Vertical breakwater Vulnerability under Monte Carlo’s Simulation

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ABSTRACT

A change of tendency in the approach of marine works verifications is being experienced at the present time. Vulnerability of such works is taking more relevance than in previous decades. Particularly, the R.O.M. 0.0 adapts from the PIANC a classification of methods of verification in which the highest level, Level III, is required to verification of relevant works. These methods are based on the computation of failure probability of the system or structure. The Level III requires the estimation of such a probability avoiding simplifications both in the kind of probability models (distributions) and the failure regions. In the framework of these Level III methods of verification, Monte Carlo simulation methods are the most useful ones.

This document is a consequence of the cooperation project between Puertos del Estado and the Departament de Matemàtica Aplicada III of the Universitat Politècnica de Catalunya (UPC) for the development of a methodology of verification (Level III) based on Monte Carlo simulation. In fact, the main goal is the study of vertical breakwater vulnerability, as an important step in the verification procedures.

The vulnerability of a vertical breakwater is defined as the probability of attaining a level of damage under different classes of external actions. Firstly, the damage level is described by global failure criteria and the external action is defined with a global descriptor. The descriptor will be the maximum significant wave height in a storm. From this descriptor and complementary parameters, the method generates storms characterized by the individual description of each wave by means of eight parameters, non independent to each other. Secondly, global failure is determined from nine failure modes. Failure modes are geometric or mechanical. They cause interruption of services, structure dysfunction or collapse.

The vertical breakwater considered is decomposed into parapet, caisson, armour rubber, rubber, soil at the basement of the rubber. The previous components are described by geometric and physical parameters and state variables. State variables are allowed to change during a storm and described the actual resistant and service state of the breakwater. Failure modes and their degrees are defined as conditions on the state variables. In order to estimate the vulnerability, both wave and breakwater conditions are simulated. Storms are generated as a sequence of irregular individual waves given the maximum significant wave-height.

Many breakwater parameters are assumed random and accordingly simulated. Using simulated values, failure modes are verified and then, global failure is decided as a combination of failure modes and their probabilities. Accuracy of estimated probabilities depends on the number of simulated storms. The larger this number, the more accurate results. A thousand storms have been used in the examples; larger simulations cause significative computational costs.

This methodology has been applied to the Bastarreche breakwater-wharf of Cartagena and to the Santa Cruz de Tenerife breakwater. The fist one is a pure vertical breakwater. However, the second one is a mixed vertical-rubber breakwater. In both cases it has been possible to estimate their vulnerability. Vulnerability has been estimated for three different levels of global failure: nothing occurs; permissible tolerance is exceeded and intermediate situations. In conclusion, methodology used is able to estimate the vulnerability reasonably and with sufficient accuracy. Accuracy depends on the number of simulations that will be take place.