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Action mechanism of geotextile-reinforced cushion under breakwater on soft ground

Yuzhen Yu*, Bingyin Zhang, Jian-Min Zhang

Department of Hydraulic Engineering, Tsinghua University, Beijing 100084, China

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Abstract

Various measures including material experiments, centrifuge modeling tests and FEM numerical analyses were performed to study systematically the action mechanism of the geotextile-reinforced cushion under breakwater on soft ground and the effects of the strata characterization and the reinforcement condition on the stability of the breakwater-ground system. In the aspect of controlling the deformation, the geotextile-reinforced cushion under breakwater constrains the lateral displacement of both the embankment and the ground. From the viewpoint of stress, the reinforcement suppressed the range of high stress level in the system. In general, the weaker the ground is and the greater the modulus of the geotextile is, the more effective the reinforcement is. The tensile force in the geotextile is greater in the range of the main part of the embankment.

Keywords: Action mechanism; Geotextile-reinforced cushion; Breakwater; Soft ground

1. Introduction

The breakwater is an important part of a port and the main functions of a breakwater include resisting stormy waves, ocean current and floating ice to enter into the sea route, and reducing the soil-filling-up. There are various types of breakwater, among which the slope type is widely employed because of simple construction and low cost.

A breakwater is usually built on soft clay layer with low strength, high compressibility and low permeability, therefore, large settlement and differential settlement are prone to

* Corresponding author. Fax: +86 10 62785593.
E-mail address: yuyuzhen@tsinghua.edu.cn (Y. Yu).

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occur or even result in caving, slope slide and global failure. Geotextile reinforcement is one of the common countermeasures to solve this problem and is compiled into the relevant specification in China (Ministry of Communication of the People's Republic of China, 1998).

A lot of practice has verified the effect of the geotextile-reinforced cushion under the breakwater on soft ground. Many researches have been performed on the geotextile reinforced embankment built on soft clayey ground. Some researchers performed case studies of full-scale geotextile reinforced test embankments to investigate the effect and mechanism of the reinforcement (Rowe et al., 1995; Bergado et al., 2002; Chai et al. 2002). This method is effective but expensive. Sharma and Bolton (1996) explored the behaviour of reinforced embankments on soft clay using the technique of centrifuge modeling. Controlled in-flight construction of the embankment was carried out and a new technique for measuring the tension induced in the reinforcement was developed. Centrifuge modelling accompanying with numerical analysis is a effective and economical way to study the reinforced embankments on soft clay (Sharma and Bolton, 2001). As for the stability analysis of the geotextile reinforced test embankments on soft ground, various methods were suggested by modifying the conventional slice methods (Kaniraj, 1994; Palmeira et al., 1998; Srbulov, 1999; Tandjiria et al., 2002). Finite element method is also often employed in recent years (Chai et al., 2002; Bergado et al., 2002; Borges and Cardoso, 2002; Hinchberger and Rowe, 2003).

However, because the working condition of the reinforced ground is rather complex, many problems have not been made clear yet and the knowledge about the mechanism does not follow the practice.

The action mechanism of the geotextile-reinforced cushion under breakwater was investigated in this study in the light of the Huanghua Port Project.

The Huanghua Port Project is located in the bank of Bohai Sea, 90 km east to Cangzhou City, Hebei Province, China. The first phase of the project includes four 35-thousand-ton berths with an annual transporting capacity of 30 million tons. The slope-type breakwater is composed of two parts, the south embankment and the north embankment, which are 5030 and 4082 m in length, respectively. The depth of the embankments is typically 6.3–7.7 m and the plan of the project is shown in Fig. 1.

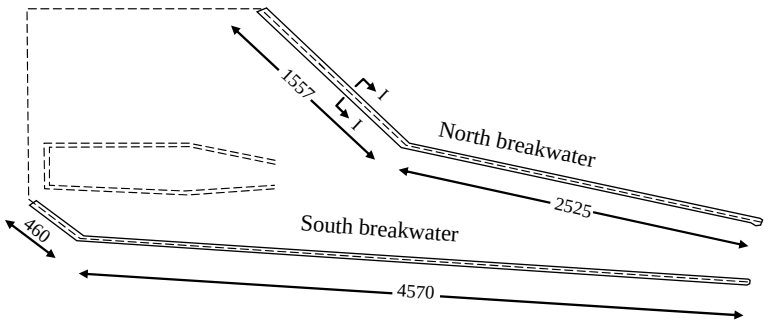

Fig. 1. Sketch of the plan of the breakwater of Huanghua Port.