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Hydroelastic analysis of ice shelves under long wave excitation

Theodosios Papathanasiou (1), Angeliki Karperaki (2), Efstathios Theotokoglou (3), and Kostas Belibassakis (4)

(1) School of Applied Mathematical and Physical Science, National Technical University of Athens, Athens, Greece (papaththh@gmail.com), (2) School of Applied Mathematical and Physical Science, National Technical University of Athens, Athens, Greece (karperaki.ang@gmail.com), (3) School of Applied Mathematical and Physical Science, National Technical University of Athens, Athens, Greece (stathis@central.ntua.gr), (4) School of Naval Architecture and Marine engineering, National Technical University of Athens, Athens, Greece (kbel@fluid.mech.ntua.gr)

The transient hydroelastic response of an ice shelf, under long wave forcing, is analysed by means of the Finite Element method. Our main goal is to provide a simple model for tsunami wave – ice shelf interaction, capable of reproducing, in an at least qualitative manner, the stress field induced in the ice shelf, when excited by a tsunami wave. The analysis is aimed to model ice calving caused by wave impact, as was the case after the Honsu 2011 incident [1]. Adopting several simplifying but realistic assumptions, the ice shelf is modeled as a variable thickness, Euler-Bernoulli, cantilever beam, while the 1+1 linear shallow water equations are employed for the hydrodynamic field representation, as described in [2]. The fixed cantilever beam resembles a constrained, continuous ice shelf extending into the ocean. The solution of such a system, for a freely floating plate, has been presented by Sturova [3], where a modal expansion of the hydroelastic response with respect to the dry modes of the beam has been used. Our solution approach is based on the development of a special hydroelastic finite element for the governing equations. Cases of constant and variable bathymetry are considered. Bending moment time profiles yield the maximum tensile stress at the upper and lower surfaces of the ice shelf, which is the critical parameter for crack initiation or propagation. As expected, maximum absolute bending moment values appear at the base of the ice shelf, where no deflection or rotation occurs. The fact that the wave is fully reflected on the vertical impermeable boundary, corresponding to the continental shelf under the base of the floe, leads to extreme focusing and thus extreme bending moment values. Finally, the case of cracked shelves has been considered with use of the elementary defective beam theory of Kienzler and Herrmann [4]. Future enhancement of the present model is proposed on the grounds of a higher order beam/plate theory and a 2-D formulation.

References

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