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ENHANCING COASTAL FLOODING PREPAREDNESS TO CLIMATE CHANGE: AN EXPERIMENTAL ANALYSIS OF URBAN-INTEGRATED NON-CONVENTIONAL ADAPTATION SOLUTIONS

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ABSTRACT

Coastal areas are particularly vulnerable to climate change due to their exposure to mean sea-level rise and an intensification in the frequency and intensity of extreme events. Among the most vulnerable areas in Europe are the coastal urban areas of the Macaronesia Islands territories, since they are characterized with urban settlements in low land areas, being highly exposed to flooding. Within the scope of sustainable development and at the same time with the aim of increasing resilience in these areas, the development of a new methodological framework for implementing risk reduction and adaptation measures in coastal flood-prone areas is being applied with the framework of the LIFE-Garachico project (Tenerife, Spain). One of proposed adaptation options is the implementation of concrete blocks in the form of a bench to be disposed along the municipality seafront with the aim of reducing the impact of water sheets into building, generated by wave overtopping. This study presents the results obtained by means of a hybrid numerical and experimental technique to define the hydraulic performance of different bench configuration. Results are included in a global methodology to define the optimum time to implement this solution due to the consideration of different climate change scenarios.

KEYWORDS: Climate Change, Risk Assessment Flexible Adaptation, Coastal Flooding, Wave Impact, Hybrid Modelling.

1 INTRODUCTION

Coastal areas are particularly vulnerable to climate change due to their exposure to mean sea-level rise and an intensification in the frequency and intensity of extreme events. Moreover, it is expected that these effects will be increased according to the latest climate change projections (AR6, 2022). Among the most vulnerable areas in Europe are the coastal urban areas of the Macaronesia Islands territories. They are characterized with urban settlements in low land areas, being highly exposed to flooding. In fact, several examples in the past have been recorded all along the Macaronesia islands where the effect of extreme weather events has already produced severe coastal flooding with dramatic effects. Within the scope of sustainable development and to cope with climate change, which it is expected to be very relevant in these areas, and at the same time with the aim of increasing resilience of coastal comunities, the development of a new methodological framework for the implementation of risk reduction and adaptation measures in coastal flood-prone areas is being applied within the framework of the LIFE-Garachico project. The coastal front of Garachico, located in the northwest of the island of Tenerife (Canary Islands), has suffered throughout history and currently suffers multiple coastal flooding events. This causes high material damages, as well as the consequent risk for people and vehicles, road infrastructures, etc. The main premise in the project is that coastal flooding cannot be fully prevented and that the coastal island areas of Macaronesia need to learn to coexist with flooding events, but through adaptation programs and local awareness that increase the resilience of the coastal urban assets. The existing coastal dynamics in this area presents a very complex behaviour, mainly due to the heterogeneity of the seabed morphology and the urban sea front. The latter is composed by coastal protection infrastructures with very diverse typologies (rubble-mound protections with rocks and concrete units and vertical seawalls) and the presence of a partially emerged boulder that provides partial shelter to the coastal front. This situation gives rise to an area with very complex wave breaking and overtopping patterns that are very difficult to be represented through existing state-of-the-art formulations. The work will present results for one of the tasks of the LIFE-Garachico project, in which the design of one of the coastal adaptation measures proposed in the project is carried out. The objective is to evaluate the ability to reduce the impact of wave overtopping on buildings located on the front line of the promenade of the municipality through the staggered placement of concrete blocks on the promenade. In order to increase the integration of the blocks into the coastal area of the municipality, it has been decided that they will be in the form of a bench. The results of this analysis will be included in a comprehensive methodology that evaluates risk reduction through the implementation of adaptation measures and determines the optimal time horizon for their implementation at the site.

2 METHODOLOGY AND RESULTS

The methodology followed has been a combination of a numerical approach and laboratory experimental methods. The numerical approach combines wave propagation models to the study area (i.e.: SWAN), models to solve the wave interaction in the coastal area and subsequent wave overtopping and flooding (i.e.: IH2VOF). Whereas the experimental methods have allowed obtaining the hydraulic behavior parameters, and thus the ability to reduce the impact of waves, and consequently flooding risk. Numerical models were used in the pre-design phase and definition of the laboratory tests only, which includes a wave characterization not only of the present wave climate, but also includes compound wave and water level climate for climatic projections (AR5), for two scenarios RCP4.5 and RCP8.5, in the middle and at the end of the century. The presentation in the conference will show the complete risk methodology, but will focus especially on the experimental study, explaining the technical characteristics and specific results of the study.

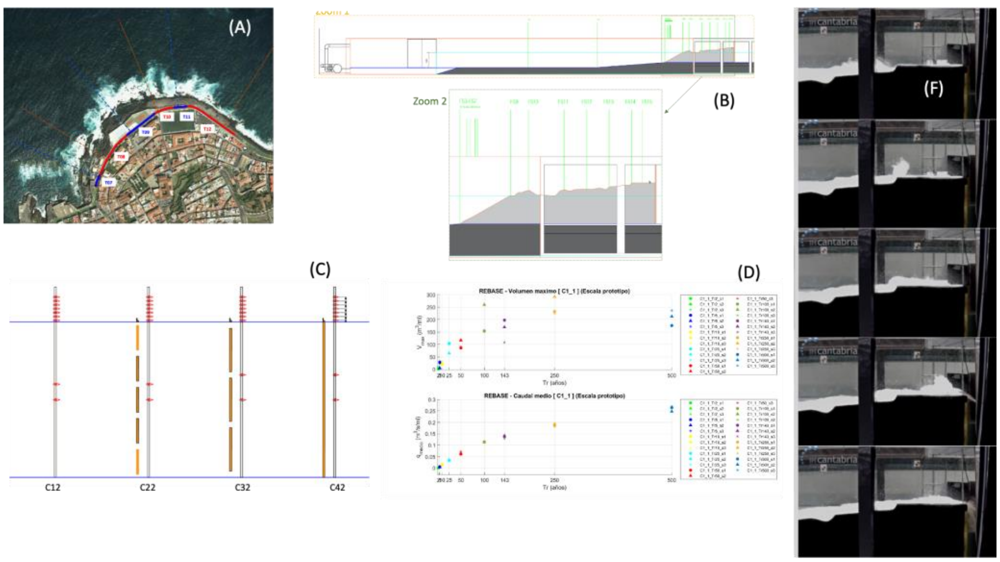

Figure 1. (A) Studied profiles in the study area; (B) Experimental set-up and free surface gauges location; (C) Bench configurations tested; (D) Wave overtopping flow discharge results; (F) Wave overtopping sequence.

The tests were performed using a 1/25 scale of a representative section of the waterfront, where the overtopping rate calculated with the IH2VOF model was higher. The coastal cross-section, made of concrete, was represented in the flume of the IHCantabria CCOB, which is 70 m long, 2 m high and 2 m wide. In the section, and in the area representing the waterfront, which includes the pedestrian walkway, the road and the building area, different configurations of benches were arranged to act as a barrier to the penetration of the wave overtopping layer. Figure 2 shows these configurations, which comprise the situation without banks (used as a reference), a continuous barrier, and two bench arrangements with openings between them. Because the flume is 2 m wide, it was possible to reproduce an adequate hydraulic behavior of the wave beach interaction, including diverting flow around them and within the gaps between benches. To monitor, free-surface sensors were used to record not only the wave characteristics along the cross-shore profile, but also in the emerged zone, and to characterize the thickness of the water sheet. Also, a central section of the benches was instrumented to measure forces and moments exerted by the waves on them, and on a vertical wall at the end of the model, which represented the presence of the buildings. Figure 1 shows the experimental setup and part of the results obtained in the study. It should be noted that the test was divided into two phases. In the first phase, the vertical wall was not included in the section, to record only the overtopping rates in the different configurations. In the second phase, it was included, and allowed the recording of wave loads.

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