Comparative Study on Breaking Waves Interaction with Vertical Wall Retrofitted with Recurved Parapet in Small and Large Scale


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This paper presents the ISOPE-2022 conference comparative study on the interaction between breaking waves and a vertical wall with a recurved parapet. The experiments, on the basis of which the comparative study has been conducted, were carried out at small scale (1:8) in the Department of Ocean Engineering, IIT Madras, as well as at large scale (1:1) in the Großer Wellenkanal (GWK), Hannover. The paper discusses the qualitative and quantitative comparisons between 10 different numerical solvers from various universities across the world. The numerical solvers presented in this paper are the recent state of the art in the field; some are commercial, and some have been developed in-house by various academic institutes. The participating codes have been benchmarked for their ability to capture interactions between the incident waves and waves reflected from the seawall. The codes have also been benchmarked for their ability to replicate multiple loading cycles, in time domain, evaluated at selected pressure probe locations over the vertical wall and recurved parapet. The same pressure-time histories have also been compared in the frequency domain to evaluate the solvers’ capability to capture the multitude of harmonics characterizing the impact load. Furthermore, the values of peak impact pressure over five loading cycles have been compared to assess the overall robustness of the codes in simulating repeated impact events at model and prototype scales.

INTRODUCTION

In the field of ocean and coastal engineering, today’s computational fluid dynamics (CFD) practitioners have a wide array of solvers to choose from. These include general-purpose commercial codes, longstanding, community-developed open-source codes, as well as up-and-coming in-house codes that are usually tailor-made for specific applications. These developments in numerical modeling have been complemented with equally great strides in physical modeling wherein an increasing number of experiments are being conducted at (e.g., Stagonas et al., 2020) or close to the prototype-scale (e.g., Ravindar and Srinar, 2021). As the number of international collaborations increase in academia, more and more researchers now have access to experimental datasets despite the fact that there exist only a handful of large-scale experimental facilities worldwide. This presents an opportunity to conduct massively collaborative computational studies in which numerical solvers belonging to several different classes of methodologies are applied to the same problem and are then compared mutually as well as against the experimental data. Some examples of such comparative studies include: ISOPE Benchmark 1 (Clément, 1999), ISOPE Benchmark 2 (Tanizawa and Clément, 2000), Loysel et al. (2012), Ransley et al. (2019, 2020), and, more recently, Srim et al. (2021) and Agarwal et al. (2021). Collaborative computational studies are beneficial in that they: (a) help in developing a broad understanding of the capabilities of different algorithms toward simulating a particular class of problems, (b) help in establishing best practices in CFD modeling wherein, more often than not, it is identifying the constituents of the “best simulation” that matters more than identifying the “best solver,” and (c) provide researchers with an opportunity to place their self-developed codes under assessment and gain confidence through the benchmarking process.

In the present study, data pertaining to small-scale (1:8) as well as prototype-scale (1:1) experiments involving a train of regular waves shoaling and breaking over a recurved seawall have been released to the participants as part of the 2022 International Ocean and Polar Engineering Conference (ISOPE-2022). Simulation data pertaining to time series of free-surface elevation and pressure at designated wave and pressure-probe locations were in turn received. The present paper contributes to the state-of-the-art insofar as comparative computational studies in wave-structure interaction are concerned. None of the previously mentioned studies involve breaking wave-induced slamming effects or the assessment of the participating codes at both small and large scales. Thus, the present study gives researchers an opportunity to assess their models in a comparative framework for violent breaker-structure interaction scenarios. The objectives of the comparative study include evaluating the solvers in terms of their capability to: (a) replicate the complex free-surface elevation patterns developed near the seawall as a result of interactions between the incident and reflected waves, (b) replicate the trend of hydrodynamic...