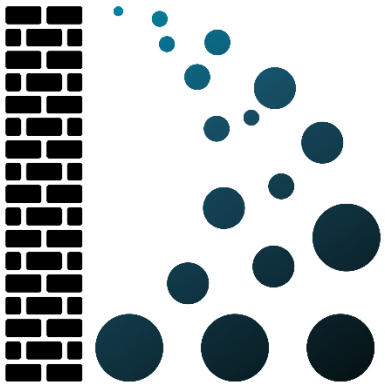
amending the Design criteria of URban defences in LECZs through Composite-modelling of WAVE overtopping under climate change scenarios



DualSPHysics validation vs experimental results for WSI problems

Project Information

Acronym	DURCWAVE
Title	amending the Design criteria of URban defences in LECZs through Composite-modelling of WAVE overtopping under climate change scenarios
Deliverable	D1.2 DualSPHysics validation vs experimental results for WSI problems
Location(s)	Universitat Politècnica de Catalunya – BarcelonaTech (UPC)
WWW link(s)	durcwave.es
Social Media	@durcwave_msca
Start date	01/03/2019
End date	04/04/2021

Project Personnel

Role	Name	Institution	Email	ORCID-iD
Project Supervisor	Xavier Gironella I Cobos	UPC	xavi.gironella@upc.edu	0000-0002-8862-5704
Main Researcher	Corrado Altomare	UPC	corrado.altomare@upc.edu	0000-0001-8817-0431

Document objective

This document summarizes the results of model validation of DualSPHysics solvers with experimental data for Wave-Structure Interaction (WSI) problems. An experimental campaign has been carried out in the small-scale wave flume CIEMito at Universitat Politècnica de Catalunya. Besides, other data from other experimental campaign have been used for further model validation (e.g. Hydralab+ WaLoWa project).

Acknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 792370.

Disclaimer

Document History

Date	Status	Author(s)	Reviewer (s)
10/12/2020	v.1	C. Altomare	X. Gironella
31/03/2021	v.2	C. Altomare	

License

Contents

1 Introduction

An experimental campaign to study the overtopping flow properties on sea dikes has been carried out within the framework of the MSCA-IF DURCWAVE. Data of overtopping volumes and discharges have been employed to validate the SPH-based meshless and open-source DualSPHysics solver (Crespo et al., 2015). Besides, data from other experimental campaigns (e.g. Hydralab + WaLoWa project, Kortenhaus et al., 2019), have been employed for further model validation of Wave-Structure-Interaction (WSI) problems.

2 Abstracts of performed DualSPHysics validations

The performed validations led to 2 accepted presentations in international conference/workshop and 3 papers in peer-reviewed international scientific journals, as listed as follows:

Conference presentations

- Altomare C., Gironella X., Robustelli M.L., Viccione G. *Wave overtopping assessment in DualSPHysics for real sea states of 1000 random waves*. 15th International SPHERIC Workshop, June 8-11, 2021, New Jersey Institute of Technology, Newark NJ, USA.
- Gruwez V., Altomare C., Suzuki T., Streicher M., Cappietti L., Kortenhaus A. & Troch P. *Numerical modelling of large-scale coastal wave impacts in shallow foreshore conditions*. virtual International Conference on Coastal Engineering 2020 (vICCE2020), 6th-9th October, 2020

Journal papers

- Gruwez V., Altomare C., Suzuki T., Streicher M., Cappietti L., Kortenhaus A., Troch P. *An Inter-Model Comparison for Wave Interactions with Sea Dikes on Shallow Foreshores*, Journal of Marine Science and Engineering, 2020, 8, 985.
- Lowe R.J., Buckley M.L., Altomare C., Rijnsdorp D.P., Yao Y., Suzuki T., Bricker J.D., *Numerical simulations of surf zone wave dynamics using Smoothed Particle Hydrodynamics*, Ocean Modelling, Volume 144, 2019, 101481, ISSN 1463-5003.
- Subramaniam S.P., Scheres B., Schilling M., Liebisch S., Kerpen N.B., Schlurmann T., Altomare C., Schüttrumpf, H. *Influence of Convex and Concave Curvatures in a Coastal Dike Line on Wave Run-up*. Water 2019, 11, 1333

2.1 Altomare et al. (2021) [SPHERIC Workshop]

DualSPHysics model has been applied to study the complex phenomenon of wave overtopping characterizing dike-promenade coastal defence layout. The model has been first validated, by comparing the results versus laboratory data obtained during a project campaign at the Maritime Engineering Laboratory of Universitat Politècnica de Catalunya – BarcelonaTech (LIM/UPC). The coastal area of Premià de Mar, in Catalonia, has been selected as case study. This stretch of the coast presents both railways and a bike path very close to the shore and therefore exposed to possible sea storms (Figure 1a). Numerical modelling was employed to extend the experimental database beyond the range of tested conditions. Cumulative overtopping volumes are calculated and compared with the experimental ones (Figure 1c), showing a very good agreement and accuracy in terms of overtopping not showing before in previous studies. Despite the initial relatively coarse resolution (=0.01cm), results were accurate. Same accuracy was found for different tests. Upscaling the overtopping discharge to real conditions, it results about 11 l/s/m, beyond the safety limits imposed in literature for design of coastal defences (EurOtop, 2018). Hence, the applicability and impact is focused on reducing discharge under tolerable values. One solution corresponds to hard countermeasures to reduce overtopping discharge, employing a storm wall located on

the dike crest. The other one is representative of soft countermeasures, namely beach nourishment, where the beach profile has been changed to shallower conditions (cotθ=30) to provoke more intense wave breaking and dissipate the incoming wave energy (Figure 1b). Both alternatives guarantee tolerable discharges for coastal safety (Figure 1c). Results of the numerical modelling are going to be presented during the 15th International SPHERIC Workshop.

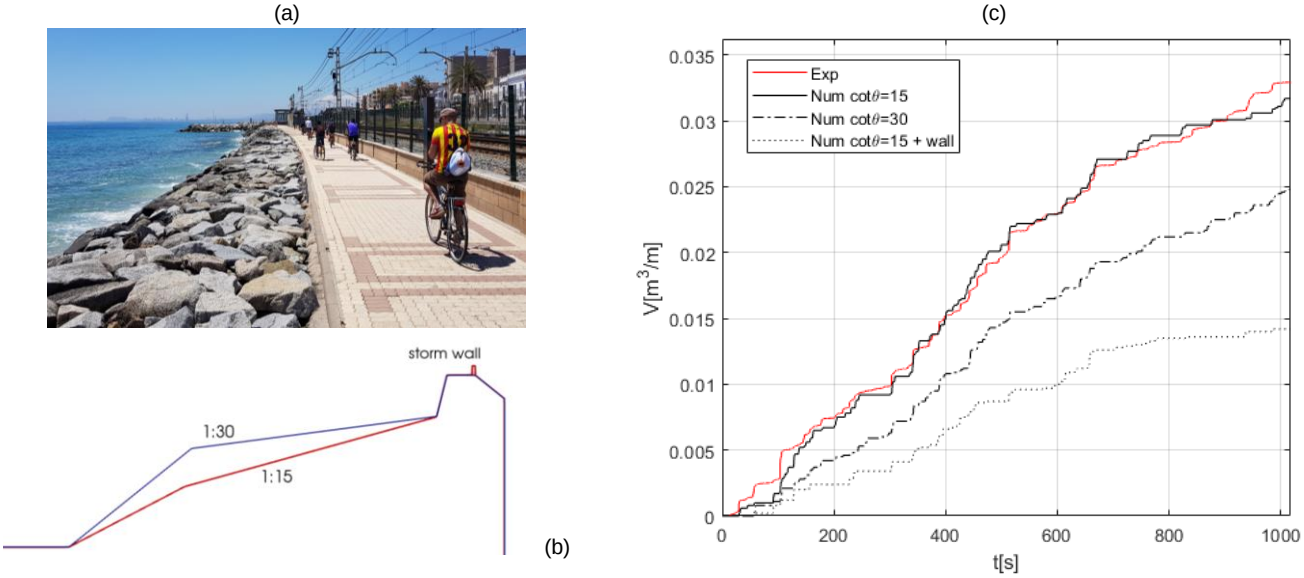


Figure 1. Coastal area and railway in Premià (a), tested geometries (b) and cumulative overtopping volume for different alternatives (c)

2.2 Gruewz et al. (2020) [vICCE], Gruewz et al. (2020) [JMSE]

Three open-source CFD models are applied to simulate the wave impact on storm walls or buildings on sea dikes in presence of shallow foreshores. Data from the Hydralab+ WaloWa campaign (Kortenhaus et al., 2019) have been employed for the scope.

The three selected models are: (1) a RANS model (OpenFOAM), (2) a weakly compressible SPH model (DualSPHysics), and (3) a non-hydrostatic NLSW equations model (SWASH). The models are compared both qualitatively (time series, snapshots) and quantitatively (model performance and pattern statistics) to determine their practical applicability for this case.

The results of this model validation and intercomparison have been presented at the virtual Interenational Conference on Coastal Engineering (2020). The recorded presentation can be found at the following YouTube Link: https://youtu.be/lOBMI8HGACs. Besides, a paper has been published in the Journal of Marine Science and Engineering, as part of the Special Issue *Wave Interactions with Coastal Structures*. Here the link to the publication (Gold Open Access): https://doi.org/10.3390/jmse8120985

2.3 Lowe et al. (2019) [Ocean Modelling]

The capabilities of DualSPHysics to simulate the detailed hydrodynamic processes generated by both spilling and plunging breaking waves within the surf zone has been assessed within this work. The solver has been applied for simulation of wave breaking over two distinct bathymetric profiles (a plane beach and fringing reef). The numerical results have been compared with to experimental data of waves, flows, and mean water levels. The results demonstrated that DualSPHysics is actually able to predict the nonlinear evolution of wave shapes (e.g., asymmetry and skewness properties), the rates of wave dissipation within the surf zone, and the wave setup distributions. All validation details are contained in the published paper that can be found at the following link: https://doi.org/10.1016/j.ocemod.2019.101481

2.4 Subramaniam et al. (2019) [Water]

In the present work DualSPHysics model has been employed together with the mesh-based OpenFoam model to model the influence of dike curvature on wave run-up. The numerical model results have been compared with experimental data from a 3D experimental campaign carried out in a wave basin. The numerical model aided the experimental one to determine new influence factors for wave run-up formulas. All details of the work are reported in the journal paper published in Gold Open Access in Water: https://doi.org/10.3390/w11071333.

3 References

- Crespo AJC, Domínguez JM, Rogers BD, Gómez-Gesteira M, Longshaw S, Canelas R, Vacondio R, Barreiro A, García-Feal O. 2015. DualSPHysics: open-source parallel CFD solver on Smoothed Particle Hydrodynamics (SPH). Computer Physics Communications, 187: 204-216. doi:10.1016/j.cpc.2014.10.004.

- Kortenhaus, Andreas, Streicher, Maximilian, Gruwez, Vincent, Altomare, Corrado, Hofland, Bas, Chen, Xuexue, … Klein Breteler, Mark. (2019). WALOWA (WAve LOads on WAlls) - Large-scale Experiments in the Delta Flume on Overtopping Wave Loads on Vertical Walls [Data set]. Zenodo. http://doi.org/10.5281/zenodo.2843140