Array of point absorbers in front of a wall-type coastal structures: Optimum layouts under regular waves

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Arrays of heaving Point Absorbers (PAs) deployed at near-shore areas may be installed on existing coastal structures, such as vertical (wall-type) breakwaters, facilitating cost reduction. In those cases, hydrodynamic interactions between the vertical barrier and the PAs are introduced, which can improve the array's power absorption ability (e.g. [1]-[2]). It is evident, however, that this improvement depends strongly upon the location of the PAs with respect to the wall and within the array. Hence, optimizing the layout of the array is a key factor towards the efficient deployment of heaving PAs in front of wall-type coastal structures. Motivated by this, in the present work, we investigate optimum, in terms of power absorption optimization, layouts of an array of five, semi-immersed, oblate spheroidal heaving PAs situated in front of a bottom-mounted vertical wall of finite length under the action of regular waves. The optimum layouts are determined for a given incident wave frequency and incident wave direction and they satisfy spatial constraints related to: (a) the perpendicular distance of the PAs from the wall, (b) the PAs' in-between distances, (c) the length of the wall available for the PAs' placement and (d) symmetry considerations (for perpendicular to the wall waves). The required diffraction/radiation problem is solved in the frequency domain by utilizing the conventional Boundary Integral Equation method, which is numerically realized using WAMIT software (www.wamit.com). For solving the constrained optimization problem, a Genetic Algorithm solver is developed and it is coupled with WAMIT in the MATLAB computational environment. The developed algorithm is validated by comparing its results with the parametric results of Loukogeorgaki *et al.* [2] for the case of a linear PA array. Under the action of perpendicular to the wall waves with frequency equal to the PAs' heave natural frequency, the formation of the array's optimum layout depends upon the length of the wall available for the PAs' placement. When the total available length of the wall is utilized, an "arrow"-shaped optimum layout, situated at a large perpendicular distance from the wall, is formed. However, by exploiting part of the total available length of the wall, a "trapezoidal" optimum layout is realized. Under the action of perpendicular to the wall waves with frequency smaller than the PAs' heave natural frequency, the devices are arranged as close as possible to the wall along a straight line parallel to the boundary regardless of the wall length utilized for the PAs' placement. Moreover, the PAs are grouped into 2-body "clusters". The above optimum layouts satisfy symmetry considerations with respect to the incident wave direction, which enhance the array's power absorption ability compared to the case of a totally random PAs' placement. Finally, the action of oblique incident waves leads to optimum layouts that show a significantly decreased power absorption ability compared to the layouts obtained for perpendicular to the wall waves.

References

[1] Loukogeorgaki, E., Chatjigeorgiou, I.K., 2019. Hydrodynamic performance of an array of wave energy converters in front of a vertical wall. 13th European Wave and Tidal Energy Conference, Napoli, Italy, September 1-6, 2019, Paper No. 1464.
[2] Loukogeorgaki, E., Boufidi, I., Chatjigeorgiou, I.K., 2020. Performance of an array of oblate spheroidal heaving wave energy converters in front of a wall. Water, 12(1), 188.

Keywords
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