NUMERICAL SIMULATION OF THE IMPACT FORCES GENERATED BY A SWASH-TYPE FLOW ON AN OVERTOPPED OBSTACLE

Mohamed Rozki, Université de Pau et des Pays de L'Adour, SIAME, mohamed.rozki@univ-pau.fr
Stéphane Abadie, Université de Pau et des Pays de L'Adour, SIAME, stephane.abadie@univ-pau.fr
Denis Morichon, Université de Pau et des Pays de L'Adour, SIAME, denis.morichon@univ-pau.fr

INTRODUCTION

The projected increase in sea levels will undoubtedly exacerbate the impact severity of storm events in the foreseeable future. In light of this, temporary protective measures are emerging as compelling alternatives to inflexible structures like breakwaters. However, the design and sizing of such temporary protections usually rely primarily on empirical approaches in the absence of well-established and comprehensive guidelines. The present study endeavors to address this deficiency and acquire a more profound understanding of the mechanical forces loading on these protective systems.

Figure 1 – Protective barrier made of sand bags.

MOTIVATION AND OBJECTIVES

In pursuit of this objective, we first studied an extreme storm event that occurred on an intermediate-reflective embayed beach (Grande Plage of Biarritz, France), during which the sandbags were displaced. This investigation combined phase-resolved numerical simulations with an observational dataset. This work allowed an initial approximation of the mechanical forces applied to the movable protective dike (Figure 1), along with flow characteristics responsible for this failure.

Previous studies investigated experimentally (Van Doorslaer (2017), Streicher (2019)) and numerically (Gruwez (2020)) impact forces generated by irregular waves. Our research focus shifts towards a more comprehensive examination of impact forces at an individual wave scale. While Liu (2022) have recently explored the impact of swash type flow, there remains an uncharted domain concerning the analysis of such impact forces on a structure experiencing overtopping. This applies to our study site, as well as to temporary coastal protection systems in numerous Western Europe coasts.

METHODOLOGY

To conduct our study, a Reynolds-Averaged Navier-Stokes (RANS), volume of fluid (VOF) model (InterFoam) is employed to simulate the impact of a collapsed bore which was generated by a dam break. The model configuration and settings aim to replicate the hydrodynamics conditions observed at our study site during the storm event that led to the failure of the removable dike.

RESULTS

Examining the profiles of impact forces derived from RANS simulations reveals two distinct peaks (Figure 2). The first peak corresponds to the impulsive phase of the swash flow impact at the wall bottom, a well-documented phenomenon extensively studied in the literature (Mokrani (2016)). A second peak, of similar or even greater magnitude (Figure 2), emerges during the return descent phase of the flow, coinciding with the closure of an air cavity. This second peak is of particular interest given its potential influence on the movement of sandbags. Noticeably, this peak was referred to in prior studies (Liu (2022)), but its underlying physical attributes remained unexplained.

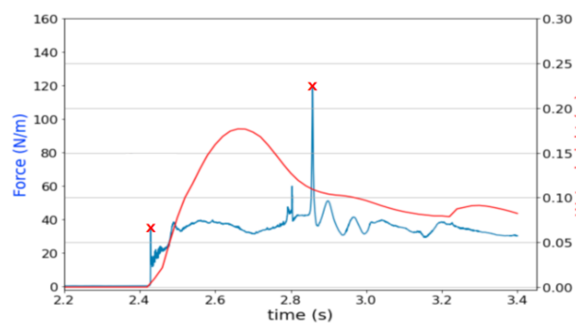

Figure 2 – Temporal evolution of impact force and water height from RANS simulations (red crosses: force peaks).

An in-depth analysis of our numerical results reveals that the period coinciding with the entrapment of the air cavity is characterized by a notable increase in pressure in its vicinity, resulting in occurrence of a force in the middle of a hydro-static pressure field stage.

A deeper analysis is currently being performed based on a comparison of incompressible and compressible simulations. These valuable numerical results will enable a deeper understanding of this specific impact physics. Ultimately, simulations will be juxtaposed with experimental data also currently being acquired.

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