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Influence of Wind and Grain Size on Migration of Asymmetric Sand Waves

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ABSTRACT

Large parts of shallow seas are covered by regular seabed patterns and sand wave is one kind of these patterns. The instability of the sedimentary structures may hazard pipelines and the foundations of offshore structures. In the last decade or so, it's a focus for engineers to investigate the movement mechanism of sand waves. Previous theoretical studies of the subject have developed a general model to predict the growth and migration of sand waves, which is based on the two-dimensional vertical shallow water equations and the bed-form deformation equations. Although the relation between wave-current flow and sand bed deformation has been established, the topographic influence has not been considered in the model. In this paper some special patterns, which are asymmetric and close to the reality, are represent as the perturbed seabed and the evolution of sand waves is calculated. The combination of a steady flow induced by wind and a sinusoidal tidal flow is considered as the basic flow. Finally the relations of some parameters (grain size, etc.) and sand waves' growth and migration are discussed, and the growth rate and migration speeds of asymmetric sand waves are carried out.

KEY WORDS: sand wave; growth rate; migration speed; grain size; tidal current.

INTRODUCTION

In most of shallow seas, regular patterns are formed by tidal currents on their sedimentary seabed. Sand wave is one kind of these regular patterns. Large parts of the northern South China Sea are covered with sand waves. Their formation, growth and migration will make great influence to the seabed and may hazard pipelines and the foundations of offshore structures. So it is very important to do some research in sand waves' growth and migration. In this paper, the research mainly focuses on the factors which may influence the growth and migration of sand waves.

Observations indicate that sand waves are about several meters high and their wavelengths are about several hundreds meters long. Their speeds of migration are about several meters per year, and they migrate towards the main direction of the tidal currents (Harris, 1988; Huntley et al., 1982; Ikehara and Kinoshita, 1994; Katoh et al., 1998).

In order to study the instability of sand waves, the seabed and the tidal currents above are treated as a system, the instability of the system is analyzed. Huthnance (1982) first used this method in studying sand banks. He analyzed the instability of the system which consisted of a depth-averaged shallow water model and a erodible seabed model, and then he found the fastest growth rate of the system, which was agreeable with the results of observations. The model was extended by DeVriend (1990) and Hulscher (1993, 1996), because the using of the depth-averaged shallow water equations made the model can not simulate the formation and growth of sand waves.

Hulscher (1993, 1996) introduced the vertical circulations of the flow field, so that the model could simulate the formation and growth of sand waves. The results were compared to the observations of North Sea. Hulscher and Nemeth (2002) simplified the model from 3D to 2D, and introduced the combination of a M0 current and M2 tidal current, then they calculated the migration of sand waves, they also assumed that the direction of sand waves' migration was agree with the M0 flow. However, the shapes of sand waves were not considered in the model.

Besio, Blondeaux, Brocchini and Vittor (2003) introduced the M4 current, then they found the direction of the sand waves' migration may in the opposite direction of the M0 flow. The shapes of sand waves were not considered in the model neither.

Based on these studies, this paper introduces the asymmetric sand waves, which are close to the reality. The sediment's physical properties are also included. The growth and migration of the asymmetric sand waves are studied. In Section 2 we present the non-dimensional models of flow field and sediment transport. These models are analyzed in Section 3. In Section 4 the results are shown and discussed. Finally, we get the conclusions in Section 5.

DESCRIPTION OF THE MODELS

The model here is based on the analytical model of Hulscher (2002). The Coriolis force is neglected because of its slight affect to sand waves. The tidal currents are described by the two-dimensional shallow