An Empirical Wave Envelope Spectrum and the Simulation of Irregular Sea Wave Groups

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ABSTRACT

Based on field measured sea waves, the analyzed results of the relationship between the wave group heights and group lengths indicate that their interrelation is not strong. And an empirical wave envelope spectrum with practical expression involved the group height factor $GHF$, and group length factor $GLF$ is proposed. Using this empirical wave envelope spectrum, the simulation of random wave groups is investigated theoretically and also performed in the laboratory wave flume. The experimental results show that random waves containing expected wave groupiness, meaning not only group heights but also group lengths, can be generated satisfactorily. Further, the transformation properties of the wave groupiness in a wave channel is investigated and associated proposals with the wave group simulation are given.

KEY WORDS: Wave groups; wave envelope spectrum; wave group simulation

INTRODUCTION

Ocean waves often appear in sequences of high wave elevations, which are known as wave groups. It is regarded as one of the main causes of various coastal phenomena and engineering problems, such as surf beat, harbor resonance, etc. Hence, its influence has come to be considered for the design of the ocean structures, and the study on the simulation of harbor resonance, etc. Hence, its influence has come to be considered for the design of the ocean structures, and the study on the simulation of wave groups for physical and numerical model tests is necessary.

Rye (1982) simulated wave groups only with the wave spectrum as the target. Funke and Mansard (1980) pointed out that not only the wave spectrum but also the phase spectrum should be simulated to generate the desired wave groups. In their method, wave groups were simulated with the wave spectrum and the $SIWEH$ (smoothed instantaneous wave energy history) spectrum as targets, and the groupiness factor $GF$ defined as the ratio of the square-root of the zeroth moment of the $SIWEH$ spectrum to the zeroth moment of the wave spectrum was introduced to describe wave groupiness. Xu et al. (1993) considered the envelope approach and tried to simulate wave groups with the wave spectrum and the wave envelope spectrum as targets. Two parameters $GHF$ (ratio of envelope and wave spectrum moments) and $GLF$ (ratio of wave and envelope peak frequencies) were used for the description of the wave group height and group length respectively. However, the target wave envelope spectrum given in their method was merely intended to formulate the approach and didn’t have the typical form of the envelope spectrum of ocean waves.

So far, little has been done in the study of the wave envelope spectrum. A reference to the theoretical form of it was given by Nolte and Hsu (1972). Later a more practical approximation of it was explored by Tayfun (1989), however, it was also not accepted as a usual form on the grounds that it predicts a main spectral peak at zero frequency. Then, an empirical form of the envelope spectrum in terms of groupiness factors $GHF$ (defined as $\sqrt{2 \sigma_t / \overline{A(t)} }$ ) and $GLF$ was proposed by Yu and Gui (1996), based on real sea wave records. Here $\sigma_t$ and $\overline{A(t)}$ are the standard deviation and the mean value of envelope $A(t)$, respectively. However, an evident drawback of the empirical form was that the factor $GLF$ was given in an artificial manner, which may deviate from its real distribution. The primary purpose of the present study is to investigate the form of the actual wave envelope spectrum and develop an effective method to simulate wave groups.

WAVE GROUPINESS FACTORS

In general, the various wave groupiness factors are defined either for specifying the height of wave groups such as $GF$, $GF_s$ (List, 1991), $GHF$, or for the length of wave groups such as $GLF$ and the mean length $\overline{j_1}$, where $\overline{j_1}$ represents the statistical run length obtained directly from the wave record and it can describe groupiness intuitually.

To date, it is not clear whether the group would tend to be with long run as the magnitude of the variation of its energy become pronounced. Here the relationships between the wave group heights and group lengths are examined through two sets of field data. One data set was recorded by bottom squeeze-type wave gauges installed in water depth of 10m at the mouth of the Zhu Jiang River of China. The records were sampled at 4Hz for 20min. The significant wave heights range from 0.50m to 1.58m, and periods from 2.79sec to 5.25sec. The other data...