USING STILLING WAVE BASIN FOR ADAPTATION MEASURES TO SEA LEVEL RISE IN COASTAL AREAS

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INTRODUCTION

İzmir, a coastal city in Turkiye, has rapidly expanded due to economic growth and urban development centered around Izmir Bay. However, haphazard growth and inadequate infrastructure have left the region vulnerable to natural disasters, particularly with the increasing risk of sea level rise caused by global warming. This situation could lead to severe coastal flooding, erosion, and damage to important structures and properties. In the inner bay of Izmir, the current coastal protection structures, including vertical and armoured rubble mound sloping structures, may not be sufficient to withstand the challenges posed by climate change (Kisacik, 2022). This study underlines the importance of implementing resilient adaptation measures in the low-lying and coastal areas of Izmir Bay in response to the urgency of the situation. Increasing the crest height of current flood defense structures is a common method for reducing wave overtopping; however, its applicability in densely populated coastal areas is limited by negative social acceptance. As an alternative solution, this research focuses on developing the Stilling Wave Basin (SWB) crest modification approach. The study focuses on the experimental modeling of the SWB approach, demonstrating its potential efficiency in reducing wave overtopping to tolerable levels. The findings of this study contribute to the expanding body of knowledge about coastal resilience strategies, especially in the urbanized coastal regions susceptible to sea level rise caused by climate change.

METHODOLOGY

Experiments are conducted in the medium-sized Wave-Current Flume, one of three wave flumes at the Maritime Engineering Laboratory (LABIMA) at the University of Florence in Italy. The flume is entirely made of steel and glass with the dimensions of 37.27 m long, 0.80 m width, and 0.80 m height. Regular and random waves with a maximum wave height of 35 cm, a period of approximately 2 s, and a water depth of 60 cm can be generated. Based on the case of Izmir Bay, the hydrodynamic conditions and geometric properties of the coastal protection structures are Froude scaled 1/16. The scale model consists of three major parts (Figure 1): the simple caisson, the rubble-mound armour protection, and the superstructure components. The rubble-mound armour consists of two-layer rocks weighing 0.490 kg for the inner core and 0.654 kg for the outer armour, totaling 0.71 m in length. The simple caisson height is 0.25 m. The height of the armour crest is 0.25 m from the horizontal platform, while its width is 0.22 m, and its seaward slope is 1:2.

In all experiments, the components of the simple caisson and the rubble-mound armour protection remain unchanged. However, the superstructure part has a changing geometry depending on two models: Model A and Model B. Model A consists of a superstructure including one continuous seaward storm wall with changing heights integrated on the crest of a sloping armoured seawall structure. On the other hand, Model B refers to another superstructure consisting of the Stilling Wave Basin modification at the crest of the sloping armoured seawall. Since this experimental study focuses on examining the effect of SWB on overtopping discharge, Model A is considered the reference case for Model B. Consequently, both Model A and Model B are subjected to the same hydrodynamic conditions in the same relative freeboard range. This methodology helps to quantify the reduction effect of SWB on overtopping discharge accurately.

Instead of a single continuous storm wall along the seaward, the SWB is created by means of one storm wall with gaps located on the seaward, while a continuous wall is on the landward side (Cavani, 1999 and Aminti, 2001). Figure 1 shows the SWB crest modification for a sloping armoured seawall.

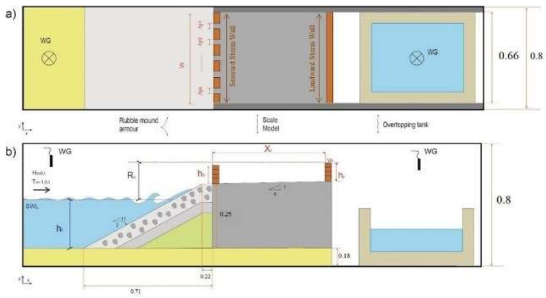

Figure 1. Experimental setup of SWB a) plan view, b) middle line cross-section (length units in meters)

The parameters of h_b, h_r, X_r, and C_b determine the geometric configurations of the Stilling Wave Basin. Different values of each parameter are systematically evaluated while keeping the other parameters constant to investigate the influence on the overtopping discharge. The heights specified for the seaward storm walls (SSW) and the landward storm walls (LSW) range between 0.014 m and 0.042 m. Experiments are conducted with four different values, considering that the heights of SSW and LSW are equivalent. The X_r parameter specifies the horizontal length of the promenade, and it is arranged as a function of the h_b parameter. The X_r values are obtained by multiplying the corresponding h_b values by 8, 12, 18, and 24 constants. The range of the X_r is between 0.11 m and 1 m. The seaward storm wall is constructed with gaps, and the blocking coefficient, C_b, quantifies the proportion of all gaps to the total width of SSW. C_b is determined as 40, 45, 50, and 55 percent. The values of the SWB parameters are listed in Table 1.

Table 1 Values of Stilling Wave Basin parameters

h_b (m)		X_r (m)		C_b (%)	
h_{b1}	0.023	X_{r1}	$8h_b$	C_{b1}	40
h_{b2}	0.032	X_{r2}	$12h_b$	C_{b2}	45
h_{b3}	0.042	X_{r3}	$18h_b$	C_{b3}	50
h_{b4}	0.014	X_{r4}	$24h_b$	C_{b4}	55

The experimental procedure is divided into two main parts. The first part is related to Model A as a reference case, while the other part, Model B, aims to investigate the effect of the Stilling Wave Basin and its design parameters on overtopping discharge. Model A has four different heights of the continuous seaward storm wall (h_b) within the relative freeboard range of $0.30 \leq R_c/H_{m0} \leq 0.80$. For Model B, in total, sixty-three different geometric configurations of SWB are tested. The geometric configurations of both Model A and Model B are arranged from the parameters in Table 1 and tested under four different hydrodynamic conditions (H1, H2, H3, and H4) summarized in Table 2. The hydrodynamic conditions are defined for a broader range, covering the İzmir Bay prototype conditions.

Table 2 Target hydrodynamic conditions

	h_t (m)	H_{m0} (m)	T_{m0-1} (s)
H1	0.2200	0.075	1.15
H2	0.2200	0.091	1.26
H3	0.2375	0.075	1.15
H4	0.2375	0.091	1.26

The mean overtopping discharge, represented as q, serves as the key parameter to evaluate the results of the experiments. After each successful test, the water overtops from the crest is collected in an overtopping tank through a chute (0.1 m width), and the amount of water is carefully measured as the mean overtopping discharge (m^3/s per meter).

RESULTS

The relative overtopping rate of both Model A and Model B in relation to the relative freeboard is presented in Figure 2. The orange ones refer to the measured results of Model A as a reference, while the purple ones are the outcomes from the Stilling Wave Basin crest modification.

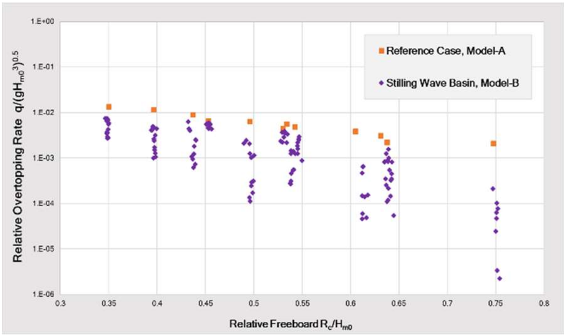

Figure 2. Relative overtopping rate comparison of Model A and Model B

When the mean overtopping discharges measured from the reference case and Stilling Wave Basin are compared, it is clear that the SWB reduces the overtopping discharge significantly. At the same relative freeboard (R_c/H_{m0}), high scattering is observed in the Stilling Wave Basin dataset. This scatter is caused from the different geometric configurations of SWB. It is concluded that the SWB reduces the overtopping discharge according to the related geometric configuration. For instance, in one test, where the SWB has the highest wall height (h_b) and the largest promenade length (X_r), the amount of overtopping discharge is measured 0.5 l while it is measured 39.5 l in its reference case. Consequently, this study experimentally presents the effectiveness of the crest modification by the Stilling Wave Basin approach in reducing the overtopping discharge.

ACKNOWLEDGMENT

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