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Following up DURCWAVE project

Internal report

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Suzuki, T.; Altomare, C.; Verwaest, T.; Mostaert, F.

DURCWAVE

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Author(s):	Suzuki, T.; Altomare, C.

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Project leader:	Suzuki, T.	Getekend door:Tomohiro Suzuki (Signatu Getekend op:2021-03-25 19:57:50 +01:0 Reden:Ik keur dit document goed Tomohiro Suzuki

Approval

Head of Division:	Mostaert, F.	Getekend door:Frank Mostaert (Signatur Getekend op:2021-03-26 07:06:40 +01:0 Reden:Ik keur dit document goed Frank Mostaert

Abstract

This document reports a following up of the EU-funded research project DURCWAVE (amending the Design criteria of URban defences in LECZs through Composite-modelling of WAVE overtopping under climate change scenarios).

The role of FHR was an external advisor for the project. FHR exchanged the knowledge on overtopping design criteria and coastal management policy with Dr. Altomare (PI of the research project) through some communications including some workshops.

Dr. Altomare hired a composite-modelling approach, consisting of both physical and numerical modelling. Physical model tests were carried out in two different wave flume facilities in UPC, meanwhile the numerical modelling using mesh-free DualSPHysics model was performed. On top, the EPR data-driven technique was also used to find new correlations between wave impacts and overtopping flows.

As a result, Dr. Altomare published 14 articles (8 are collaboration with FHR) – at the moment of mid-March 2021. Through this following up project, FHR obtained further knowledge on wave overtopping processes, more specifically directional spreading effect on coastal dikes in shallow foreshores and overtopping flow characteristics on a dike in shallow foreshores. These knowledge are very relevant to the work of FHR, especially for the risk assessment of the coasts.

Contents

1 Introduction

Dr. Corrado Altomare (a former colleague at FHR) obtained a funded research from EU (Marie-Curie Action). The topic of the research is "amending the Design criteria of URban defences in LECZs through Composite-modelling of WAVE overtopping under climate change scenarios" (DURCWAVE).

The research topic of this project is relevant for the subgroup KUST in FHR and its client aK, since it deals with coastal defences and risks in urbanized coastal areas. The contents of the project are summarized as follows (extracted from cordis website amending the Design criteria of URban defences in LECZs through Composite-modelling of WAVE overtopping under climate change scenarios | DURCWAVE Project | H2020 | CORDIS | European Commission (europa.eu)):

The growth in coastal zone population increases the exposure of large numbers of people and assets to hazards related to climate change. Sea level rise and increased storminess represent major threats to coastal defences preventing the inundation of the hinterlands. This is true especially in low elevation coastal zones (LECZs). Understanding the mechanisms that govern the interaction between overtopping waves and coastal defences to changing climate conditions is of outmost importance to amend the current design criteria of coastal defences. The present project, named "DURCWAVE" (amending the Design criteria of URban defences in LECZs through Composite-modelling of WAVE overtopping under climate change scenarios), aims to identify new design criteria for wave action by modelling wave overtopping and post-overtopping processes of urban defences (storm walls, stilling wave basins, buildings along coastal boulevards). To reach these objectives the project will implement a composite-modelling approach, consisting of both physical and numerical modelling. Physical model tests will be carried out in two different wave flume facilities at the host organization (UPC), meanwhile the numerical modelling will be performed through the secondment at the partner organization (UVigo). The mesh-free DualSPHysics model will be used for the scope. The EPR data-driven technique will be used to find new correlations between wave impacts and overtopping flows. The Action will provide a methodology to help decision-makers to estimate the vulnerability of coastal zones to climate change, by assess the threats for sea frontages and buildings on the coastline. The project outcomes will trace the path at National and European levels for further extensions from urban defences in LECZs to all kind of coastal defences. Furthermore, a unique numerical model technique to simulate post-overtopping processes and estimate wave loadings on coastal defences will be release open-source for public use.

2 Summary of the activities

The role of FHR was an external advisor for the Marie-Curie project. FHR exchanged the knowledge on overtopping design criteria and coastal management policy with Dr. Altomare through a workshop in FHR on 25.9.2019 and CREST final conference on 26.9.2019, and shared data with UPC and Dr. Altomare (including experimental and numerical model results).

2.1 Workshop in FHR

In the workshop on 25.9.2019 in FHR, we discussed safety of people in coastal areas. The summary of the meeting is shown below.

- Dr. Altomare did presentation about his Marie Curie project, DURCWAVE.
- His research focuses on the assessment of the safety of the people living in LECZs (low elevation coastal zones) aiming to improve knowledge on wave overtopping / post-overtopping processes and design criteria of coastal defences
- Reported about his first physical model test results obtained from the small wave flume in UPC, CIEMito.
    - There is a big variability on the measurement of u and h even in the same q, while the scatter of V is relatively small.
    - Those results are plotted against the stability curves of human beings with different ages, which shows a big risk for the people on the dike/promenade
- Discussions
    - Why is it important to think about the risk of the people standing on dike/promenade (vertical evacuation is not enough)? -> it is import to gain knowledge on the link between physical phenomena and risk. Present guide lines eg EurOtop II does not show detailed information and reasonings. DURCWAVE will tackle on this issue.
    - Where do the scatters come from? -> scatter is an inherent nature but it can be partly due to the method used to quantify the values. Further investigation will follow.
- Varia
    - DualSPHysics workshop will be held in UPC. Dr. Altomare is the chair of the LOC. It is important to participate the workshop to get the latest version of DualSPHysics code. -> TSI is planning to participate it using the resource of this project (18_131 DURCWAVE following up)

2.2 CREST final conference

Dr. Altomare gave a keynote speech in the CREST final conference. The title of the presentation is *prediction of wave impact (overtopping and loads) on the dike during storms*. The powerpoint presentation is available on http://www.vliz.be/sites/vliz.be/files/public/CREST1100_Theme4.pdf.

2.3 Data sharing

FHR shared the physical model test data from 17_039 CREST golftankproven with Dr. Altomare.

2.4 Workshop in UPC/UVigo

Two visits (to UPC and UVigo) were foreseen during the project, however, these were not happened due to the COVID-19 pandemic and related travel restrictions.

2.5 5th DualSPHysics users workshop

The DualSPHysics users workshop originally planned in 2020 was postponed to March 2021 due to COVID-19. Eventually the workshop was organized online. Dr. Altomare was the chair of the Local Organizing Committee. Dr. Suzuki attended this online meeting and gave a presentation on a coupling method. See presentations including Suzuki's in Programme | 5th DualSPHysics Users Workshop (most of the presentation has youtube video, just click the title of the presentations).

3 Output

Dr. Altomare hired a composite-modelling approach, consisting of both physical and numerical modelling. Physical model tests were carried out in two different wave flume facilities in UPC, meanwhile the numerical modelling using mesh-free DualSPHysics model was performed. On top, the EPR data-driven technique was also used to find new correlations between wave impacts and overtopping flows.

As a result, Dr. Altomare published 14 articles (8 are collaboration with FHR) at the date of mid-March 2021 as listed below (extracted relevant info – title, authors, journal paper and repository link if applicable, from the database of the project).

On top, the outcomes of the conducted research have been accepted for presentation in 6 international conferences (PARTICLES 2019 with a keynote lecture, vICCE 2020 with two co-authored presentations, SPHERIC 2021, SPHERIC Harbin International Workshop 2020, Breakwaters 2021, SPHERIC 2019). Finally dissemination activities comprise 1 publication in the Hydrolink IAHR Magazine, 3 invited keynote lectures and 2 organized training events on DualSPHysics.

1 Influence of Convex and Concave Curvatures in a Coastal Dike Line on Wave Run-up.; Suba Periyal Subramaniam, Babette Scheres, Malte Schilling, Sven Liebisch, Nils B. Kerpen, Torsten Schlurmann, Corrado Altomare, Holger Schüttrumpf; *Water*; https://zenodo.org/record/4063343#.X3bYVWj7SUk

2 Numerical simulations of surf zone wave dynamics using Smoothed Particle Hydrodynamics.; R.J. Lowe, M.L. Buckley, C. Altomare, D.P. Rijnsdorp, Y. Yao, T. Suzuki, J.D. Bricker; *Ocean Modelling*; http://arxiv.org/abs/2002.00827

3 Influence of directional spreading on wave overtopping of sea dikes with gentle and shallow foreshores; Corrado Altomare, Tomohiro Suzuki, Toon Verwaest; *Coastal Engineering;* https://arxiv.org/abs/2002.04531

4 Benchmarking of numerical models for wave overtopping at dikes with shallow mildly sloping foreshores: Accuracy versus speed.; Christopher H. Lashley, Barbara Zanuttigh, Jeremy D. Bricker, Jentsje van der Meer, Corrado Altomare, Tomohiro Suzuki, Volker Roeber, Patrick Oosterlo; *Environmental Modelling & Software*; https://arxiv.org/abs/2006.03508

5 Overtopping Metrics and Coastal Safety: A Case of Study from the Catalan Coast; Corrado Altomare, Xavi Gironella, Tomohiro Suzuki, Giacomo Viccione, Alessandra Saponieri; *Journal of Marine Science and Engineering*; https://www.preprints.org/manuscript/202007.0164/v1

6 Determination of Semi-Empirical Models for Mean Wave Overtopping Using an Evolutionary Polynomial Paradigm; Corrado Altomare, Daniele B. Laucelli, Hajime Mase, Xavi Gironella; *Journal of Marine Science and Engineering*; https://zenodo.org/record/4057964#.X3LktWj7SUk

7 Reduction of Wave Overtopping and Force Impact at Harbor Quays Due to Very Oblique Waves; Sebastian Dan, Corrado Altomare, Tomohiro Suzuki, Tim Spiesschaert, Toon Verwaest; *Journal of Marine Science and Engineering*; https://zenodo.org/record/4057962#.X3LkN2j7SUk

8 Validation of RANS Modelling for Wave Interactions with Sea Dikes on Shallow Foreshores Using a Large-Scale Experimental Dataset; Vincent Gruwez, Corrado Altomare, Tomohiro Suzuki, Maximilian Streicher, Lorenzo Cappietti, Andreas Kortenhaus, Peter Troch; *Journal of Marine Science and Engineering*; https://zenodo.org/record/4057960#.X3LitWj7SUk

9 Grand challenges for Smoothed Particle Hydrodynamics numerical schemes; Renato Vacondio, Corrado Altomare, Matthieu De Leffe, Xiangyu Hu, David Le Touzé, Steven Lind, Jean-Christophe Marongiu,

Salvatore Marrone, Benedict D. Rogers, Antonio Souto-Iglesias; *Computational Particle Mechanics*; https://link.springer.com/article/10.1007/s40571-020-00354-1

10 Characterization of Overtopping Waves on Sea Dikes with Gentle and Shallow Foreshores; Tomohiro Suzuki, Corrado Altomare, Tomohiro Yasuda, Toon Verwaest; *Journal of Marine Science and Engineering*; https://zenodo.org/record/4057955#.X3Lg_Wj7SUk

11 Efficiency and survivability analysis of a point-absorber wave energy converter using DualSPHysics; Pablo Ropero-Giralda, Alejandro J.C. Crespo, Bonaventura Tagliafierro, Corrado Altomare, José M. Domínguez, Moncho Gómez-Gesteira, Giacomo Viccione; *Renewable Energy*; https://zenodo.org/record/4072862#.X37IysL7SUk

12 SPH Simulations of Real Sea Waves Impacting a Large-Scale Structure; Corrado Altomare, Angelantonio Tafuni, José M. Domínguez, Alejandro J. C. Crespo, Xavi Gironella, Joaquim Sospedra; *Journal of Marine Science and Engineering*

13 An Inter-Model Comparison for Wave Interactions with Sea Dikes on Shallow Foreshores; Vincent Gruwez, Corrado Altomare, Tomohiro Suzuki, Maximilian Streicher, Lorenzo Cappietti, Andreas Kortenhaus, Peter Troch; *Journal of Marine Science and Engineering*; https://www.mdpi.com/2077-1312/8/12/985

14 Refinement of integrated formula of wave overtopping and runup modelling; Masatoshi Yuhi, Hajime Mase, Sooyoul Kim, Shinya Umeda, Corrado Altomare; *Ocean Engineering*

4 Conclusion

Through this following up project, FHR obtained further knowledge on wave overtopping processes, more specifically, directional spreading effect on coastal dikes in shallow foreshores and overtopping flow characteristics on a dike in shallow foreshores. These knowledge are very relevant to the work of FHR, especially for the risk assessment of the coasts.

On top, there are some good advancements on wave/overtopping modelling as listed below.

- during the project focused wave group generation was implemented and tested in the DualSPHysics model, as well as it was employed for the physical model test carried out at large-model scale in the wave flume CIEM
- new generalized overtopping formulas were derived, one based on deep-water incident wave conditions (in collaboration with Kyoto University)
- the numerical work contributed significantly to the SPHERIC Grand Challenge #4 "Coupling to other models". Coupling schemes between wave propagation solvers (i.e. SWASH) and SPH-based solvers (i.e. DualSPHysics) are of outstanding importance for studying wave structure-interaction in very large and shallow domain, as the Belgian coast

Not only limited to these advancements, the collaboration went further in other directions as well, for instance, collaboration of publications and technical support of numerical simulation techniques (e.g. SWAN, SWASH, DualSPHysics).

DEPARTMENT **MOBILITY & PUBLIC WORKS**
Flanders hydraulics Research

Berchemlei 115, 2140 Antwerp
T +32 (0)3 224 60 35
F +32 (0)3 224 60 36
waterbouwkundiglabo@vlaanderen.be
www.flandershydraulicsresearch.be