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The Introduction of the Characteristic Groups in Random Wave Fields

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ABSTRACT

Characteristic groups of random sea waves on deep water and finite depth are introduced by adopting and extending the well-known concept of characteristic waves. The characteristic groups are defined starting from random wave groups formed by zero upcrossing waves obtained by numerical simulations carried out in the time domain with a random phase method. The behaviour of the heights and periods of the nominal waves which form the characteristic groups and the energy conveyed by these groups are examined. Tests of some results using suitable field data are carried out and the effect of the spectral shape is then highlighted.

INTRODUCTION

The phenomenon of wave grouping in the random wave field, i.e., the formation of wave sequences, has been examined in the time domain by several authors with reference to two different approaches, a discrete one concerning the random wave heights and a continuous one concerning the envelope function of the random wave process. As regards the discrete approach, Goda (1970, 1976) introduced the concept of wave grouping as a threshold level-crossing problem associated with the heights of successive random waves, both for the ordinary groups and the conditional ones, i.e., those which include the maximum wave in each sea state. The quasi-deterministic groups considered in the Boccotti theory (1989) can be referred to this approach, although these groups do not need any threshold. As regards the continuous approach, Longuet-Higgins (1962) referring to Rice (1945) introduced the concepts of wave grouping as a threshold level-crossing problem associated with the envelope of the random wave process. This approach may be used to define the mean value of the time duration of the continuous group, bounded by two successive crossings, and the mean number of waves which belong to the group. It is interesting to note that Ochi and Sahinoglou (1989) identify a continuous group only if at least two waves are included in that time duration. A significant comparison between the two approaches may be found in Longuet-Higgins (1984) and an up-to-date review of grouping methodologies has been given by Medina and Hudspeth (1990).

A new way to describe the wave groups in the time domain is suggested in the present investigation by introducing the characteristic groups (*CG*), constructed starting from random wave groups (*RWG*), free from threshold. The *RWG* are regarded as made by p zero upcrossing random waves, p being odd: The central wave of each group shows the maximum height ${}_pH_{0,u}$, with the period ${}_pT_{H0,u}$, and it is both preceded and followed by $(p-1)/2$ waves of heights ${}_pH_{i,u}$ and periods ${}_pT_{Hi,u}$, where i is the wave order index ($i = -1$, $i = +1$, and so on). These groups are obtained by operating in the following way: The first group is formed by the p waves where the central one is the highest of the N_W available random waves; this group is removed and the resulting gap is closed up. The second group is formed by the p waves where the central one is the highest of the remaining $N_W - p$ random waves, and so on, until all the N_W random waves have been worked out. The operation was performed on the continuous time history formed by adding all the simulations referred to below end to end.

If N is the number of available *RWG* of p waves, the relevant one-nth *CG* takes into account the N/n most severe *RWG*, ordered with reference to the heights of the central waves, n being the characteristic index which keeps the same meaning as the index relevant to the characteristic waves. Thus, the heights $({}_pH_i)_{1/n}$ and the periods $({}_pT_{Hi})_{1/n}$ of the nominal waves which form the *CG* are obtained by averaging the heights and the periods of the actual waves that have the same position in the *RWG*. The heights $({}_pH_i)_{1/n}$ and the periods $({}_pT_{Hi})_{1/n}$ being known, other important quantities can be defined, such as the energy per unit width $({}_pE_{fT})_{1/n}$ conveyed by the one-nth *CG*. This energy is given by the product of the mean energy flux times the total temporal extension of the group.

The investigation refers to both deep water and finite depth conditions; on deep water, the mean *JONSWAP* frequency spectrum was assumed, whereas on finite depth the corresponding modified *TMA* frequency spectra were adopted. For each spectrum and selected depth, several sea states were carried out by using linear numerical simulations able to give, through the Gaussian components of the surface elevation, the random waves. Thus, the *RWG* and the one-nth *CG* of 3, 5, 7 actual and nominal waves were constructed and, for the latter, the range of n from 1 to 50 was considered.

The following topics concerning the *CG* were dealt with: a) the behaviour of the dimensionless heights and periods of the central waves; b) the behaviour of the dimensionless heights and periods of the other nominal waves; c) the behaviour of the dimensionless energy conveyed; d) the comparison of some results with suitable field data. For the last topic, the *PM* and sharp *JONSWAP* frequency spectra on deep water were also used.

From an engineering point of view, the present investigation provides, for example, the basis for a possible way to evaluate the stability of rubble mound breakwaters and to design vertical wall structures through dynamic criteria.

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