Assessing the impact of model simplifications during an experimental campaign of a floating wind turbine

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ABSTRACT

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1. Introduction

Ensaio com SIL com algumas limitações

2. Description of the experiment and its limitations

2.1. Model properties and experimental setup

- Caracteristicas da FOWT, RNA, ancoragem
- Principais dimensoes do tanque
- Condições de onda e vento

2.2. Implementation of a software-in-the-loop approach for aerodynamic loads

2.3. Main limitations of the experiment

3. Numerical models

Modelos numéricos que foram feitos com diferentes graus de proximidade pro ensaio

3.1. Drag coefficients from decay tests

Já falar do problema de ter pra uma direção só, mas que isso será discutido com mais detalhes mais pra frente

4. Comparison between the experiments and numerical simulations

Deixar guardado um resultado como tava antes no relatório p/ mostrar:

- A dificuldade de escolher qual coeficiente de arrasto usar, já que o pontoon afeta a vertical e a horizontal. A ideia é ilustrar que é importante pra forçante na vertical, mas que acaba sobrestimando a horizontal. Colocar um gráfico do decaimento de surge com o espectro de surge à direita; mesma coisa p/ heave e pitch, mostrando que p/ esse grupo de coeficientes é os verticais que pega bem. Gráfico do RAO em heave, mostrando que é a forçante viscosa que tá sendo importante;

- A necessidade de incluir as forças de 2a ordem na vertical;

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5. The impact of model simplifications on the response of the FOWT

- Comparar resultados das simulações nas condições reais e identificar diferenças pro modelo.
- Usar simulações intermediárias p/ explicar essas diferenças
- Avaliar o impacto da inclinação do casco

6. Conclusions

CRediT authorship contribution statement

Lucas H. S. Carmo: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing – original draft. **Alexandre N. Simos:** Conceptualization, Formal analysis, Writing – review, Supervision. **Pedro C. de Mello:** Experiments.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Agarwal, P., Manuel, L., 2011. Incorporating irregular nonlinear waves in coupled simulation and reliability studies of offshore wind turbines. Applied Ocean Research 33, 215–227.

Aranha, J.A.P., Fernandes, A.C., 1995. On the second-order slow drift force spectrum. Applied Ocean Research 17, 311–313.

Carmo, L., 2021. A slender-body approach for computing second-order wave forces in seakeeping simulations of floating offshore wind turbines. Ph.D. thesis. University of São Paulo.

Carmo, L.H.S., Simos, A.N., 2022. On the complementarity of the slender-body and Newman's approximations for difference-frequency second-order wave loads on slender cylinders. Ocean Engineering 259, 111905.

Coulling, A., Goupee, A., Robertson, A., Jonkman, J., 2013. Importance of second-order difference-frequency wave-diffraction forces in the validation of a FAST semi-submersible floating wind turbine model, in: 32th International Conference on Ocean, Offshore and Arctic Engineering, ASME. p. V008T09A019.

Faltinsen, O.M., 1993. Sea loads on ships and offshore structures. Cambridge University Press.

Gueydon, S., Duarte, T., Jonkman, J., 2014. Comparison of second-order loads on a semisubmersible floating wind turbine, in: 33th International Conference on Ocean, Offshore and Arctic Engineering, ASME. p. V09AT09A024.

John, F., 1950. On the motion of floating bodies II. Simple harmonic motions. Communications on pure and applied mathematics 3, 45–101.

Jonkman, J., Buhl, M., 2005. FAST User's Guide. Technical Report. National Renewable Energy Laboratory (NREL). Golden, CO, USA.

Jurado, A., Bredmose, H., 2020. Accelerated hydrodynamic analysis for spar buoys with second-order wave excitation, in: 39th International Conference on Ocean, Offshore and Arctic Engineering, ASME, Virtual, Online.

Kim, M.H., Chen, W., 1994. Slender-body approximation for slowly-varying wave loads in multi-directional waves. Applied Ocean Research 16, 141–163.

Kim, M.H., Yue, D., 1990. The complete second-order diffraction solution for an axisymmetric body - Part 2. Bichromatic incident waves and body motions. Journal of Fluid Mechanics 211, 557–593.

Lee, C., 1995. WAMIT Theory Manual. Cambridge, MA, USA.

Lighthill, J., 1986. Fundamentals concerning wave loading on offshore structures. Journal of Fluid Mechanics 173, 667–681.

Lopez-Pavon, C., Watai, R.A., Ruggeri, F., Simos, A.N., Souto-Iglesias, A., 2015. Influence of wave induced second-order forces in semisubmersible FOWT mooring design. Journal of Offshore Mechanics and Arctic Engineering 137.

Ma, Q.W., Patel, M.H., 2001. On the non-linear forces acting on a floating spar platform in ocean waves. Applied Ocean Research 23, 29–40.

Madsen, O., 1986. Hydrodynamic force on circular cylinders. Applied Ocean Research 8, 151–155.

Manners, W., 1992. Hydrodynamic force on a moving circular cylinder submerged in a general fluid flow. Proceedings of the Royal Society of London. Series A: Mathematical and Physical Sciences 438, 331–339.

Molin, B., Chen, X.B., 2002. Approximations of the low-frequency second-order wave loads: Newman versus Rainey. Proc. 17th IWWWFB, Cambridge (UK) .

Morison, J.R., O'Brien, M.P., Johnson, J.W., Schaaf, S.A., 1950. The force exerted by surface waves on piles. Journal of Petroleum Technology 2, 149–154.

Newman, J.N., 1974. Second-order, slowly-varying forces on vessels in irregular waves, in: Proc. Int. Symp. Dynamics of Marine Vehicles and Structures in Waves, Mechanical Engineering Publications Ltd., London, UK.

Newman, J.N., 1977. Marine Hydrodynamics. MIT press.

Pinkster, J.A., 1980. Low frequency second order wave exciting forces on floating structures. Ph.D. thesis. Delft University of Technology.

Press, W.H., Teukolsky, S.A., Vetterling, W.T., Flannery, B.P., 1992. Numerical recipes in C. 1. 2 ed., Cambridge University Press.

Rainey, R., 1989. A new equation for calculating wave loads on offshore structures. Journal of Fluid Mechanics 204, 295–324.

Rainey, R., 1995. Slender-body expressions for the wave load on offshore structures. Proceedings of the Royal Society of London. Series A: Mathematical and Physical Sciences 450, 391–416.

Robertson, A., Jonkman, J., Masciola, M., Song, H., Goupee, A., Coulling, A., Luan, C., 2014. Definition of the semisubmersible floating system for phase II of OC4. Technical Report. National Renewable Energy Lab.(NREL), Golden, CO, USA.

Robertson, A., Wendt, F., Jonkman, J., Popko, W., Dagher, H., Gueydon, S., Qvist, J., Vittori, F., Azcona, J., Uzunoglu, E., Soares, C.G., Harries, R., Yde, A., Galinos, C., Hermans, K., de Vaal, J.B., Bozonnet, P., Bouy, L., Bayati, I., Bergua, R., Galvan, J., Mendikoa, I., Sanchez, C.B., Shin, H., Oh, S., Molins, C., Debruyne, Y., 2017. OC5 project phase II: Validation of global loads of the DeepCwind floating semisubmersible wind turbine. Energy Procedia 137, 38 – 57. 14th Deep Sea Offshore Wind R&D Conference, EERA DeepWind.

Simos, A., Carmo, L., Camargo, E., 2018a. On the use of the white-noise approximation for modelling the slow-drifts of a FOWT: An example using FAST, in: 37th International Conference on Ocean, Offshore and Arctic Engineering, ASME.

Simos, A.N., Ruggeri, F., Watai, R.A., Souto-Iglesias, A., Lopez-Pavon, C., 2018b. Slow-drift of a floating wind turbine: An assessment of frequency-domain methods based on model tests. Renewable energy 116, 133–154.

Taylor, R.E., Rainey, R.C., Dai, D.N., 1992. Non-linear hydrodynamic analysis of TLP's in extreme waves: Slender body and diffraction theories compared, in: BOSS 1992 6th International Conference on the Behaviour of Offshore Structures, ASME, London, U.K.

WAMIT, I., 2004. WAMIT User Manual - Versions 6.2, 6.2PC, 6.2S, 6.1S-PC. Chestnut Hill, MA, USA.

Wehausen, J., 1971. The motion of floating bodies. Annual Review of Fluid Mechanics 3, 237–268.