# NUMERICAL AND EXPERIMENTAL STUDY OF A MULTIPLE-ROW PILE BREAKWATER

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**Paper topic:** Coastal and port structures

## 1. Introduction

A multiple-row pile breakwater consists of an array of vertical piles and constitutes an alternative solution to conventional breakwaters which can be used for coastal protection under mild wave conditions. The smaller construction costs and less environmental impacts compared with conventional gravity-type breakwaters as well as environmental requirements, such as phenomena of intense shore erosion, water quality and aesthetic considerations advocate the application of such structures. Recently, several researchers studied the wave reflection and transmission from similar perforated breakwaters, such as a single-row pile breakwater (Zhu, 2011), a multiple-row curtain wall-pile breakwaters (Ji and Suh, 2010), a partially perforated-wall caisson breakwater (Suh et al, 2006), a perforated wall with vertical slits (Suh et al, 2011).

In this work, both numerical and physical experiments are conducted for the evaluation of the breakwater's performance. Figure 1 shows the definition sketch of the proposed multiple-row pile breakwater that consists of rows of cylindrical piles, with diameter D, height $h_s$ and freeboard, Fr that constitute the total width of the structure, W. The structure is examined either submerged or emerged for monochromatic water waves. The efficiency of the breakwater is evaluated through the transmission coefficient $C_t$ (=$H_t/H_i$, $H_t$=transmitted wave height, $H_i$=incident wave height). Additional information of the structure response under the wave action is obtained through the evaluation of the reflection and dissipation coefficient, $C_r$ (=$H_r/H_i$, $H_r$=reflected wave height) and $C_d$ ($1-C_t^2-C_r^2$, evaluated indirectly through energy conservation concept).

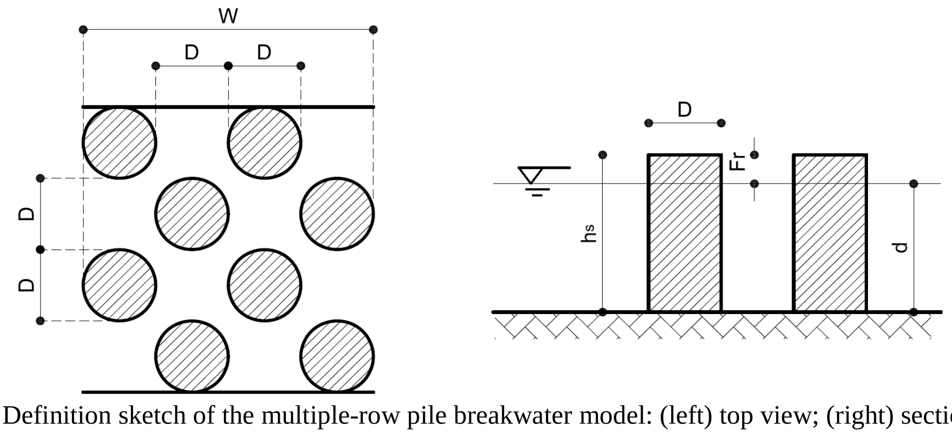


Figure 1. Definition sketch of the multiple-row pile breakwater model: (left) top view; (right) section view at a row of cylinders.

## 2. Experimental and numerical setup

Physical modeling is performed in the wave flume in the Laboratory of Hydraulics, Department of Civil Engineering, Aristotle University of Thessaloniki, which is 16 m long, 0.4 m wide and 0.5 m

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deep. It is equipped with a piston-type wave maker at one end, a wave absorbing beach at the other end and resistive wave-gauges for measuring the wave height. The water depth in the flume is d=28 cm and the emerged breakwater consists of piles with diameter D=10 cm and height $h_s$=31cm and porosity r=0.61. The layout of the experimental wave flume and the measurement sections are shown in Figure 2.

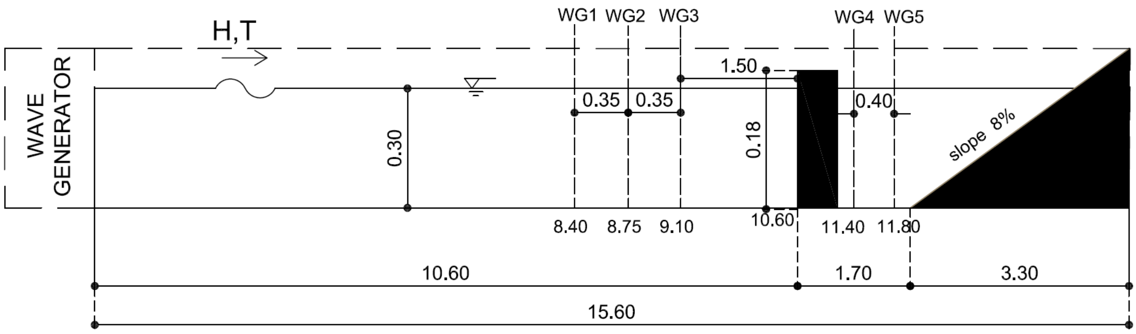


Figure 2. Layout of the experimental wave flume and measurement sections (units in m).

The numerical experiments are performed in a Numerical Wave Flume (NWF) with the use of the CFD code FLOW-3D v.10.0.3, that solves the RANS equations in conjunction with the RNG k-ε turbulence model and the VOF method for “tracking” the free surface variation. The numerical model results are compared against the experimental ones and the analysis is extended for various breakwater configurations, regarding the submergence and the width. Figure 3 shows a characteristic snapshot of a wave propagating over a submerged 4-row piles breakwater in the NWF.

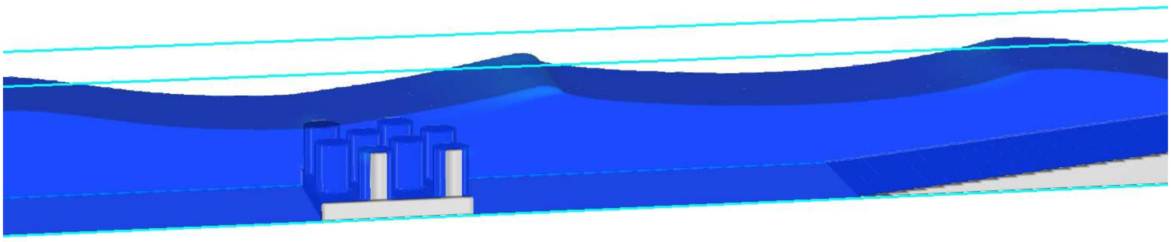

Figure 3. Wave transmitted over submerged 4-row piles breakwater in the NWF.

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