Hydroelasticity in Marine Hull Bottom Panels - Modeling and Characterization

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Abstract

The work in this thesis is concerned with the localized problem of hydroelasticity in marine panel-water impacts with an overall aim to increase the efficiency of high-speed craft by application of more refined methods in the structural design. The work mainly focuses on numerical modeling of the hydroelastic problem and therewith related aspects in the modeling and characterization of hydroelasticity. In addition, the work also addresses aspects regarding design methods of high-speed craft and experimental analysis of hydroelasticity.

Two-dimensional panel-water impacts are simulated by using the commercial finite element code LS-DYNA. For the modeling of the panel-water impact situations a generalized approach for determination of fluid discretization and contact parameters is derived and extensively used throughout this work. The hydroelastic problem is studied through systematic series of numerical simulations regarding different impact situations. The work advances the understanding of the hydroelastic problem and introduces concepts such as kinematic and inertia related hydroelastic effects. The work further presents hydroelastic effects in contrast to previously published results, in the sense that it may not be conservative to ignore hydroelasticity in the structural design. This increase in the structural response when accounting for hydroelasticity can partly be related to kinematic effects, and partly to inertia related added mass effects. The results further show that, the effects of hydroelasticity increase with increased impact velocity, increased panel width, decreased deadrise angle, decreased panel flexural and in-plane stiffness, and decreased rotational and in-plane fixation at the boundaries.

A tentative method is derived to characterize the hydroelastic problem, which, despite its simplicity and limitations, is found to successfully capture the complexity of the hydroelastic interaction in the design of the experimental setup. The experimental water slam testing of composite hull panels are conducted to study the effect of hydroelasticity for panels with different stiffnesses. The observed hydroelastic effects included changes in panel geometry, local velocity and hydrodynamic pressures. These effects also correlate with the observed hydroelastic effects from the numerical simulations.

Keywords
fluid-structure interaction, hydroelasticity, hull-water impact, high-speed craft, slamming, explicit finite element methods