Higher-order FEM for nonlinear hydroelastic analysis of a floating elastic strip in shallow-water conditions

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ABSTRACT

The hydroelastic response of a thin, nonlinear, elastic strip, floating in shalow-water environment, is studied by means of a special higher order finite element. By considering non-negligible stress variation in lateral direction, the nonlinear beam model developed by Gao [1] is used for the simulation of large flexural displacement. Full hydroelastic coupling between the floating strip and incident waves is assumed. The derived set of equations is intended to serve as a simplified model for tsunami impact on Very Large Floating Structures (VLFS) or ice floes; see, e.g., [2,3].

The proposed finite element method incorporates Hermite polynomials of fifth degree for the approximation of the beam deflection/upper surface elevation in the hydroelastic coupling region and 5-node Lagrange finite elements for the simulation of the velocity potential in the water region. The resulting second order ordinary differential equation system is converted into a first order one and integrated with respect to time by the use of Crank-Nicolson method. This finite element scheme has already been applied to the hydroelastic analysis of linear Euler-Bernoulli beams [3] and is now extended to a nonlinear strip simulation.

Representative numerical results for the present model are derived and the effectiveness of the proposed solution procedure is studied. Two distinct cases of long wave forcing, namely an elevation pulse and an N-wave pulse, are considered. Comparisons against the respective results of the standard, linear Euler-Bernoulli floating beam model are performed and the effect of large displacement in the beam response is studied.

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