AN EXPERIMENTAL INVESTIGATION OF A RECTANGULAR TANK FREEBOARD ON THE IMPACT ROOF PRESSURE

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Keywords: Experimental Investigation, Liquid Storage Tanks, Roof Pressure, Roof Total Force

Large amplitude liquid sloshing and applied loads caused by hydrodynamic pressure of this phenomenon are always one of the most important factors in designing liquid storage tank roofs, especially in LNG (Liquefied Natural Gas) tanks (Malhotra, 2005).

Codes approach in dealing with this matter is to provide sufficient freeboard in order to prevent liquid collision to the tanks roof. However, due to the technical reasons, providing a proper freeboard is not always an optimum solution. Therefore, the impact forces should be reasonably evaluated based on the experimental measurements and analytical solutions. In this paper, an investigation has been implemented in order to clarify the influence of various geometrical parameters on the impact roof pressure and force values of a rectangular tank (ACI, 350).

In this regard, a series of shaking table tests are conducted at International Institute of Earthquake Engineering and Seismology. The dimensions of rectangular tank are $100\times100\times30$ (height$\times$length$\times$width). The tank comprises of plexiglass with a thickness of 1cm. The tank is excited by harmonic oscillation with amplitude of 1 and 3 cm for various tank aspect ratios and freeboards. In addition, there are four force transducers and one pressure transducer mounted on the roof. The tank model is shown in Figure 1.

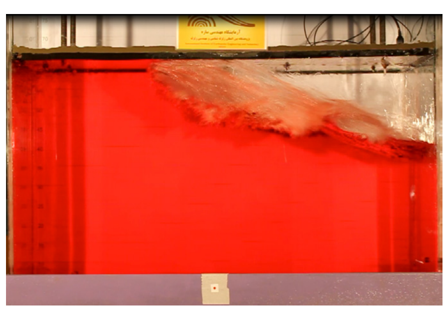

Figure 1. Tank model excited by harmonic oscillation

As an example, the time histories of total roof force and roof pressures at a specific point placed on the roof are shown in Figures 2 and 3.

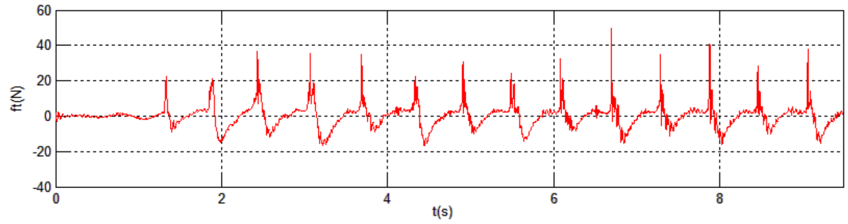

Figure 2. Time history of total roof force for harmonic oscillation with the amplitude of 1cm

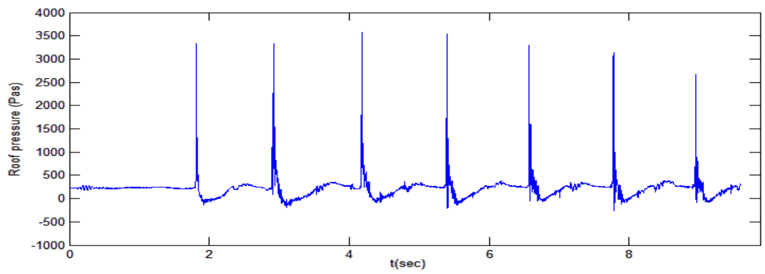

Figure 3. Time history of roof pressure for harmonic oscillation with the amplitude of 1cm

The maximum values of impact pressure and related forces are presented in Figures 4 and 5. As can be seen, increase in the freeboard heights results in enhancement of impact pressure and force values of tank roof. It should be noted that force enhancement continues up to a specific freeboard height and then the line slope becomes negative. Therefore, it can be concluded that there is an optimum freeboard height in tanks for different liquid height levels. The reason of this issue would be justified by the fact that the higher freeboard lets the liquid to increase the wave velocity. However, due to the increment of liquid inertia, this trend does not continuous after a certain freeboard height. The optimum value of freeboard height directly affects the roof resistance designing system.

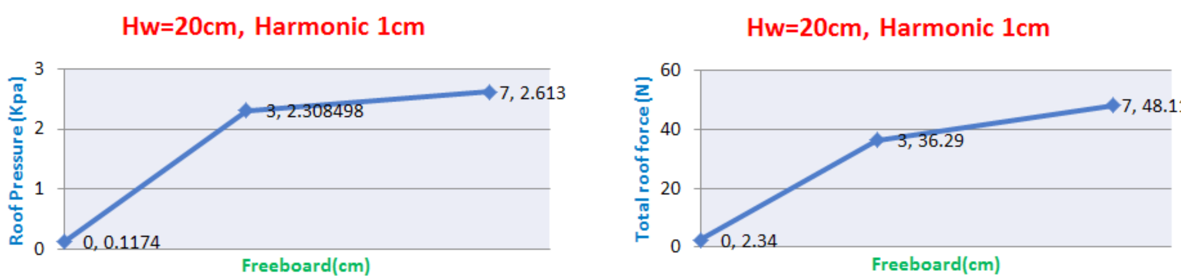

Figure 4. Roof pressure and force values of different freeboard heights for H_w=20 cm

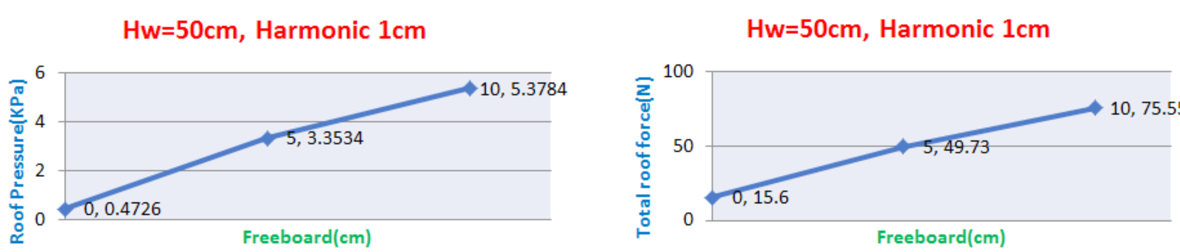

Figure 5. Roof pressure and force values of different freeboard heights for H_w=50 cm

REFERENCES

American Concrete Institute (ACI) Committee 350 (2006) Seismic design of liquid-containing concrete structures (ACI 350.3-06) and commentary (350.3R-06), ACI 350.3-06, Environmental Engineering Concrete Structures, Farmington Hills, MI

Malhotra PK (2005) Sloshing loads in liquid-storage tanks with insufficient freeboard, *Earthquake Spectra*, 21(4): 1185-1192