

University of Groningen

A Cost-Effective Method for Modelling Wave-OWSC Interaction

Wei, Yanji; Abadie, Thomas; Dias, Frederic

Published in:
International journal of offshore and polar engineering

DOI:
[10.17736/ijope.2017.as21](https://doi.org/10.17736/ijope.2017.as21)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2017

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Wei, Y., Abadie, T., & Dias, F. (2017). A Cost-Effective Method for Modelling Wave-OWSC Interaction. *International journal of offshore and polar engineering*, 27(4), 366-373.
<https://doi.org/10.17736/ijope.2017.as21>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

A Cost-Effective Method for Modelling Wave-OWSC Interaction

Yanji Wei

Faculty of Science and Engineering, University of Groningen
Groningen, The Netherlands

Thomas Abadie and Frederic Dias*

School of Mathematics and Statistics, University College Dublin
Dublin, Ireland

Bottom-hinged Oscillating Wave Surge Converters (OWSCs) are an efficient way of extracting power from ocean waves. In our previous studies, wave and OWSC interaction has been investigated via computational fluid dynamics (CFD) models. However, these models were highly time-consuming, and significant re-reflection was observed. The present work couples a Boussinesq wave model with a CFD model in order to extend the scope of the applications of the previous models. This model takes advantage of the Boussinesq wave model, which simulates the wave propagation effectively, and the CFD model, which provides the local flow details comprehensively. The model is validated by a comparison of the present results with those obtained with the pure CFD model and the experimental tank testing. The final objective of the present work is to simulate some events experienced and recorded by the full-scale prototype (Oyster 800 developed by Aquamarine Power) incorporating the real bathymetry at the Oyster 800 site.

INTRODUCTION

Waves interacting with a bottom-hinged Oscillating Wave Surge Converter (OWSC) were investigated by the use of the computational fluid dynamics (CFD) method to understand the viscous effects (Wei et al., 2015) and the 2D wave slamming (Wei et al., 2016) on OWSCs. Although the vortex shedding from the edges and the wave overtopping device were properly described in the 3D model, the computational cost was expensive because this model essentially reproduced the experiment numerically; the computational domain included the entire experimental tank. Moreover, it was observed in the 2D experiments and simulations that the reflected wave from the device might be reflected off the paddle. Such a wave will contaminate the incident wave; hence, there is less confidence in the measured impact pressure for the design. In this paper, we use the terminology “re-reflection” to denote such a wave. In order to simulate the 3D slamming on the OWSCs at an acceptable computational cost, an affordable numerical model was developed (Wei and Dias, 2015). A truncated computational domain was used in the model, and the momentum sources were adopted to avoid the re-reflection from the outer boundary. However, the simulations were performed only under simplified conditions, i.e., the input waves were theoretical waves, and the sea bottom was ideally flat.

The full-scale prototype OWSCs (Oyster 1 and Oyster 800) have been installed at the European Marine Energy Centre (EMEC). High-quality prototype and wave data were simultaneously recorded in over 750 distinct sea states to demonstrate the performance of the OWSC concept in the real sea (O’Boyle et al., 2015). Due to the influence of the resonance of the channel slosh-

ing modes on the performance of the OWSCs (Renzi and Dias, 2012), errors might occur when the replication of the prototype flap dynamics is attempted in an experimental wave tank, especially near resonant frequencies. In addition, the bathymetry characterization cannot be fully replicated in the experimental wave tank. It is unknown what effects different seabed slopes have on the dynamics of a prototype OWSC. It is interesting to investigate numerically the wave-OWSC interaction under the real sea conditions to further understand the local flow around the device in the time domain, which may help facilitate device optimization studies.

The Boussinesq wave model is a popular wave model in the near-shore region, which has been applied to various coastal engineering problems. It can predict the propagation of the nonlinear waves over a bathymetry accurately and efficiently. The disadvantage of the Boussinesq model is that overturning waves, splash, and overtopping on structures are out of its scope as it is a depth-averaged model with a primary interest in wave propagation. The enhanced version of the Boussinesq model, i.e., the cut-cell approach developed by Ning et al. (2008), might be applied to the modelling of wave and coastal structure interaction, but their interest was mainly in the complex wave field rather than the force on the structure.

The idea of the present work is to couple a Boussinesq wave model with a Navier-Stokes solver in order to extend the application scope of the previously developed model. This model can take advantage of the Boussinesq wave model, which describes the wave propagation efficiently, and the CFD model, which provides the local flow details comprehensively. Coupling a cost-effective wave model with a CFD model is not a new concept. Christensen et al. (2009) demonstrated a one-way coupling model that combined the Boussinesq wave model with a 3D Navier-Stokes solver to study wave loading on monopiles.

Narayanaswamy et al. (2010) developed a hybrid model combining a Boussinesq model (FUNWAVE) with an SPH model (SPHysics) to study the solitary wave runup on planar beaches. Kim et al. (2010) presented a two-way coupling model to combine the Boundary Element Method (BEM) with the Volume of

*ISOPE Member.

Received November 15, 2016; updated and further revised manuscript received by the editors April 21, 2017. The original version (prior to the final updated and revised manuscript) was presented at the Twenty-sixth International Ocean and Polar Engineering Conference (ISOPE-2016), Rhodes, Greece, June 26-July 1, 2016.

KEY WORDS: OWSCs, Boussinesq model, CFD model, domain decomposition.