of the models with various staging patterns are analysed is shown in figure 7. On an average, the displacement of the tank with basic andcross type of bracing pattern increased by13.42%and 16% respectively for soft soil, 10% for medium soil and 18% for hard soil when compared to radial system.

2. ResponsespectrumcurveforbasicstagingpatternunderIS1893response spectra



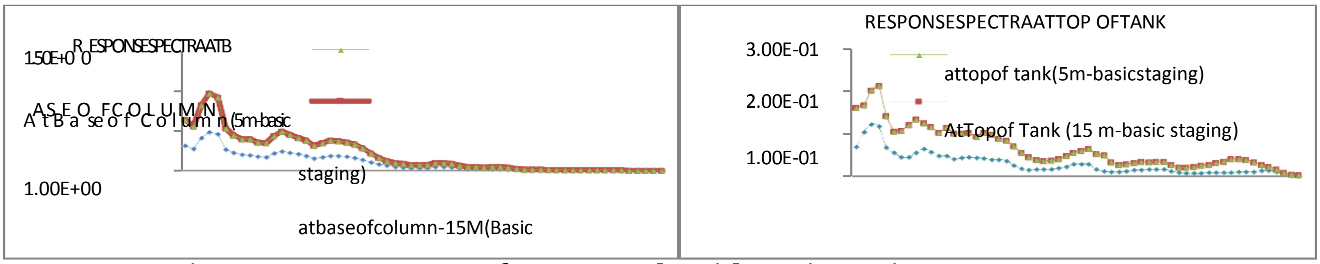



**Figure No.6Responses ofWater Tank With Basic staging Pattern**

4. Response spectrum curve for cross staging pattern under IS 1893 response spectra

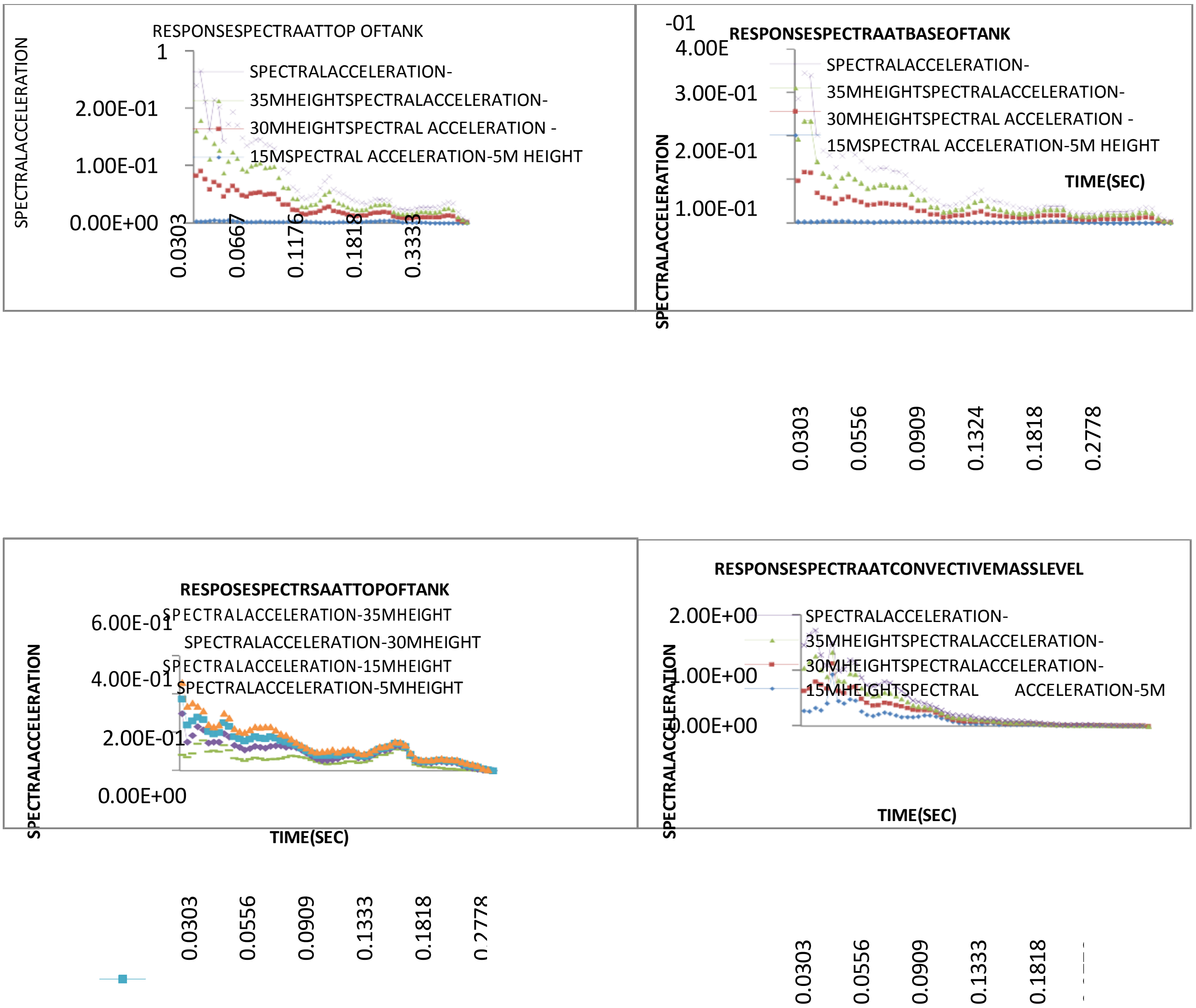



**Figure No.7 Responses of Water Tank With cross staging pattern**

5. Displacement of tank under IS 1893 response spectra

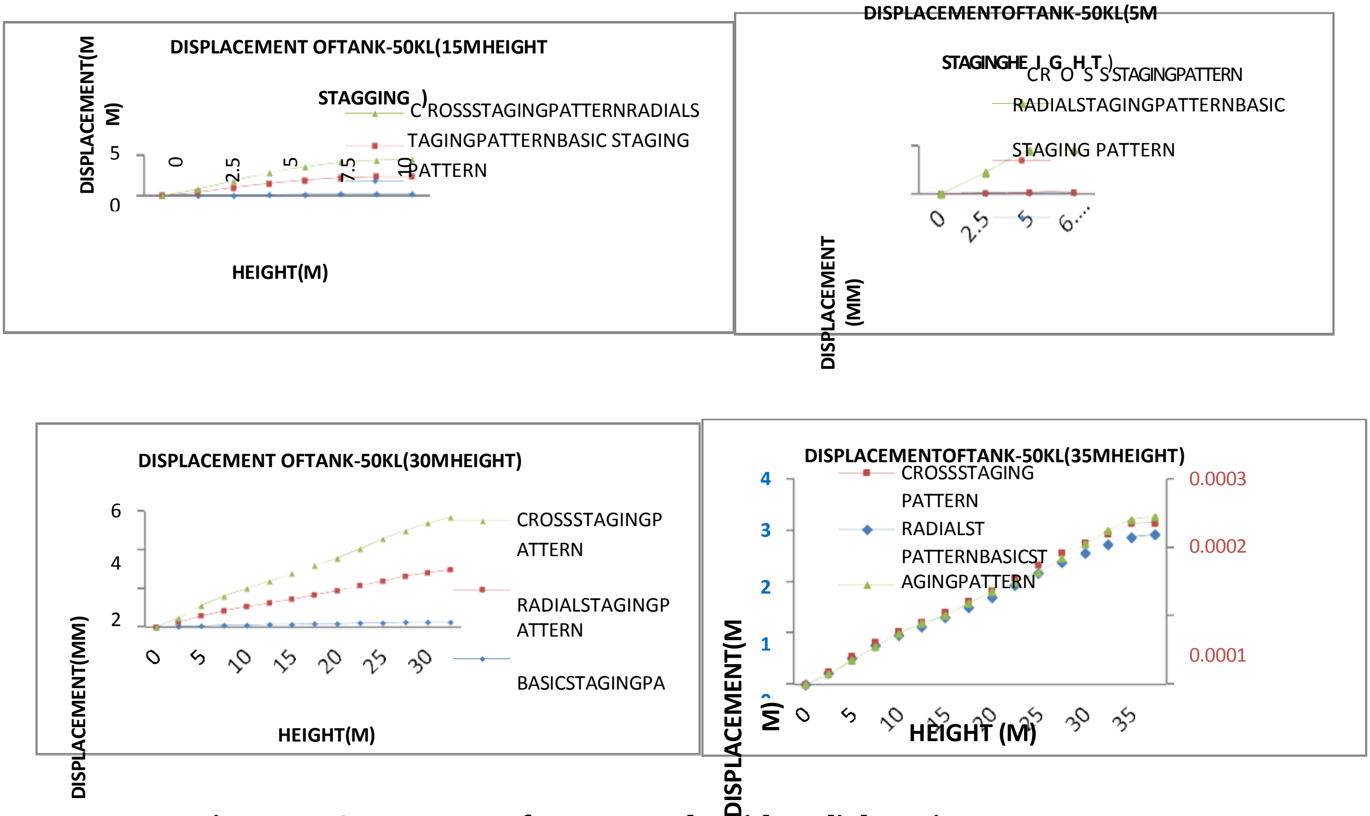



**Figure No.8Responses of Water Tank With radial staging pattern**

The behaviour of different staging pattern has been analysed by using IS-1893 response spectra, it is observed that the basic staging pattern requires more attention as compared to radial and cross staging pattern.

## Conclusion

From response spectrum curve of staging pattern, it is concluded that all staging height behaves satisfactory i.e. Response spectra value gets under controlled value of applied response spectra from IS-1893-2002.Only it is found that response for increasing height of staging slightly decreases. In radial and cross staging pattern the response obtained for convective mass is less with increasing height of staging but in all over position the response increases with increase in height of staging. Time period of tank increase with increase in height of staging due to the fact that structure become flexible with increase of height of structure.

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