Title of Diploma Thesis

3D Experimental Investigation of the Dynamic/Structural Behaviour and the Effectiveness of Floating Breakwaters

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ABSTRACT

Floating Breakwaters (FBs) are nowadays considered as a technologically modern and environmental friendly alternative solution to conventional, bottom mounted breakwaters. The most typical configuration of FBs consists of an array of floating individual modules of trapezoidal longitudinal cross section, which are connected to each other with flexible connectors (usually made of wire rope covered with neoprene) and are moored to the seabed with inelastic mooring lines (made of chain). The above configuration presents a dynamic structural system characterized by flexibility resulting mainly from the existence of the flexible connectors. Consequently, the relative displacements between the individual modules under the action of the waves (hydroelastic response) affect directly both the functionality (i.e. effectiveness) and the structural response (e.g. internal forces of the connectors, mooring lines' tensions) of the FB. Moreover, the individual components of the FB (i.e., modules, connectors, mooring lines) interact strongly with each other, while the whole structure has different possible failure mechanisms (i.e. failure of the connectors, failure of the mooring lines and/or failure of the modules). Combining all the above, it is straightforward that the consideration of both functionality and structural integrity (e.g. failure of the connectors) issues as well as the inclusion of the aspect of hydroelasticity in the investigation/assessment of the behavior of the FB are necessary for the implementation of an integrated and sustainable design of this type of structure.

The aim of this thesis is the experimental investigation and the assessment of the dynamic/structural behavior and the effectiveness of a FB that consists of three modules, connected to each other with flexible connectors and moored with inelastic mooring lines under the action of perpendicular and oblique regular waves. The experimental data are obtained from corresponding 3D experiments (scale 1:20) that were conducted by the supervisor of the thesis in a 3D basin at the Technical University of Istanbul. The experimental equipment enables the measurement of: (a) the strains applied at the flexible connectors of the FB and, consequently, the determination of the internal forces at these structural elements of the floating system, (b) the tension at the top of the mooring lines and (c) the wave field in the seaward and leeward side of the FB. The measurement of the FB's hydroelastic response was achieved through the video recording of the 3D displacements at specific, predefined points on the FB relatively to some fixed (reference) points. For this purpose, two HD video cameras were used together with appropriately colored markers placed on the FB and fixed (reference) markers mounted close to the FB.

With regard to the assessment of the FB's hydroelastic response, appropriate methodology is developed in the present thesis that enables the required image processing of the video frames for calculating the 3D displacements at the corners of the three modules of the FB. Moreover, appropriate codes are developed and applied (programming language MATLAB), enabling the calculation of the axial and shear

forces of the connectors, as well as of the statistical quantities describing the tensions at the top of the mooring lines (e.g. average of the 1/3 maximum values of the tensions‘ time series etc.). It is mentioned that the displacements, the connectors‘ internal forces and the mooring lines‘ tensions are used in order to describe the dynamic behavior of the FB, while the last two aforementioned physical quantities enable additionally the assessment of the FB‘s structural behavior. Finally, the effectiveness of the FB is expressed by the wave height at specific points at the leeward and seaward side of the FB.

Based on the above post processing of the experimental results, the effect of the incident wave characteristics (wave period, wave height and wave direction) on the FB‘s dynamic/structural behavior, described by the aforementioned physical quantities, and on its effectiveness is presented and analyzed. Emphasis is also given on the correlation between the connectors‘ internal forces and the hydroelastic response of the FB.

Keywords: Floating breakwaters, 3D Experimental investigation, Hydroelastic response, Connectors’ forces, Mooring lines’ tensions, Effectiveness.