Seismic response of flexibly supported liquid storage tanks and its application to Eurocode 8

J. Habenberger and J. Schwarz

The dynamic behaviour and the activated pressure distributions of anchored liquid storage tanks under earthquake excitation are mainly determined by the interaction of the flexible tank wall with the containing liquid and by the interaction of the tank with the supporting soil.
In view of damages to tanks observed in recent earthquakes question arises whether design practice and guidelines suggested in seismic codes are appropriate. In a recently finished research project comprehensive parameter studies were performed by a finite element model to provide the background for checking the capability of seismic design procedures. Critical pressure distributions during seismic actions are examined which may related to the peaks of the dynamically activated mass, the overturning moment and the pressure ordinates.
Special consideration is given to Part 4: "Silos, tanks and pipelines"of Eurocode 8 (prEN 1998-4) which has to transverted into its final stage in 2002. For strength and stability verifications the maximum stresses resulting from dynamically activated pressures have to be determined. In seismic codes, the interaction between the tank and subsoil is calculated by assuming a rigid basement. In reality, the foundations of storage tanks are often very flexible. Therefore, an engineering design procedure is proposed to take into consideration the flexibility of the foundation. Impedance functions are derived for a circular plate resting on the elastic half space under anti-metric harmonic load (circumferential wave number n = 1).
The impedance functions are implemented into simplified mechanical models according to the substructure method enabling the determination of the interaction between tank and subsoil in the frequency domain. With the proposed models (see Figure 1), the effect of foundation flexibility on the dynamic characteristics and the response of the tank-fluid-soil system can be considered. Damping and frequency values of the decoupled mechanical model were derived providing the basis for code-related response-spectra-calculations (Fig. 1).
The reliability and capability of the developed approach will be verified by the comparison of results with those of finite element calculations using special boundary conditions to consider the energy absorbing properties of the infinite soil.

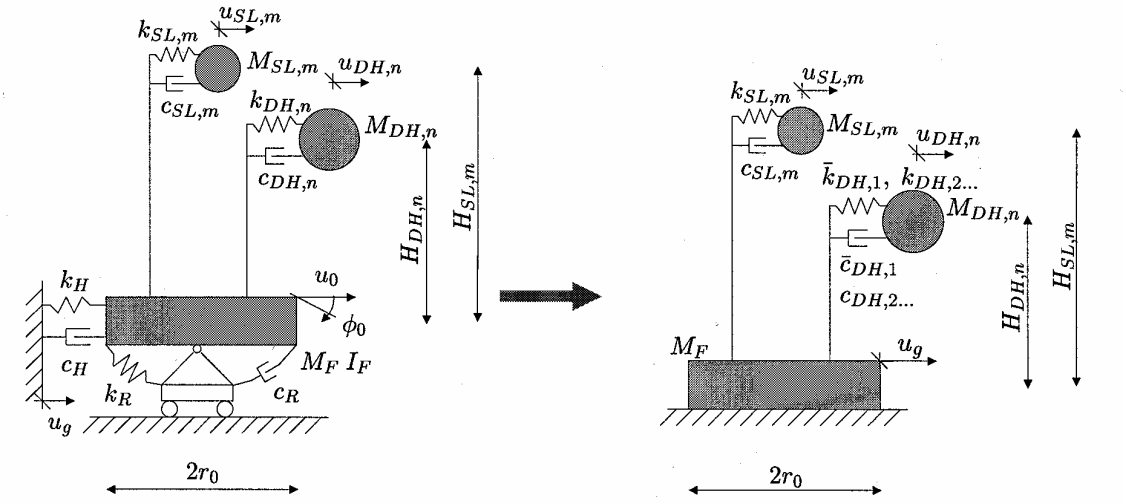

Fig. 1. *Proposed coupled and decoupled simplified model of tank-fluid-soil system.*