Proceedings of EWTEC 2021

The 14th European Wave and Tidal Energy Conference was held from 5-9 September 2021 at the University of Plymouth. For the first time, in response to the global pandemic, EWTEC was held in a hybrid format, allowing attendees to present online as well as in person. There were 12 different thematic tracks:

- Wave resource characterization
- Wave hydrodynamic modelling
- Wave device development and testing
- Tidal resource characterization
- Tidal hydrodynamic modelling
- Tidal device development and testing
- Structural mechanics: materials, fatigue, loadings
- Station-keeping, moorings and foundations
- Operations and maintenance
- Grid integration, power take-off and control
- Environmental impact and appraisal
- Economical, social, legal and political aspects of ocean energy

From the 403 abstracts initially submitted, 236 full papers were finally selected by a peer-review process, during which 48 Track Directors requested 963 single blind reviews and 427 reviews were finally carried out. These papers comprise the present proceedings, totalling 1952 pages.

This USB flash drive contains the searchable conference proceedings.

On behalf of the EWTEC Committee, I would like once again to warmly thank all the reviewers and Track Directors for their essential and voluntary work, and all authors for their contribution to the scientific content of the 14th EWTEC.

I would also like to sincerely thank our Sponsors for their valuable support to the conference.

Professor Deborah Greaves

Chair of EWTEC 2021

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Scaling and shape effects on the decay tests of heave plates

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***Abstract*—The Digital Prototype (DP) [1] procedure gets an approximation of the viscous hydrodynamic forces that apply to full-scale floating offshore structures. It uses a Computational Fluid Dynamics (CFD) model validated against experimental tests at a lower scale, to get the best fit of a model based on Cummins' equation with hydrodynamic coefficients including additional Morison's coefficients. To extend the validity of this method, multiple experimental tests on different configurations of heave plates have been carried out at the University of the Basque Country (UPV/EHU) hydrodynamics laboratory. Unlike other tests conducted on the same subject, these analyse the experimental and numerical results at different scales, extrapolating the results thanks to the DP method up to full scale.**

The contribution of the paper is the extension of this method to be used in a heave plate geometry, applicable to many different offshore devices, and the study of the advantages of a larger number of Morison coefficients in the equation of motion.

***Index Terms*—Experimental tests scaling, CFD, Decay tests, Morison terms.**

I. Introduction

WAVE energy sector is at an early stage of development and several challenges related to device dynamics such as the precise determination of the power production and the fatigue loads need to be overcome aiming to enable large-scale deployment of these technologies. The analysis and resolution of these problems require the availability of tools and procedures that allow estimating loads and performance in a more reliable manner and with greater efficiency to be able to study the space of cases necessary for the correct dimensioning and optimisation of these devices. Added to this problem is the fact that the lack of devices in this category on a real scale makes it difficult to obtain experimental data to refine numerical models based on empirical data. Besides, scale tests, due to the incompatibility between Froude and Reynolds nondimensional numbers, distort the effects of viscosity, the limited dimensions of the ocean basins prevent full-scale testing, and the costs and risks associated with full-scale devices mean that only limited characterisation testing can be done with them.

To progress in this area, several studies have focused on the analysis of the heave plates. This simple and relatively inexpensive design solution due to the low amount of structural material required concerning the hydrodynamic damping and the increased added mass-produced is widely used in the offshore industry. It allows to increase the damping of the structure by making use of the fluid viscosity, also increasing the added mass and therefore increasing the period of oscillation of the structure, thus moving it in some cases away from the period of the prevailing swell. Different studies have therefore analysed the influence of different design features on the performance of heave plates. The following are some of the most relevant ones:

Tian et. al. [2], presents an experimental investigation on the hydrodynamic coefficients of oscillating flat plates. The plates are forced to oscillate harmonically in still water. The range of Keulegan–Carpenter number ($KC = 2\pi a/D$, where a is the single amplitude of oscillation and D is the equivalent diameter of the plate) is $0.15 \leqslant KC \leqslant 3.15$. The hydrodynamic forces acting on the plates are measured and the hydrodynamic coefficients including quadratic added mass and damping coefficients are calculated following the Fourier analysis [3] using Morison's equation. The influences of the thickness ratio, shape, edge corner radius, perforation ratio and hole size on the hydrodynamic coefficients of a single plate are analysed and presented for different KC numbers. For twin- and triplet-plate configurations, the spacing effects are also evaluated. The central spar diameter is negligible. It is shown that the dependence of the hydrodynamic coefficients turns out to be strong with respect to the KC number and weak with respect to the oscillation frequency. The main dimension of the test facility is 1.5 m long, 1.1 m wide and 3.0 m high, and the reference diameter of the plate is 200 mm.

In Tao et. al. [4], the influence of shape and porosity are analysed. As expected, porosity increases the drag and reduces the added mass. For deep-water offshore structures such as a spar or truss spar, vertical oscillations normally occurred at low KC (< 1.0) and even lower for a Tension Leg Platform (TLP) due to the pretension provided by tendons. Therefore, the model tests are carried out in the range of $KC = 0.2 - 1.2$ with a forced vertical oscillatory movement jig. Horizontal test dimensions are 4.94x2.12 m, disk diameter is 0.4 m, oscillation frequencies are 0.1, 0.5 and 1 Hz, and oscillation amplitudes are 2.7 and 76.4 mm. The spar

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TABLE VIII: CFD results at 1:1 scale, scaled from 1:100 scale, of the 1 mm plate.

m''	c_a	b	b'
3345360		559420	
2955366			934045
2749374	2099998	521290	
2730383	1824872		869845
2678687	2349858	232915	374982

TABLE IX: CFD results at 1:100 scale of the 1 mm plate.

m''	c_a	b	b'
100%		97%	
103%			96%
96%	122%	99%	
97%	158%		98%
99%	117%	79%	128%

- c_a: $\lambda^{2.5}$
- b: $\lambda^{2.5}$
- b': λ^2

Applying these scaling coefficients to the values obtained from the coefficients at a scale of 1:100 to scale them to a scale of 1:1 gives the results shown in table VIII.

Table IX shows the degree of difference in percentage between the results obtained at 1:1 scale and the scaled results.

The results show that, although the Morison coefficients obtained on the basis of laboratory-scale results do have some similarity with the full-scale results, the differences between them are not negligible. This is why estimating the damping coefficients of real devices directly based on laboratory data can produce inaccurate results for parameters such as accelerations and forces in full-scale simulations. As a consequence, this can lead to incorrect design decisions.

VI. Conclusions

In this paper, we have reviewed the results of simulations and experimental tests of a series of spars with heave plates of different thicknesses. The effects of different scales have also been analysed with the use of CFD simulations. Despite testing with 1:100 test models, it has been shown that based on these experiments it is possible to reproduce tests at larger scales, so they may serve as a basis for the validation of higher-scale CFD models.

A Morison equation with additional coefficients has also been presented and tested for different geometries in experimental tests and different scales using CFD simulations. It has been shown that this equation allows better reproduction of the different cases tested, including higher-scale simulations, than using equations with fewer coefficients.

However, despite the greater similarity between the CFD and experimental results, with the results of the Cummins' equation improved with the Morison coefficients including these new terms, it is noted that scaling them using the Froude criterion in order to estimate the behaviour of full-scale devices can lead to erroneous results, resulting in design flaws in real offshore devices.

Therefore, in order to obtain more realistic estimates of the behaviour of full-scale devices, it is advisable to rely on procedures based on CFD simulations directly, as in the case of extreme loads, or indirectly through the fitting of the equation of motion coefficients, as in cases for performance or fatigue analysis. These CFD simulations would have to follow simulation strategies that have been validated at smaller scales in laboratory tests.

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