A Rational Design of Armor Block and Foot-Protection Block Covering Rubble Mound of Composite Breakwaters

Shin-ichi Kubota
FUDO TETRA CORPORATION, Technical Research Institute
Tsuchiura, Ibaraki, Japan

Ken-ichiro Shimosako
Ministry of Land, Infrastructure, Transport and Tourism, Yokohama Research and Engineering Office for Port and Airport
Yokohama, Kanagawa, Japan

Masashi Hamaguchi
FUDO TETRA CORPORATION, Block & Environment Division
Chuo-ku, Tokyo, Japan

Akira Matsumoto
FUDO TETRA CORPORATION, Technical Research Institute
Tsuchiura, Ibaraki, Japan

Minoru Hanzawa
FUDO TETRA CORPORATION, Block & Environment Division
Chuo-ku, Tokyo, Japan

Masato Yamamoto
FUDO TETRA CORPORATION, Technical Research Institute
Tsuchiura, Ibaraki, Japan

ABSTRACT

Wave forces acting on armor blocks were measured and a rational shape of block which reduces the uplift force was proposed. Hydraulic stability tests for the proposed armor block were conducted and improved stability was confirmed. Hydraulic stability tests for foot-protection blocks of various sizes were conducted and rational designs were considered. These tests revealed that even a block with one opening of half the size of a conventional foot-protection block also proved to be stable against the design wave conditions.

KEY WORDS: composite breakwater; armor block; foot-protection block; hydraulic stability; wave force.

INTRODUCTION

A rubble mound of a composite breakwater is usually covered with armor blocks and foot-protection blocks to prevent deformation. Although the design method for armor blocks and foot-protection blocks seems to have been almost established, in recent years, the site conditions are becoming severer. Therefore more rational design methods are required. With respect to armor blocks covering the rubble mound of a composite breakwater, if the hydraulic stability of thinner blocks having large openings could be ensured, they would contribute to cost reduction through the reduced amount of concrete needed. Although the possibility to improve stability of armor blocks by making openings to reduce uplift pressure has been described before, little information is available on the influence of the size and placement pattern of such openings. With respect to foot-protection blocks, their stability is ensured by the thickness depending on the design wave height. However other dimensions such as length and width are given empirically. Therefore more rational design methods are required.

The purpose of this study is to obtain new knowledge to contribute to the rational design of armor blocks and foot-protection blocks from the viewpoint of their stability and cost reduction.

First, wave forces acting on rectangular blocks were measured to investigate the hydrodynamic effects of the opening size and placement pattern on the uplift force reduction. Second, the wave force acting on a flat type armor block was measured to reveal its hydraulic and stability characteristics. Based on the results of these tests, a new shape flat type block was proposed. Furthermore, hydraulic stability tests for foot-protection blocks of various sizes were conducted and rational designs were considered.