Structural Assessment of RCC Elevated Service Reservoir For Different Capacity

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ABSTRACT. Elevated service reservoir is one of the maximum important infrastructures that is utilized by society. Our every day existence relies upon at the water supply, that is procured through an elevated service reservoir. Therefore, the safety of the service reservoir is of utmost importance. Most of the damage on elevated service reservoirs is caused by an earthquake, as the horizontal forces acting on the structure make the service reservoir vulnerable. Our predominantly study is based on extracting the dynamic forces mainly to determine critical condition of the structure. In this paper, different capacities of elevated service reservoir are taken and the design and analysis are done according to Indian standards. Dynamic analysis of the service reservoir is done and parameters such as time period, hydrodynamic pressure, base shear, base moment are compared with different capacities. Hence, the capabilities of the structure are substantially necessary to examine within the sub-continent region.

1. INTRODUCTION

Civil Engineering had always played an important role right from the ancient civilization, whether its canal system of Harappa or road construction in Rome, it was always a part of our culture. As time moves on, the use of infrastructure has improved by a substantial amount. The discovery of cement, concrete, steel is used as reinforcement brings the revolution in it. In today's scenario, the stature of any country is decided by the infrastructure development done by them. Many developed and developing countries are focusing to enhance the structural ecosystem such as the creation of extensive highways for faster transportation, bridges, and tunnels to connect offshore areas, Dams and power plants for storage and electricity generation, High rise structure for housing, WTP and STP for utilisation and collection within the distributing system of water. Elevated water reservoirs are also part of this water distribution system. These are primarily small artificial reservoirs that collects largely water and these water then distributed to unit via gravity flow. This ESR has high strength and durability, but they are vulnerable to lateral forces like earthquakes [1], mainly because of the large mass concentration at the top. Hence, the capabilities of the structure are much necessary to visualize within the sub-continent region.[2]
2. METHODOLOGY

When elevated service reservoir are subjected to earthquake, a strong lateral forces are generated, causing the reservoir to oscillate. These fluids are comprises two parts, the container and the fluid kept in it. When lateral forces are induced, the bottom portion of the fluids undergoes oscillations along with container walls. This portion is called impulsive fluids mass ($m_i$) and creates impulsive hydrodynamic pressure. Similarly, the top portion goes under sloshing phenomena. This portion is called as convective fluids mass ($m_c$) and it creates convective hydrodynamic pressure.[3] To analyze their effect, model mass system is used. Since this system contain both container and fluid, two mass system are more effective than one mass system. A two mass system means it has two degrees of freedom, but these are obtained as two single degrees of freedom because of their difference in time period. Following figure 1 shows idealization of two mass system. The structural mass ($m_s$) within the system is that the container mass additionally to at least one third mass of staging and ($k_s$) being lateral stiffness of staging.

![Figure 1. Two mass idealization of elevated tank and equivalent uncoupled system.](image1)

3. PROBLEM STATEMENT

For the analysis of the elevated service reservoir, four different capacities of the tank are taken in such a way that h/D ratio was maintained in an increase of 0.05. Where h is the depth of water and D is the inner diameter of the tank.[4] The design of the ESR is done by using staad pro in accordance with IS 456 [5] & IS 3370 [[6]-[7]]. figure 2 demonstrate staad model of 500 m3 capacity and seismic design is executed via way of means of the usage of Indian Standards 1893 Part2 [8], design statistics are taken as M25, Fe500, EC=25000 Mpa.[9]. Following Table 1. provides design constant values while Table 2 provides calculation of component of water tank, Table 3 gives data of load acting on component in ESR.

![Figure 2. Water tank of capacity 500 m3](image2)
Table 1. Design constant

| Seismic Zone | III |
|--------------|-----|
| Z            | 0.16|
| I            | 1.5 |
| R            | 2.5 |
| Soil         | Medium |

Table 2. Design element of water tank

| Capacity (m³) | D (m) | H (m) | Wall thk (m) | H/D | Bottom slab Dia (m) | Bottom slab thk (m) | No. of column |
|---------------|-------|-------|--------------|-----|---------------------|---------------------|---------------|
| 50            | 5.7   | 2     | 0.20         | 0.35| 6.1                 | 0.2                 | 4             |
| 100           | 6.9   | 2.8   | 0.20         | 0.4 | 7.3                 | 0.2                 | 6             |
| 250           | 9     | 4     | 0.20         | 0.45| 9.4                 | 0.250               | 8             |
| 500           | 11    | 5.5   | 0.25         | 0.5 | 11.6                | 0.350               | 10            |

Table 3. Load Calculation Of Water Tank (in KN)

| Container | Roof Slab | Top Ring Beam | Cylindrical wall | Weight of water | Floor Slab | Bottom Ring Beam | Column Load | Bracing Load |
|-----------|-----------|---------------|------------------|-----------------|------------|------------------|-------------|--------------|
| 50        | 118.37    | 8.95          | 185.56           | 510.35          | 118.94     | 21.56            | 193.75      | 144          |
| 100       | 173.5     | 16.26         | 242.93           | 1047            | 205.91     | 43.45            | 353.43      | 216          |
| 250       | 295.57    | 28.28         | 466.6            | 2544.7          | 453.17     | 63.62            | 570.2       | 288          |
| 500       | 441.6     | 64.8          | 1266.32          | 5226.83         | 924.73     | 273.46           | 848.23      | 333          |

4. RESULT AND ANALYSIS

4.1. Time period
Time Period of impulsive mode and convective mode are analysed with respect to empty and full condition. Figure 3 gives H/D vs Time Period for full tank and Figure 4 gives H/D ratio for Empty tank.
4.1.1. Full Tank condition

![Figure 3. H/D vs Time period](image)

4.1.2. Empty tank condition

![Figure 4. H/D vs Time period](image)

4.2. Base Shear

Base shear determines maximum dynamic force acting on base of body. Figure 5 gives base shear for both full and empty condition.
Figure 5. Base shear vs capacity m³

4.3. Base Moment
Overturning moment is extracted in accordance with empty and full condition of tank. Figure 6 provides base moment for impulsive and convective mode.

Figure 6. Base moment vs capacity m³

4.4. Hydrodynamic Pressure
It acts on surface of ESR during horizontal excitation of structure. In given below Figure 7, hydrodynamic pressure is the resultant of convective and impulsive pressure on wall and pressure due to inertia and excitation of wall.
4.5 Sloshing height
Sloshing height in Figure 8 represent maximum value of height at which fluid can reach during seismic forces. Free board of container depends on sloshing height.

5. CONCLUSIONS
- Time period of convective mode is larger compared to impulsive mode and the tank in full condition has more time period compared to empty condition.
- Tank fully condition has additional base shear compared to tank in empty condition and because the capability will increase the distinction between them increases.
- Base moment in full tank condition increases rapidly compared to base moment in empty tank condition, but the increase is linear.
• Hydrodynamic pressure increases linearly with respect to h/D ratio, but the increase in hydrodynamic pressure is more compared to the increase in h/D ratio.
• Sloshing height increases linearly with respect to h/D ratio, and the increase in both sloshing height and h/D are almost equal.

6. REFERENCE

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