STUDY OF WAVE REGENERATION BY WIND IN THE LEE OF A FARM OF WAVE ENERGY CONVERTERS USING THE MILD-SLOPE WAVE PROPAGATION MODEL, MILDwave

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The increasing energy demand, the need to reduce the greenhouse gasses, and the shrinking reserves of conventional energy have enhanced the interest in sustainable and renewable energy sources, a.o. wave energy. Many concepts for wave power conversion have been invented, a.o. Wave Energy Converters (abbreviated as WECs). In order to extract a considerable amount of wave power, single WECs will have to be arranged in arrays or 'farms', using a particular layout. As a result of the interaction between the WECs of a farm (near-field effects), the overall power absorption is affected. Moreover, the wave height behind a large farm of WECs is reduced, possibly influencing neighboring farms or other users in the sea or even the coastline (far-field effects). In general, the incident waves are partly reflected, transmitted and absorbed by a single WEC. Those devices can be distinguished in two main types: type (i) (different cases of floating bodies) and type (ii) (fixed or slack moored overtopping devices that capture the overtopped waves).
The present study refers to the development of the numerical modeling of the above mentioned wake effects of a WEC farm in a mild-slope wave propagation model, MILDwave. Here, the effect of wind input is introduced in order to investigate the effect of wave growth by wind on the reduced wave heights in the lee of single WECs and WEC farm layouts.
The numerical wave propagation model MILDwave has been recently used to study wake effects and energy absorption of farms of WECs (Beels *et al.*, 2010a; 2010b; Troch *et al.*, 2010; Baelus and Keppens, 2010) by using a sponge layer technique. MILDwave is a mild-slope wave propagation model based on the equations of Radder and Dingemans (1985) and developed by Troch (1998). This phase resolving model is able to generate linear water waves over a mildly varying bathymetry and to calculate instantaneous surface elevations throughout the domain. Wave transformation processes such as refraction, shoaling, reflection, transmission, diffraction and wave breaking can be simulated intrinsically. Other typical applications of the model are the study of wave penetration in harbours, e.g. Zeebrugge and Ostend in Belgium (e.g. Stratigaki and Troch, 2010; Stratigaki *et al.*, 2010), the harbour of Hanstholm in Denmark (Margheritini *et al.*, 2010), wave transformation studies, e.g. in the Norwegian coast (Kofoed *et al.*, 2008) and in the Belgian coast for the Thorntonbank, etc.
The physical process of wave regeneration by wind in a phase resolving model has been developed. The wakes behind single WECs and WEC farms are investigated for various wave conditions under the effect of wind. The evolved technique is applied on farms composed by hypothetical WECs with basic dimensions 36mx36m exhibiting a certain amount of absorption and on WECs known as Wave Dragons. Results in the lee of WEC farms when the wind effect is incorporated confirm that the available wave power increases when wind is applied. Moreover, taking into account wave regeneration by wind represents in a better way the actual wave and wind conditions in the field.

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References
Baelus L., and Y. Keppens. 2010. Numerical modelling of wave regeneration by wind in the lee of a farm of wave energy converters using MILDwave for multiple wakes (in English). Thesis, Ghent University.

Beels C., P. Troch, G. De Backer, M. Vantorre, and J. De Rouck. 2010a. Numerical implementation and sensitivity analysis of a wave energy converter in a time-dependent mild-slope equation model, Coastal Engineering 57(5): 471-492.

Beels C., P. Troch, K. De Visch, J.P. Kofoed and G. De Backer. 2010b. Application of the time-dependent mild-slope equations for the simulation of wake effects in the lee of a farm of Wave Dragon wave energy converters. Renewable Energy, 35(2010):1644-1661.

Kofoed J.P., L. Margheritini, V. Stratigaki and P. Troch. 2008. Estimation of wave conditions for SSG breakwater at Svåheia SSG pilot site, Aalborg: Aalborg University. Department of Civil Engineering. 154p. (DCE Contract Reports; 52).

Margheritini L., J.P. Kofoed, V. Stratigaki, and P. Troch. 2010. Estimation of wave conditions for SSG breakwater at Hanstholm location, Aalborg: Aalborg Universitet. Institut for Byggeri og Anlæg. 78p. (DCE Contract Reports; 90).

Radder A., and M. Dingemans. 1985. Canonical equations for almost periodic, weakly nonlinear gravity waves. Wave Motion 7: 473-485.

Stratigaki V. and P. Troch. 2010. Design of Ostend harbour: numerical simulation of wave diffraction through the gap at Montgomery dock using the ‘mild slope’ wave propagation model, MILDwave. March 2010. Flemish Government, Brussels, Belgium.

Stratigaki V., D. Vanneste, P. Troch, S. Gysens, M. Willems. 2010. Numerical modeling of wave penetration in Ostend harbour. 32nd International Conference on Coastal Engineering, Shanghai, China, ASCE, in press.

Troch P. 1998. A numerical model for propagation and transformation of linear water waves. Department of Civil Engineering, Ghent University.

Troch P., C. Beels, J. De Rouck and G. De Backer. 2010. Wake effects behind a farm of wave energy converters for irregular long-crested and short-crested waves. 32nd International Conference on Coastal Engineering, Shanghai, China, ASCE, in press.