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Onset of Breaking in Front of Vertical and Composite Breakwaters

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ABSTRACT

This paper analyses experimental results from 2d and 3d model tests. The purpose was to derive a criterion to predict breaking wave height in presence of simple and composite vertical breakwaters. A new empirical formula is discussed and its validity is examined by the laboratory experiments. Subsequently a description is given of a model developed for the prediction of the percentage of waves impacting on this structure in a sea state.

KEY WORDS: Coastal structures, vertical and composite breakwaters, wave breaking, wave impact

INTRODUCTION

Forces on vertical breakwaters may be very severe, particularly when the incoming waves break against the wall causing impact loads.

Through a recent case-history of the collapse of vertical breakwaters it has been possible to point out the destructive potential of these loads (Oumeraci, 1994) and recent research by Takahashi et al. (1994 a, b) Oumeraci et al. (1995) has confirmed that in a sea state a large number of impact loads can be generated of such severity as to cause cumulative sliding and eventually bring about the failure of the breakwater-foundation system.

Historically, wave loads on vertical breakwaters and related structures have been derived as quasi-static forces using the empirical method by Goda (1985). Goda's method calculates wave loads equivalent to the effective sliding force inducted by standing and slightly breaking waves (not impulsive), but was never intended to estimate impact loads

This gave rise to studies, most of them experimental, aimed at better understanding of their generation and at improving the reliability of the design procedures of vertical breakwaters.

However, the research carried out cannot be considered exhaustive and further work is in progress under the Research Project "PROVERBS" ('Probabilistic design tools for vertical breakwaters'), included in the Programme "Marine Advanced Science and Technology" (MAST III) financed by the European Community.

Among the recent contributions aimed at clearly identifying those conditions which lead to impulsive breaking wave pressures, the experimental investigations performed by Oumeraci et al. (1993), Allsop et al. (1995, 1996 a, b), Calabrese and Allsop (1996), Calabrese et al. (1996) have stressed the importance of particular combinations of wave conditions, bottom slope, mound and vertical wall profiles.

In the work of Oumeraci et al. (1993) an empirical formula to evaluate the breaking limit in front of simple vertical walls has been proposed but it has not yet been fully tested against model study measurements.

This paper reanalyses selected experimental results from a large series of bi-dimensional and three-dimensional model tests performed during 1994 and 1995 at HR Wallingford, England.

The aim of the analysis was:

- to derive an empirical criterion to identify the starting of wave breaking in front of composite breakwaters;
- to develop a model for the prediction, in a sea state, of the percentage of waves breaking onto the structure.

As the knowledge of the phenomena linked to the interaction between waves and the structure has not yet reached a satisfactory level it was deemed prudent to build a rather simple model.

A comparison of the model results with other experimental and/or real data should serve to indicate if the model is sufficiently adequate to justify further refinements.

LABORATORY STUDIES

The results discussed in this paper were derived from a large series of bi-dimensional (2d) and three-dimensional (3d) hydraulic model tests performed at HR Wallingford and conducted by the researcher of HR Wallingford, the Queen's University of Belfast and the University of Naples Federico II. These tests are described in detail, respectively, in Allsop et al. (1996 b) and Calabrese and Allosp (1996).

Outline of Experiments

Two different bed slopes were used:

- 1:50 indicative of shallow sand beach slope (2d tests)
- 1:20 indicative of steeper sand beaches (3d tests)

Test sea states used JONSWAP spectra with $\gamma = 3.3$.