Numerical modelling of changing beach morphodynamics and wave-interactions with a dike for very shallow foreshores

Vandebeek Ine[1-2], Toorman Erik[2] and Troch Peter[2]

[1] Department of Civil Engineering, Ghent University, Technologiepark 904, 9052 Zwijnaarde (Ghent), Belgium
E-mail: Ine.Vandebeek@UGent.be
[2] Department of Civil Engineering, KU Leuven, Kasteelpark Arenberg 40 – box 2448, 3001 Leuven, Belgium

Low-lying countries such as Belgium and the Netherlands have a very typical coastal defence system along most of the coastal urban areas: a mildly sloped and (very) shallow beach in front of a dike with a promenade and high rise buildings close to the dike crest. The current threat of sea level rise and the expected increase in storminess due to climate change, may lead to a higher risk of overtopping during storm surges. To guarantee enough safety for the entire Flemish coast until the year 2050, the coastal defence systems are therefore being reinforced with beach nourishments and storm walls on top of the promenade. The presence of a shallow and morphologically dynamic foreshore in front of the dike has a significant influence on overtopping and wave loading forces as waves transform considerably before reaching the dike. Besides, substantial morphological processes take place such as erosion due to the intense hydrodynamic dissipation process. The effect of the latter on overtopping and wave loading forces and the wave-interactions with the dike are not yet fully understood and pose a challenge in current design methodologies.

The main objective of the current research, carried out within the CREST project (www.crestproject.be/en), is to develop a more accurate tool to predict wave-induced overtopping and wave loads on coastal structures including the effect of the changing beach morphodynamics for shallow foreshore conditions and to obtain a thorough understanding of the nearshore coastal processes. Numerical modelling is a suitable tool to investigate these processes and deliver reliable results. In this research, the Computational Fluid Dynamics (CFD) open-source software OpenFOAM (Weller and Tabor, 1998) is applied with olaFOAM boundary conditions for wave generation (Higuera et al., 2013a) to resolve the flow over the complete water depth and allow modelling of the complex overtopped flow on the dike and promenade. This is necessary to be able to model wave-interactions with dikes of very complex geometries (e.g. with storm walls, parapets, etc...). OpenFOAM has already shown to be able to provide accurate results for simulating coastal engineering processes (Higuera et al., 2013b). Additionally, the code can be easily adapted to account for user-specific applications, which makes it a suitable research tool for this work.

For example, the dynamic beach profile is modelled at the same time as the overtopping process to assess the effect on the overtopping flow and possible effects of the energy consumption by sediment transport on the wave transformation over the beach. Therefore, a sediment transport and morphology (i.e. bed changes) module is implemented within the OpenFOAM source code.

The new code is currently being validated with wave flume experiments including sediment transport, documented in literature. Further validation will be done by experimental data (including bed profile measurements) from the European Hydralab+ project WaLoWa (Kortenhaus et al., 2017). These experiments have been performed at very large scale (1/4.3) and include a shallow foreshore and a movable sand bed. The large scale ensures that scale effects will be limited.

Acknowledgement

This research is part of the fundamental strategic research project CREST – Climate Resilient coast (http:www.crestproject.be/en), funded by the Flemish Agency for Innovation by Science and Technology.

References

- Higuera, P., Lara, J.L., Losada, I.J., 2013a. Realistic wave generation and active wave absorption for Navier-Stokes models: application to OpenFOAM, Coastal Engineering, 71, 1, 102-118.
- Higuera, P., Lara, J.L., Losada, I.J., 2013b. Simulating coastal engineering processes with OpenFOAM, Coastal Engineering, 71, 1, 119-134.

- Kortenhaus, A., Streicher, M., Altomare, C., Gruwez, V., Hofland, B., Chen, X.,..., Kaste, D., 2017. WaLoWa (Wave Loads On Walls) - Large Scale Experiments In The Delta Flume [Data set].
- Weller, H. G., and Tabor, G., 1998. A Tensorial Approach to Computational Continuum Mechanics Using Object-Oriented Techniques, Computers in Physics, 12, 6, 620-621.

Keywords: CFD; OpenFOAM; sediment transport; wave overtopping; wave loads; Belgian Coastal Safety; CREST project

Book of Abstracts

VLIZ Special Publication 80

Book of Abstracts | VLIZ Marine Science Day | 21 March 2018 | MEC Staf Versluys | Bredene, Belgium

BOOK OF ABSTRACTS

VLIZ MARINE SCIENCE DAY

MEC STAF VERSLUYS, BREDENE
21 MARCH 2018

VLIZ SPECIAL PUBLICATION 80

This publication should be quoted as follows:

Jan Mees and Jan Seys (Eds). 2018. Book of abstracts – VLIZ Marine Science Day. Bredene, Belgium, 21 March 2018. VLIZ Special Publication 80. Vlaams Instituut voor de Zee – Flanders Marine Institute (VLIZ): Oostende, Belgium. 142 + ix p.

Vlaams Instituut voor de Zee (VLIZ) – Flanders Marine Institute
InnovOcean site, Wandelaarkaai 7, 8400 Oostende, Belgium
Tel. +32-(0)59-34 21 30 – Fax +32-(0)59-34 21 31
E-mail: info@vliz.be – Website: http://www.vliz.be

Photo cover: VLIZ

ISSN 1377-0950

PREFACE

This is the 'Book of Abstracts' of the 18th edition of the VLIZ Marine Science Day, a one-day event that was organised on 21 March 2018 in the MEC Staf Versluys in Bredene.

This annual event has become more and more successful over the years. With almost 400 participants and more than 100 scientific contributions, it is fair to say that it is the place to be for Flemish marine researchers and for the end-users of their research. It is an important networking opportunity, where scientists can meet and interact with their peers, learn from each other, build their personal professional network and establish links for collaborative and interdisciplinary research.

Marine scientists from all Flemish universities and scientific institutes – and representing all marine science disciplines – have contributed to this volume. The book thus illustrates the diversity, quality and relevance of the marine sciences in Flanders (and Belgium): it provides a beautiful and comprehensive snapshot of the state-of-the-art of marine scientific research in Flanders.

Pre-doc and post-doc scientists present their research in an exciting way and communicate their fascinating science – and its importance to society – to the wider public. We thus hope to demonstrate the excellence of Flemish marine science and to increase its national and international visibility.

The volume of research that is presented here holds a great promise for the future. It shows that marine science is a very lively discipline in Flanders, and that a new generation stands ready to address the grand challenges and opportunities that our seas and oceans represent.

For the second year, the Brilliant Marine Research Ideas are awarded, an initiative sponsored through the philanthropy scheme of VLIZ. We are proud to announce that last year's winners present their results here at the VLIZ Marine Science Day.

I want to congratulate all participants with their contributions, and I invite them all to become members of VLIZ and to actively participate in our events and activities in the future.

Bredene, 21 March 2018

Prof. Dr Jan Mees

General Director VLIZ

TABLE OF CONTENTS

Informative posters

Posters in competition