DESIGN FORMULAE FOR WAVE TRANSMISSION BEHIND FLOATING BREAKWATERS

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In the last decade environmental friendly coastal structures are of great interest. Floating breakwaters belong to this specific category for the wave protection and restoration of semi-protected coastal regions. In the present study design formulae for wave transmission behind fixed floating breakwaters, as well as for wave reflection and dissipation, are proposed based on large-scale experimental data in shallow and intermediate waters.

The experiments were conducted in the CIEM flume of the Catalonia University of Technology, Barcelona. The dimensions of the flume are 100 m length, 5 m depth and 3 m width. The floating breakwater was placed in the horizontal part of the flume in 2 m depth. The length of the breakwater was 2 m, the height 1.5 m and the transverse length 2.8 m. An HR Wallingford wedge type, wave-maker was used while the experimental equipment consisted of a number of HR Wallingford wave-gauges, Huba Control pressure transducers and two-component Delft Hydraulics current-meters. The sampling frequency during the experiments was 20 Hz. The experiments were organized into three different sets according to the draught of the structure. In every set regular and irregular waves were generated covering the range of shallow and intermediate waters ($0.04<d/L<0.35$). The draughts of the floating breakwater were 0.4 m, 0.5 m and 0.65 m for the first, second and third set respectively (d_r/d=1/5, 1/4 and 1/3 respectively). For the regular waves case two different wave heights were used, 0.2 and 0.3 m. The shortest wave period was 2.04 sec (B/L=0.32) for the 0.2 m height and 2.34 sec for the 0.3 m height. For the 0.3 m wave height shorter periods were avoided because violent wave breaking on the structure occurred. In both cases the longest wave period was 9.17 sec (B/L=0.0445). For every case the wave reflection and transmission is presented. The wave reflection analysis is based on the method proposed by Mansard and Funke (1980). Energy dissipation in the region of the breakwaters is also studied.

The efficiency of the floating breakwater is expressed accordingly with the transmission coefficient C_t defined as the ratio of the transmitted wave height, H_t over the incident wave height, H_i. A simple dimensional analysis of the phenomenon for a fixed moored floating breakwater, without wave overtopping, indicates that C_t is a function of the following wave and structural characteristics:

$$C_t = f\,(d\text{-}dr/H_i,\ B/L) \tag{1}$$

where H_i=incident wave height, L=wavelength, d=water depth, dr= draught of the structure and B=length of the breakwater (along the incident wave direction).

Hence, the influence of B/L and (d-dr)/H_i on C_t is presented which are shown to be the most important parameters for a fixed floating structure.

The influence of B/L (or d/L since B=d in the experiments) and (d-dr)/H_i on C_t is shown in Fig. 1. For B/L greater than 0.25 the performance of the structure can be considered satisfactory since C_t is less than 0.5. Similarly, for (d-dr)/H_i greater than 0.25 the C_t is less than 0.5. In all cases the wave steepness (H_i/L) is between $1.52*10^{-3}$ and $4.8*10^{-2}$.The FB performs more efficiently under the forcing of waves with short periods for intermediate and deep waters.

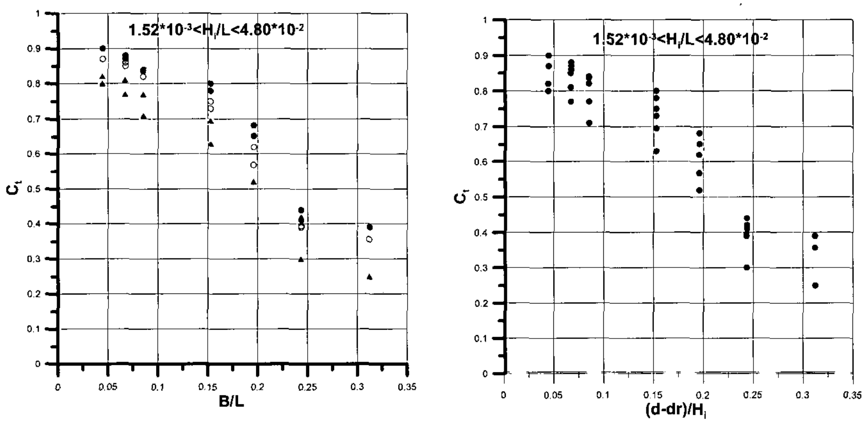

Fig. 1 Variation of C_t with B/L (=d/L) and (d-dr)/H_i.

Polynomial regression analysis, using a quadratic surface equation, of the experimental results provides the design formulae for the C_t and C_r coefficients.

$$C_t = 0.706 \quad +0.079*((d\text{-}dr)/H_i) - 0.006*((d\text{-}dr)/H_i)^2 - 3.311*(B/L) + 0.200*(B/L)*((d\text{-}dr)/H_i) - 2.36*(B/L)^2 \tag{2}$$

$$C_r = 0.301 \quad -0.056*((d\text{-}dr)/H_i) + 0.005*((d\text{-}dr)/H_i)^2 + 5.235*(B/L) - 0.184*(B/L)*((d\text{-}dr)/H_i) - 4.509*(B/L)^2 \tag{3}$$

$$C_d=(1-C_t^2-C_r^2)^{1/2} \tag{4}$$

for 0.045<B/L<0.312 and 4.5<((d-dr)/H_i)<8. The coefficients of determination (R^2) are 0.92 for both equations (2) and (3).

The above relationships were applied, in the range of its validity (0.045<B/L<0.312 and 4.5<((d-dr)/H_i)<8), in order to verify the results in the cases examined experimentally by Tolba (1998). Tolba, in his small-scale experimental work, examined the hydrodynamic interaction of regular waves with fixed floating breakwaters in shallow, intermediate and deep waters. The experiments were performed in a wave flume 24 m long, 0.3 m wide and 0.5 m high. The ratio of B/L was varied from 0.03 to 0.27 while the ratio (d-dr)/H_i from 5.0 to 8.0.

It is deduced that the above relationships over predict the experimental C_t values especially for C_t less than 0.4 while they work satisfactorily for greater values of C_t. This is mainly due to the scale phenomenon since the experimental tests of Tolba were conducted in small scale (d=0.30 m) while the present experimental work was conducted in a large-scale facility (d=2.00 m).