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The Threshold of Sand Motion Under Wave Groups

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ABSTRACT

The critical condition for general motion of a sand bottom under sea states of random waves is analysed through an experimental investigation carried out in a wave tank by adopting both proper wave groups able to describe the sea states in a synthetic form and the spectral waves associated with these groups. The analysis of the results obtained shows an analogous behaviour as regards the general motion, thus the mathematical models available for regular waves may be used to characterize the critical condition under sea states. Further experiments already scheduled, will help to confirm the present results.

INTRODUCTION

Knowledge of the response of a noncohesive bottom subjected to wave action is of considerable importance for coastal engineering as regards preservation and protection of coasts. The problem has been dealt with, theoretically and experimentally, by different authors, bearing in mind that theoretical research generally considers regular waves where experimental research takes into account both regular and irregular waves, that is, random waves.

Since the pioneering work of Bagnold (1946), research into regular waves has reached good levels of accuracy (Manohar, 1955; Vincent, 1958; Rance and Warren, 1968; Sleath, 1984; Lee-Young and Sleath, 1988; Blondeaux, 1990; Daprà, 1991; Kos'yan and Kochergin,1992; Kawata, Shirai and Tsuchiya, 1992; Vittori and Blondeaux, 1996; Tanaka and Van To, 1995; You, 1998), while research into random waves, only more recently undertaken, has certainly led to interesting (Nishi, Sato and Nakamura, 1990; Ito, Murakami and Ito, 1995) but not yet definitive results. Among the regular-wave studies, mention is made of the investigations undertaken by Rubatta (1964, 1965) on the critical condition for general motion able to provoke an initial rippled bed. This author provided a model based on the Shields criterion and obtained after having suitably averaged, on corresponding half lengths and half cycles, the shear stress at the bottom. Rubatta's model, which considers the laminar boundary layer, was subsequently extended to the turbulent boundary layer by Rebaudengo Landò and Scarsi (1982), who introduced a suitable adaptation using experimental data from several authors, including Zoccoli (1965); Horikawa and Watanabe (1967); Chan, Baird and Round (1972); Sleath (1978); and Davies (1980).

Gentile and Mordini (1998) recently carried out an experimental investigation of the critical condition for general motion of a sand bottom subjected to wave groups symmetric with respect to the central wave, on the analogy of the characteristic groups introduced by Rebaudengo Landò et al. (1993), with reference to sea states of random waves. Gentile and Mordini focused on the possibility of interpreting critical conditions relevant to the groups through those corresponding to atypical regular wave selected from among the characteristic waves which can be associated with a sea state and identified the spectral wave as the proper one.

This paper presents further experimental investigations carried out adopting nonsymmetric groups which may represent usual sea states as they exhibit realistic values of the groupiness factor. The results obtained confirm that the same typical regular wave is able to describe the general motion also under the present experimental conditions. The consequence is fairly important as it makes it possible to use the consolidated mathematical models already developed for regular waves to identify the critical condition for general motion under sea states. In any case, it needs further confirmation by utilizing also a succession of nonequal groups.

THE EXPERIMENTAL EQUIPMENT

The wave tank used for the experimental tests, sketched in Fig. 1, has a length of ~ 15 m, a width of ~ 3 m and a usable height of ~ 0.8 m. It is provided with a wavemaker, wave filters, waveguide and dampers and is connected to equipment essentially consisting of 3 probes to monitor the wave surface, an electric signal generator and a device to acquire and record these signals.

The bottom of the tank has, starting from the horizontal section where the wavemaker is located, a horizontal cemented section ~ 4 m long, situated at a depth of 0.50 m with respect to the still water level, followed by a section, also cemented, with a slope of ~ 6%,linked to a second horizontal section ~ 4 m long (test section)situated at a depth of 0.20 m or 0.15 m, partially cemented (0.80 m long) and partially covered by monogranular Massaciuccoli sand, followed by a final section with a slope of ~ 8% leading to the wave dampers.

The wavemaker consists of an oscillating plate hinged to the bottom and operated by an oleodynamic system, controlled by a computer, able to generate regular waves, wave groups and successions of random waves corresponding to pre-established frequency spectra. The wave filters consist of several layers of small mesh net, able to prevent unwanted ridges. The waveguides are made of vertical metallic plates placed longitudinally, able to maintain the wave motion 2-dimensional, without oscillations across the tank. The dampers, situated at the two ends of the tank, consist of metal-shaving mattresses, able to keep reflections at low levels (reflection coefficients 3% on average).

The 3 probes are of the resistive type and are located,respec-

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KEY WORDS: Sea states, wave groups, general sediment motion.