Effect of Directional Spreading and Spectral Bandwidth on the Nonlinearity of the Irregular Waves

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ABSTRACT

Wherever one stands, deep water, intermediate or shallow water, in extreme conditions the nonlinearity in the wave kinematics is large and has a strong influence on the design parameters. Simple models of the wave kinematics have been studied based on hypotheses of narrowband and unidirectionality.

Obviously a real sea is neither narrowbanded nor unidirectional and the width of the spectral density and the directional spreading influence the nonlinear characteristics of the waves (skewness, asymmetry, ...).

A second order directional irregular wave model is used to simulate time series of the free surface elevation. Based on a large simulated data base, a parametric study of the influence of the spectral width and directional spreading is led on several wave characteristics sensitive to nonlinearities (skewness, wave and crest heights distributions, steepness of maximum crest). Three typical situations are analysed which correspond to extreme situations in long and short fetch wind sea. The validity of the simplified assumptions of narrowband and unidirectionality is then discussed.

EFFECT OF DIRECTIONAL SPREADING AND SPECTRAL BANDWIDTH

At our knowledge, good literature does not exist about the effect of the directional spreading and spectral bandwidth on the nonlinear characteristics of waves, and particularly none can be found for shallow water.

In (Longuet-Higgins, 1963) the skewness of the free surface elevation, in deep water, is bounded with a lower bound corresponding to the superposition of two orthogonal longcrested seas and an upper bound corresponding to a single one:

\[ 0.44 \lambda_{3, \text{uni}} < \lambda_{3, \text{dir}} < 1.01 \lambda_{3, \text{uni}} \]  

with \( \lambda_{3, \text{uni}} \) the skewness in the unidirectional case.

Most of the studies about effect of the spectral bandwidth concern the wave height distribution in a Gaussian sea (Longuet-Higgins, 1980), (Naess, 1985), considered as representative of the wave height distribution in nonlinear sea. Tayfun (1983) studied the nonlinear effects on the distribution of crest-to-trough wave heights but without considering the directional spreading.

Effects of the directional spreading and spectral bandwidth on the skewness and kurtosis and cumulative distribution of maximum crest and wave heights have been also studied in (Stansberg, 1995). In that study, wave tank measurements were considered and he concluded that "extreme wave events due to nonlinear modulations are most pronounced in longcrested waves". This remark will be confirmed hereafter.