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Using a Two-Equation Turbulence Model to Study Irregular Wave Bottom Boundary Layers

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Abstract

A numerical study has been conducted to investigate the properties of irregular wave boundary layers on a rough bottom. The original version of k-ω model and two versions of blended k-ε/k-ω models have been used to predict the boundary layer properties for the existing experimental data. It was found that the model could reproduce the shear stress variation in time quite successfully but the magnitude could not be predicted adequately. This discrepancy may partly be due to the estimation of the shear stress from the velocity data by log-law.

Introduction

A large number of experimental, analytical and numerical studies have been published in the past dealing with oscillatory boundary layers under sinusoidal waves. Those studies provided valuable fundamental knowledge about turbulent characteristics of the bottom boundary layers. Thus improving our understanding of sediment transport phenomena (Sleath, [18]). However, in a real field situation, the waves are essentially irregular. The irregularity of the waves affects the dynamic properties of the bottom boundary layers and in turn sediment transport in the field. Thus, there is a need for comprehensive experimental and numerical studies in order to enhance the level of understanding of irregular wave boundary layers.

Simons et al. [17] reported some experimental results for irregular wave bottom boundary layers. Recently, Samad et al. [12] conducted experiments on irregular wave boundary layers on smooth bottom. They measured the velocity by 1D LDA and calculated shear stress using the log-law.

A number of analytical models have been developed to study the irregular wave boundary layer properties (Madsen et al., [5], Myrhaug, [7]). Numerical models have also been used in this regard. For sinusoidal oscillatory boundary layers two-equation turbulence models have been utilized by a number of researchers. For practical purposes, two equation models have been very successful in predicting the mean and fluctuating parameters of oscillatory boundary layers on smooth bottoms (Sana and Tanaka, [14], Sana and Shuy, [13]) and rough boundaries (Sajjadi and Waywell, [10]). For irregular wave boundary layers on a smooth bottom Samad and Tanaka[11] used a low Reynolds number k- ε model and predicted the bottom shear stress in order to propose an estimation method of shear stress under irregular waves. A standard version of k- ε model has been applied by Holmedal et al., [1] to study the boundary layer properties under irregular waves and current.

In the present study, the experiments have been conducted under irregular oscillatory motion on a rough bottom. For numerical prediction the blended k- ε/k- ω model developed by Menter[6] has been used. This model was developed by utilizing k- ω model in the near-wall