A Hydroelastic Finite Element for Large Floating PV Platforms

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ABSTRACT

Green energy production from floating photovoltaic systems (floating PV) is a relatively new concept [1, 2]. Large floating photovoltaic platforms operating into water reservoirs or lakes have been found to prevent excessive water evaporation, while it has been established that their efficiency increases due to the cooling effect of water [1]. A floating PV facility of approximately 57000 m^2 is currently operational in Queen Elizabeth II pond in Surrey [2]. The large horizontal dimension of such a platform and its relatively small thickness classifies it in the category of Very Large Floating Structures (VLFS). Hydroelastic models could therefore be used for analysis, design and the assessment of structural integrity of these installations.

Regarding floating PV platforms of very large width, a finite element methodology for the hydroelastic normal modes in shallow basins has been presented by Papathanasiou and Belibassakis in [3]. In [3], a combined 3-node Hermite and 5-node Lagrange interpolation, for the deflection and velocity potential respectively, was used. This type of element was initially introduced for the time domain analysis of VLFS in [4].

In the present study, a different approach is adopted. A conforming, 2-node, Hermite Finite Element is proposed for the same hydroelastic system when the latter is reformulated as a sixth order differential equation for the velocity potential [5]. Continuity of the field, its first and second derivative is imposed at the mesh nodes. The same interpolation has been successfully used in the analysis of gradient elastic beams on elastic foundations [6] and is found to perform very well in the hydroelastc analysis of large PV platforms as well. Several examples of variable bathymetry shallow basins are analysed in terms of natural frequencies and normal modes. Benchmark examples presented in [3] are reproduced and the convergence of the new approach is established. The proposed structural hydroelastic finite element enables the easy and accurate computation of bending moments and shear forces as well.

REFERENCES

[1] K. Trapani and M.R. Santafé, "A review of floating photovoltaic installations: 2007–2013", *Prog. Photovolt*., Vol. **23**(4), pp. 524-532, (2015).

[2] https://www.theguardian.com/environment/2016/feb/29/worlds-biggest floating-solar-farm-power-up-outside-london

[3] T.K. Papathanasiou and K.A. Belibassakis, "Resonances of enclosed shallow water basins with slender floating elastic bodies", *J. Fluids Struct*., Vol. **82**, pp. 538 – 558, (2018).

[4] Papathanasiou, T. K, Karperaki, A., Theotokoglou E.E. and Belibassakis, K.A.. A higher order FEM for time-domain hydroelastic analysis of large floating bodies in an inhomogeneous shallow water environment, *Proc. R. Soc. A*, **471**: 20140643, (2014).

[5] J. J. Stoker, *Water Waves: the mathematical theory with applications*, Interscience Publishers, Inc., New York, 1957.

[6] D. M. Manias, T. K. Papathanasiou, S. I. Markolefas and E. E. Theotokoglou, "Analysis of a gradient-elastic beam on Winkler foundation and applications to nano-structure modelling", *Eur. J. Mech. A/ Solids*, Vol. **56**, pp. 45-58, (2016).