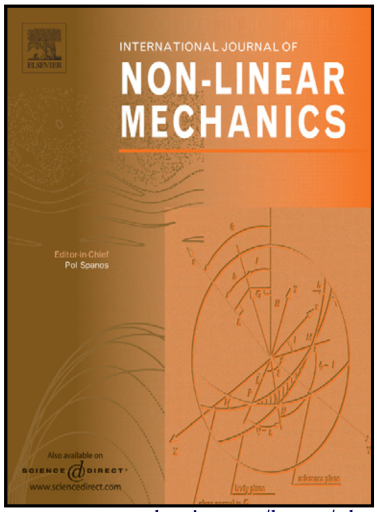

Three-dimensional nonlinear standing wave groups: Formal derivation and experimental verification

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Three-dimensional nonlinear standing wave groups: formal derivation and experimental verification

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Abstract

An analytical nonlinear theory is presented for the interaction between three-dimensional sea wave groups and a seawall during an exceptionally high crest or deep trough in the water elevation. The solution to the second-order of the free-surface displacement and the velocity potential is derived by considering an irrotational, inviscid, incompressible flow bounded by a horizontal seabed and a vertical impermeable seawall. From this, an analytical expression for the nonlinear wave pressure is obtained. The resulting theory can fully describe the mechanics at the seawall and in front of it, which are represented by a strongly inhomogeneous wave field, and demonstrate that it is influenced by characteristic parameters and wave conditions. The theoretical results are in good agreement with measurements conducted during a small-scale field experiment at the Natural Ocean Engineering Laboratory in Reggio Calabria (Italy). Comparisons of the theoretical and experimental results show that some distinctive phenomena involving the wave pressures of very high standing wave groups at a seawall, in the absence of either overturning or breaking waves, may be associated with nonlinear effects.

1. Introduction

Early studies on nonlinear standing sea waves in irrotational flow focused on periodic gravity waves. Rayleigh [1] calculated a numerical solution up to the third order for the two-dimensional case in infinite depth through a perturbation series, using the wave amplitude as a small parameter. This perturbation series was solved up to the fifth order by Penney and Price [2], providing important information about the shape of the highest crests on the water surface that was in agreement with later experiments [3,4,5]. By considering standing waves on a finite depth fluid, Tadjbakhsh and Keller [6] developed a third-order perturbation series, and Goda [7] later extended the series to the fourth order.

In subsequent research that considered sea waves of finite amplitude, several solutions were found using different approaches. A complete review of the literature dealing with nonlinear water waves, including standing waves, is given in Schwartz