Tuned Liquid Damping Problem

SPHERIC Test9

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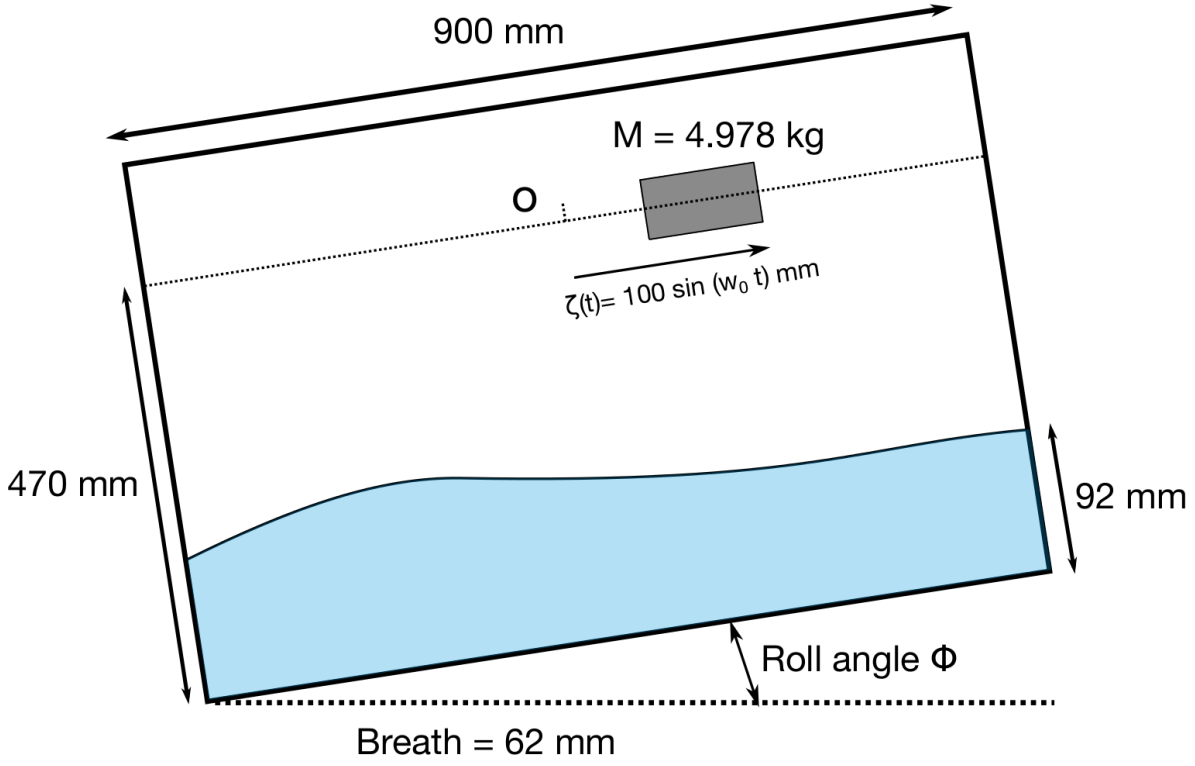
LSDYNA ICFD solver

Dev version SVN 108068

Case Description

The tank, initially in equilibrium, is free to rotate and its movement is induced by a weight that has a prescribed periodic movement along an initially horizontal rail attached to the rotation center of the tank which periodically displaces the center of gravity. The breaking waves and sloshing dynamics of the fluids placed inside the tank affect the damping characteristics of the system.



Case Description

The analytical model used to describe the behavior of the system is described in the following equations:

$$[I_0 + m\xi_m^2(t)]\ddot{\phi} + 2m\xi_m(t)\dot{\xi}(t)\dot{\phi} - gS_G sin(\phi) + mg\xi_m(t)cos(\phi) = Q_{damp}(t) + Q_{fluid}(t) \quad (1)$$

$$Q_{damp}(t) = -K_{df} sign(\dot{\phi}) - B_\phi \dot{\phi} \quad (2)$$

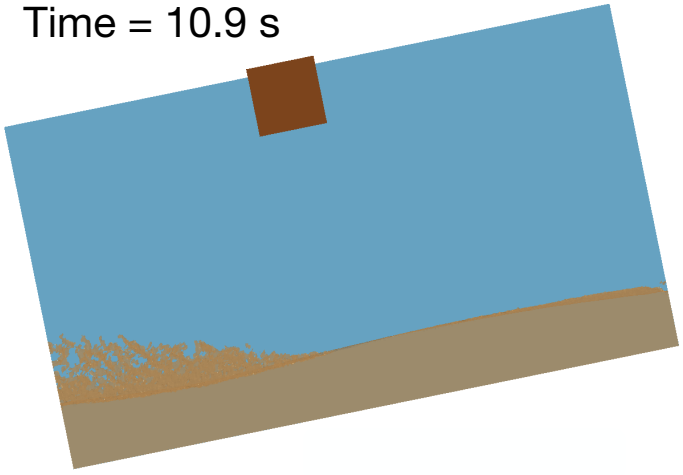
ϕ the roll angle, g the gravity constant, I_0 and S_G the polar moment of inertia and static moment of the rigid system with respect to the rotation center, $\xi_m(t)$ and $\dot{\xi_m}(t)$ the moving mass position and velocity, K_{df} the dry friction coefficient, B_ϕ the linear damping coefficient and $Q_{fluid}(t)$ the damping moment introduced by the fluid to be captured by the simulation.

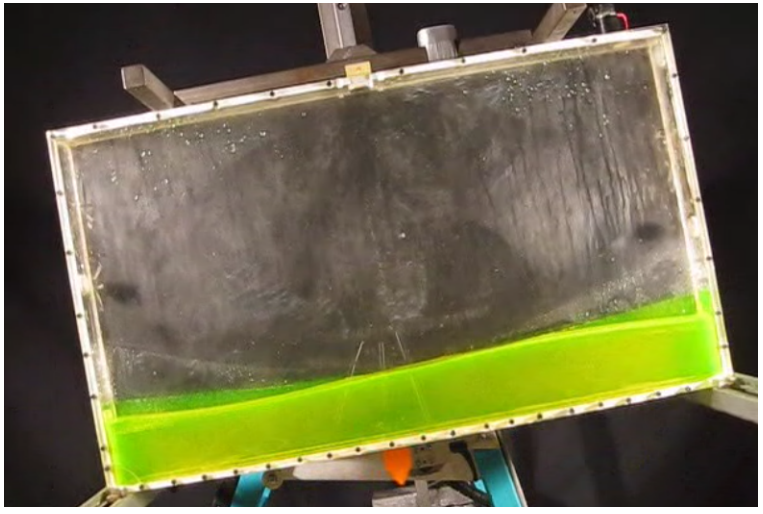
Quantity	Units	Value
S_G	$kg.m$	-29.2
I_0	$kg.m^2$	26.9
K_{df}	$N.M$	0.540
B_ϕ	$N.m.rad^{-1}.s$	0.326
w_0	$rad.s^{-1}$	3.26

Three fluids are tested, water with $\rho = 998\ kg.m^{-3}$ and $\mu = 8.94e^{-4}\ kg.m^{-1}.s^{-1}$, oil with $\rho = 990\ kg.m^{-3}$ and $\mu = 0.045\ kg.m^{-1}.s^{-1}$ and glycerin with $\rho = 1261\ kg.m^{-3}$ and $\mu = 0934\ kg.m^{-1}.s^{-1}$

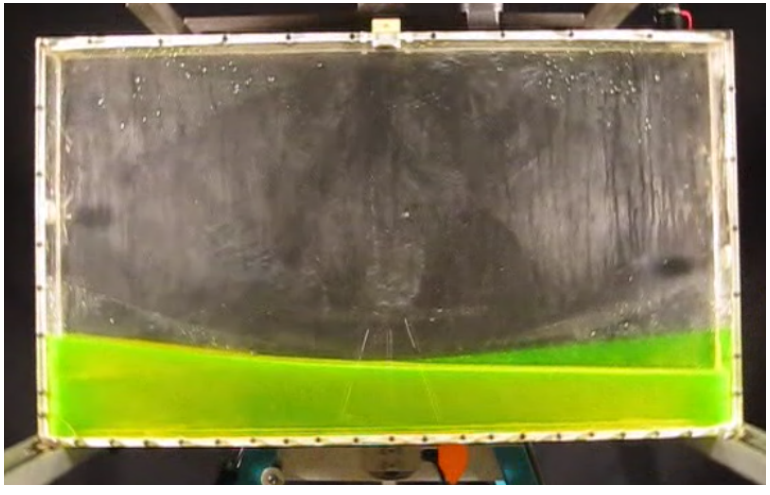
Results- Fringes- Glycerin

Time = 10.9 s



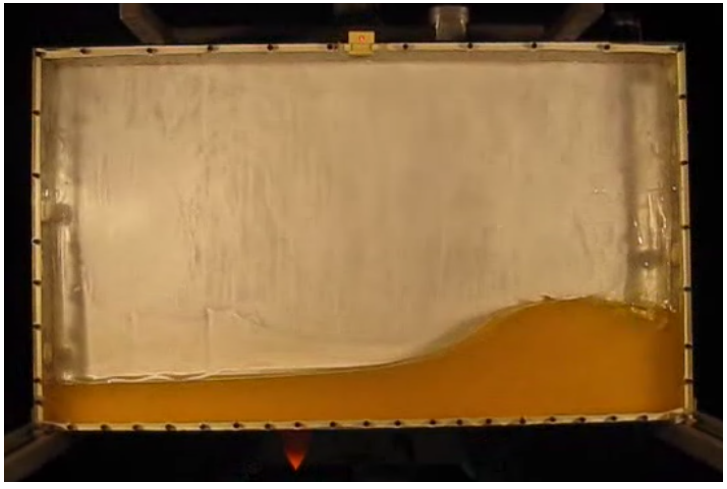


Time = 11.4 s

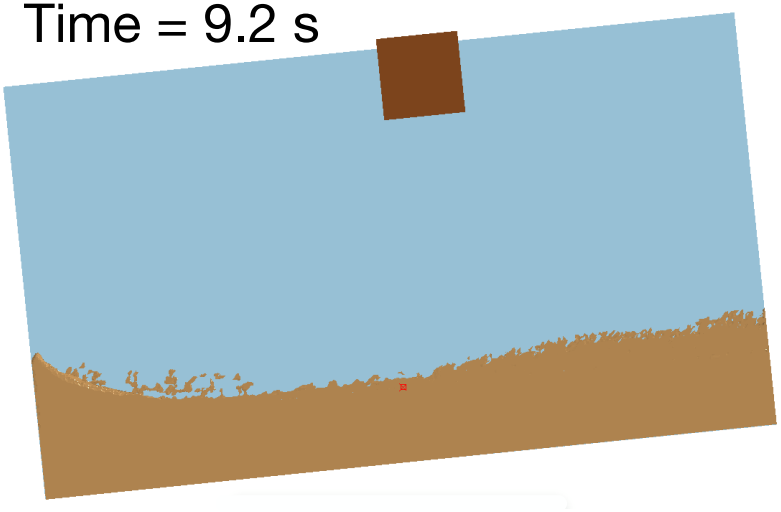


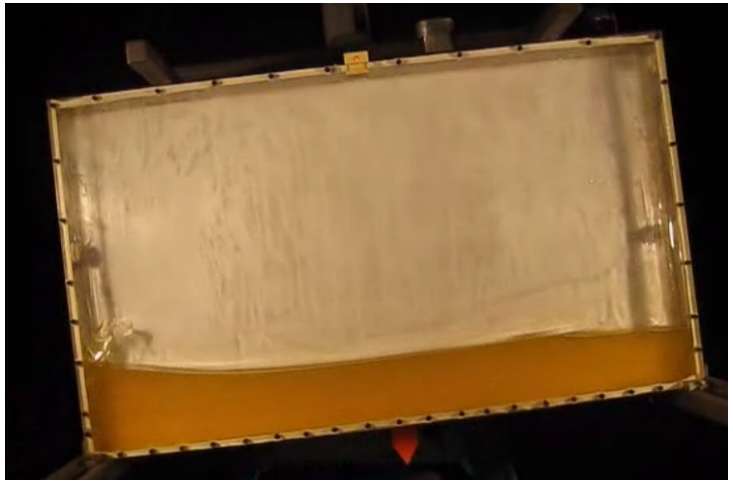
Results- Fringes- Oil

Time = 8.6 s

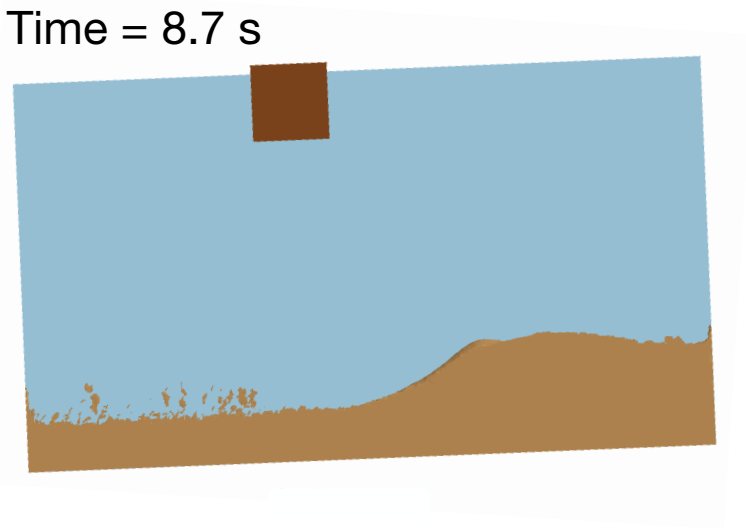


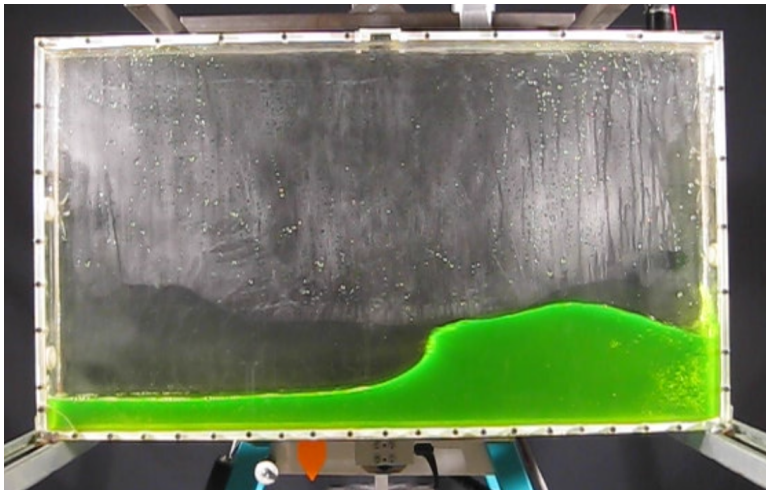
Time = 9.2 s

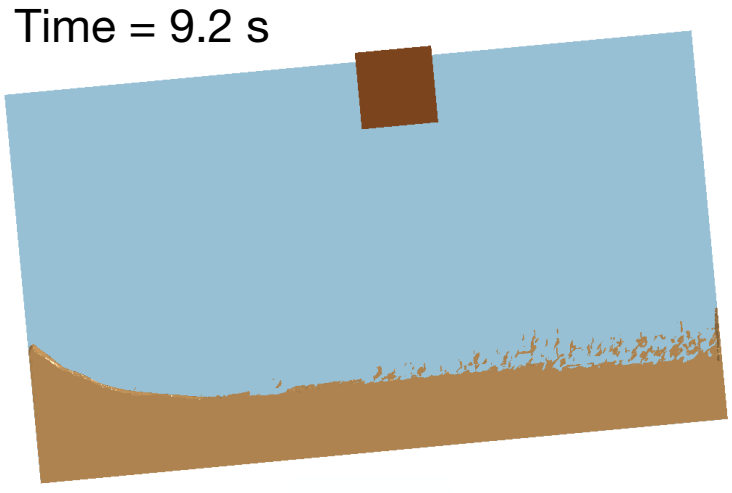


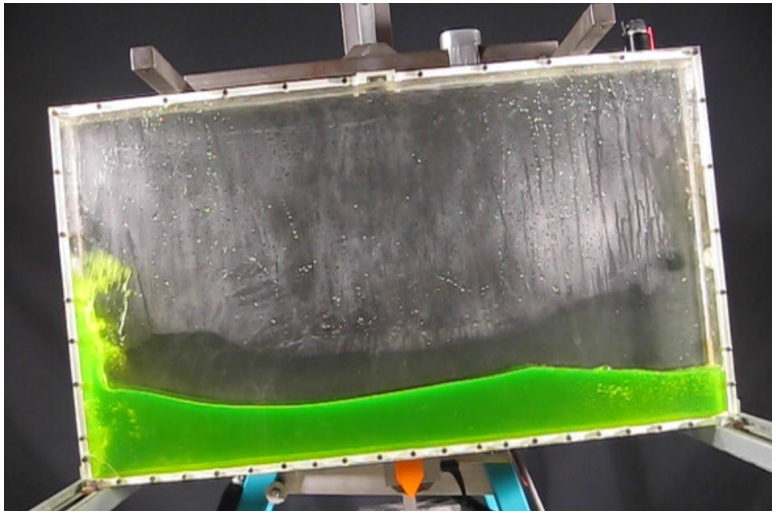


Results- Fringes- Water

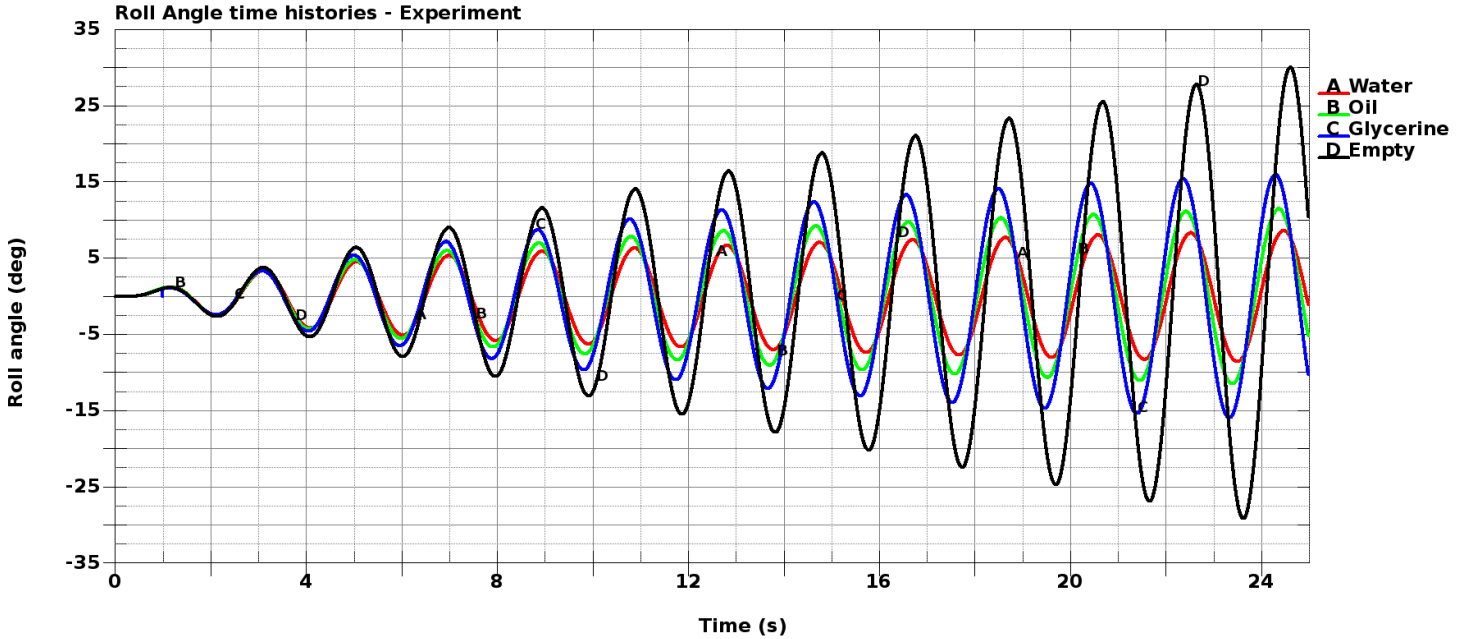


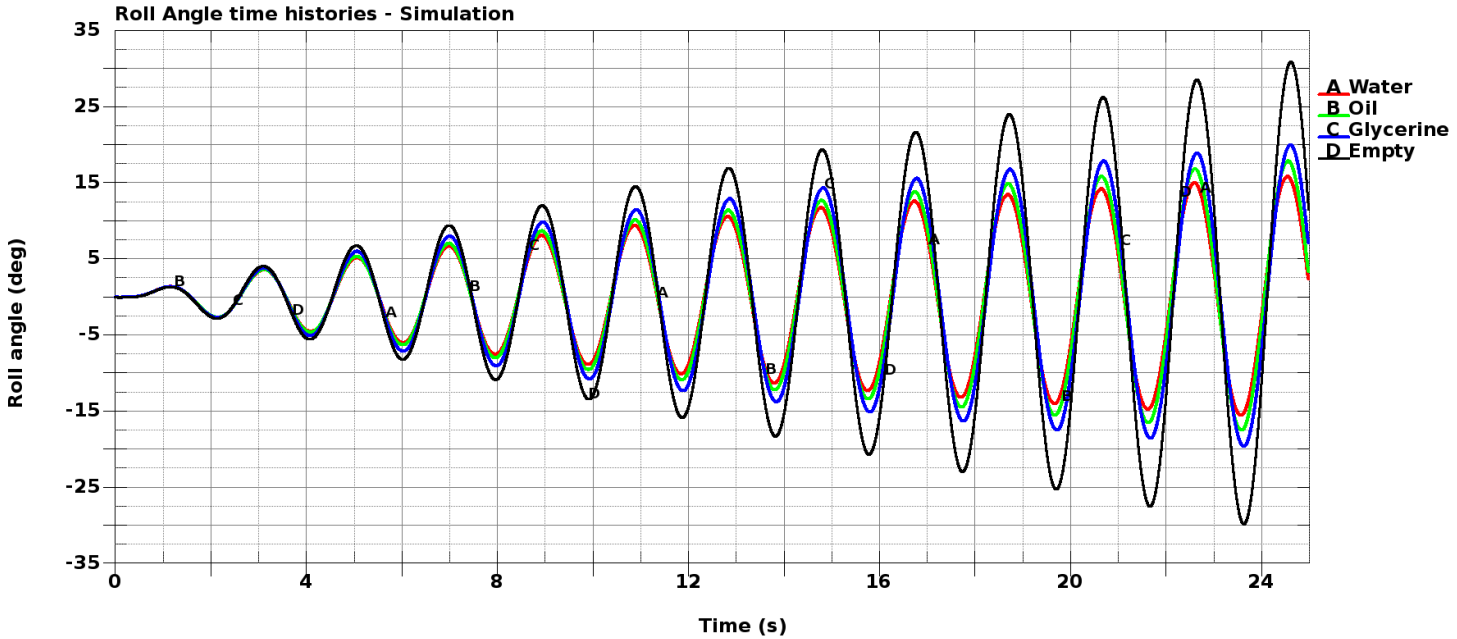




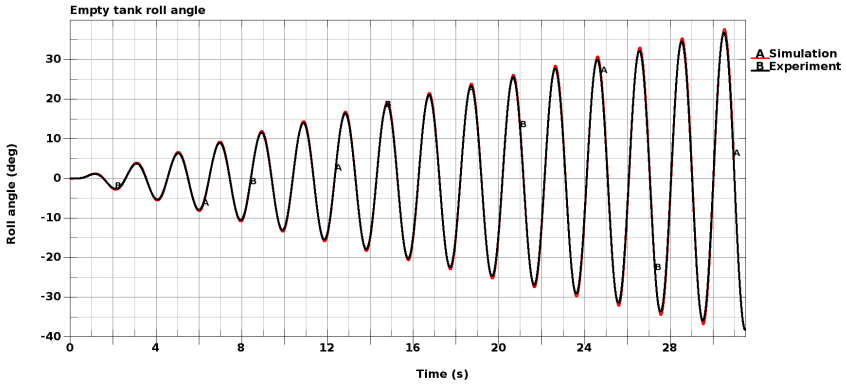


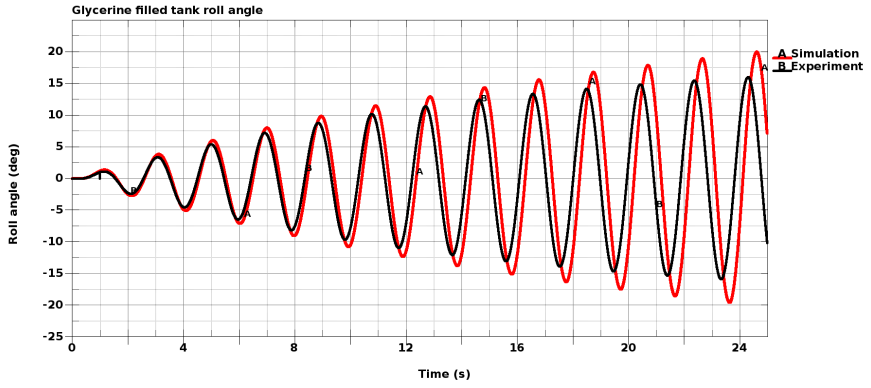
Results- Roll angle

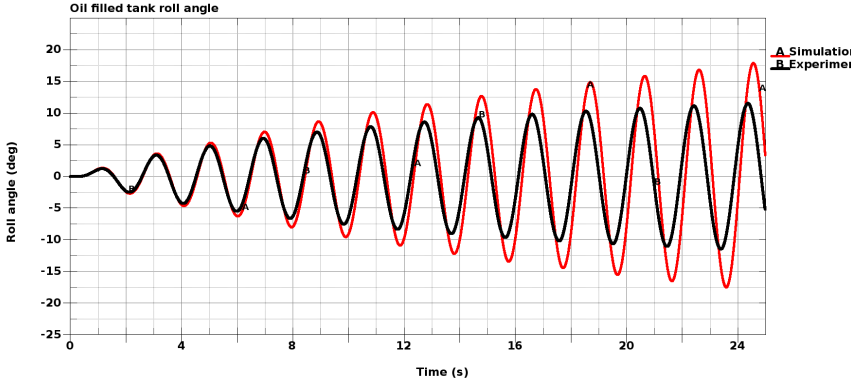


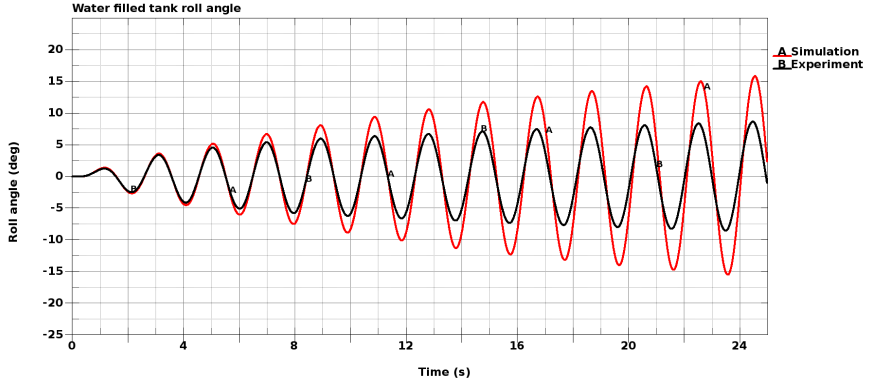


Results- Roll angle









References

[1] G. Bulian, A. Souto-Iglesias, L. Delorme, and E. Botia-Vera, "Smoothed particle hydrodynamics (sph) simulation of a tuned liquid damper," *Journal of Hydraulic Research*, vol. 48, no. sup1, pp. 28–39, 2010.

[2] E. Bota-Vera, A. Souto-Iglesias, G. Bulian, and L. Lobovsky, "Three sph novel benchmark test cases for free surface flows," 5th ERCOFTAC SPHERIC workshop on SPH applications, 2010.

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