Earthquake-Induced Response of Cylindrical Liquid-Containing Tanks

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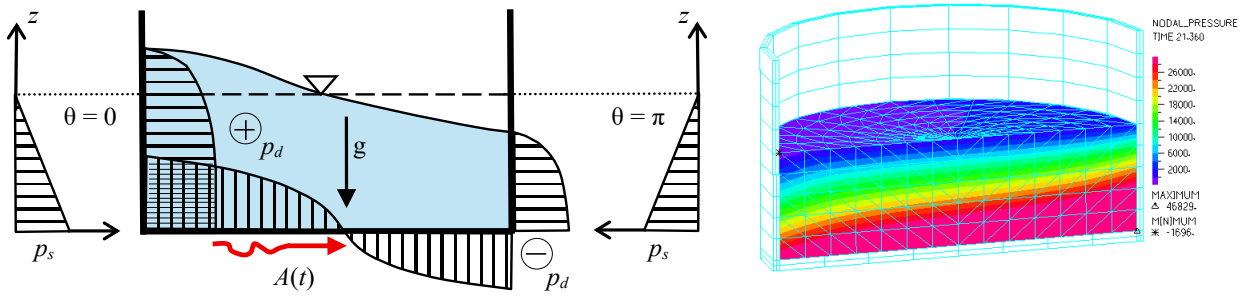
Liquid-containing cylindrical tanks are widely used in water distribution systems as well as in various industrial sectors for the storage of potable water, fire protection water, crude oil, chemicals, and other liquids, including toxic and flammable substances. The seismic response of liquid-containing tanks differs significantly from that of conventional buildings. During seismic excitation, the liquid inside the tank generates additional hydrodynamic forces acting on the tank walls and base. These forces arise from the interaction between the structure and the contained fluid. The dynamic behavior of the liquid can be described as a superposition of two main components: an impulsive (rigidly moving) component and a convective component associated with the sloshing motion of the free liquid surface [1].

The finite element method (FEM) is widely used to analyze fluid-structure interaction in liquid-containing tanks, particularly under seismic loading. The tank is modeled using structural elements, while the fluid domain is represented by fluid elements. Their interaction is captured through coupling conditions at the interface, ensuring displacement compatibility and force equilibrium [2].

Figure 1a illustrates the hydrodynamic effect of the fluid on the structural domain of the tank. The total pressure acting on the tank structure is evaluated as the sum of the hydrostatic pressure p_s and the hydrodynamic pressure p_d. Figure 1b presents results from a numerical simulation carried out using the finite element method (FEM), showing the distribution of total pressure in the fluid domain within the tank under seismic loading condition.



a) b)

Figure 1. Liquid-containing tank, a) scheme of structure of fluid pressure, b) total pressure distribution in the fluid domain during earthquake.

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