Proceedings of the Thirty-first (2021) International Ocean and Polar Engineering Conference **www.isope.org**
Rhodes, Greece, June 20 – 25, 2021

ISBN 978-1-880653-82-1; ISSN 1098-6189

Constructive and Destructive Interference Locations of Waves in a Circular Wave Basin - Study of Velocity Component Perpendicular to Wave Direction -

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ABSTRACT

The absorption of waves in a circular wave basin using segment-type wave makers is challenging due to the curvature, which may generate undesirable imperfections in long-crested regular wave fields close to the absorbing side of the FloWave circular wave tank with a diameter of 25 m and a water depth of 2 m. A velocity component perpendicular to the wave direction could be found numerically and experimentally, which is a key tool to understand and optimise the active wave absorption in a circular wave basin.

Conducting long-crested regular wave simulation using the SPH model based on Kanehira et al. (2019), the location of the hot-spots (constructive and destructive interference locations of waves) could be identified in the vicinity of absorption paddles as well as velocity components perpendicular to wave propagation direction, which are the potential cause of or caused by the hot-spots. Specific experimental investigations were conducted based on numerical results to validate the numerical model based on free surface elevation and local velocities. It could be shown that the location and strength of the hot-spots vary with wave frequencies and steepnesses as well as the connection between hot-spots and the velocity components perpendicular to wave direction. This combined approach has a high potential to provide insight into the absorption mechanism in a circular basin and helps to further improve the wave conditions in future.

KEY WORDS: reflected waves; circular wave basin; long crested waves; validation experiment; FloWave.

INTRODUCTION

In the context of the development of offshore structures such as vessels and ocean energy devices (OEDs), laboratory experiments can provide insight into how sea states affect the dynamics and the durability of structures developed as well as providing critical validation data for the numerical simulations. Therefore, a variety of wave tanks have been developed and utilised in ocean and coastal engineering.

In particular, multi-directional wave basins, incorporating multiple segment-type wave makers, are commonly used for OED model testing due to the demand to exploit renewable energy in the open-ocean (Caglayan et al., 2019, Draycott et al., 2019). A number of multi-directional wave basins have been developed such as the circular AMOEBA basin at Osaka University (Minoura et al., 2009), deep-sea basin at the National Maritime Research Institute, Japan (Maeda et al., 2004), and the FloWave Ocean Energy Research Facility circular wave and current basin at the University of Edinburgh (Ingram et al., 2014). These circular wave basins can generate realistic short-crested sea states as well as long-crested regular/irregular waves coming from any direction including combination to achieve realistic complex sea states. In particular, the correct generation and absorption system in a long-crested regular wave condition are important, as realistic waves are generated by the summation of regular wave components with different wave frequencies and directions (e.g. single/double-summation methods).

Regarding the generation of plane waves in a circular wave tank, several studies can be found for a piston-type (Mei and Zhou, 1991) and flap-type wave board (Gyongy et al., 2014). They proposed first order theory to generate intended regular waves with small amplitude in a circular basin under the assumption that the velocity component perpendicular to wave direction to be zero. For large wave amplitude, however, it is inevitable that the large paddle motions generate the velocity components where the normal vector of the rim is not parallel to the direction of incident wave.

Critical for the desirable wave fields is not only the correct generation of the waves by the wave makers, but also the absorption of the waves when they reach the opposing side of the tank. Reflection can cause unwanted artefacts in the tank and expand the needed settling time between tests. In the case of a circular wave tank, typical absorbing beaches are impractical and the wave makers also have to actively absorb the incoming waves.