A Tuned Liquid Damper Model

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For some large structures, structural damping alone has been insufficient to limit the dynamic motions to acceptable levels for serviceability considerations (e.g. the review paper by Kareem et al. 1999). Thus, auxiliary dampers have been added. Designers are faced with the task of understanding complex fluid-structure interactions when attempting to estimate energy dissipation performance of, for example, tuned sloshing dampers. To this end, a numerical wave tank can provide useful information on the free surface motions, resonant frequencies, etc.

In the present paper, the nonlinear effects of sloshing motions in moving liquid tanks (Frandsen 2002) are investigated in connection with using tuned liquid dampers (TLD) to suppress structural vibrations in tall buildings or other structures to along-wind or cross-wind forces. The current, fully nonlinear model simulates two-dimensional, non-overturning waves during structural vibrations. Numerical solutions of the governing nonlinear potential flow equations are obtained using a finite-difference time-stepping scheme on adaptively mapped grids.

Simulations of sloshing motions in forced excited tanks are carried out in which tank size and fluid-to-structure mass ratio is varied. Natural frequencies of the structure-TLD system are extracted for small to steep amplitude waves. All results obtained show that the coupling of a liquid storage tank to a structure can change the behaviour of the entire system considerably. An optimum TLD-structure system is identified relative to shift in resonance frequency. Good agreement for small horizontal forcing amplitude is achieved between the numerical model and first order small perturbation theory. The dependence of the nonlinear behaviour of the solution on the wave steepness is discussed. It is found that nonlinear effects become important when the steepness reaches about 0.1.

References

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