Numerical simulation method to study the effect of damping plates for a new-type spar platform

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Abstract

Floating offshore wind turbines (i.e., FOWTs) are emerging as one of the most promising renewable energy resources and studies have been carried out regarding the floating platform. In a previous study, a new-type spar with damping plates was proposed as a solution to reduce the overall motion characteristics of the floating platform and model scale experiments were carried out. However, there is no numerical simulation method to understand the potential use of damping plates and this is a limitation to realize new-type spar platforms. The objective of this study is to develop a numerical simulation method to obtain the response characteristics of the new-type spar models with damping plates. In this study, the calculations based on boundary element method is adopted to evaluate the added mass and damping coefficients of the new-type spar models. Overall, three spar models (i) Type-A (Conventional spar platform without damping plates), (ii) Type-B (Spar model with horizontal damping plates) and (iii) Type-C (Spar model with vertical damping plates) are studied. The calculation results are compared with the findings of the model-scale experiment. It is found that there is a good correlation between the numerical simulation and experimental findings. The potential use of the proposed numerical simulation method is confirmed.

Keywords : Spar platform, Damping plates, Wave response, Numerical simulation

1. Introduction

Various platforms have been developed over the years to host floating offshore wind turbines. In a previous study, a new-type spar platform with damping plates was proposed to reduce the pitching motion of the offshore wind turbine. The experimental study showed the potential use of damping plates replacing lower part of the spar platform. However, there is lack of numerical simulation method to understand the effect of damping plates. This study is dedicated to developing a numerical simulation method to incorporate damping plates and study the effect of different configurations.

This paper is divided into four sections. Section 2 will discuss the research methodology including the new-type spar models. The results of the study is described in Section 3 along with validation results. Section 4 will conclude the findings of the study.

2. Research models and methodology

Table 1 shows the principal particulars of the new-type spar platforms considered in the study. The experimental models were crafted based on 1/120 model scaling to host a 5MW wind turbine. The stability parameter (Mass x GM) for all the three models is almost same.

Table 1 Principal particulars of the new-type spar models with damping plates.

Model types	Type-A	Type-B	Type-C
Diameter of the main cylindrical part (m)	0.11	0.11	0.11
Diameter of the water plane (m)	0.07	0.07	0.07
Mass (kg)	7.50	5.65	5.84
Moment of inertia (kg m^2)	1.288	1.288	1.223
GM (m)	0.084	0.114	0.112
KG (m)	0.313	0.346	0.350

Figure 1 shows the CAD models of spar platform. Type-B model has horizontal damping plates and Type-C has vertical damping plates. Type-A will be used as a base case without any damping plates. Figure 2 explicitly describes the proposed numerical simulation procedure. After modelling the damping plates in a CAD software, the open source BEM (Boundary Element Method) solver NEMOH is utilized for calculating the added mass, damping coefficients and wave excitation forces. The equation of motion is setup in frequency domain, and solved to obtain the response amplitude operators. It is noted that modelling only the floating body below the free water surface is sufficient to obtain the added mass and damping coefficients

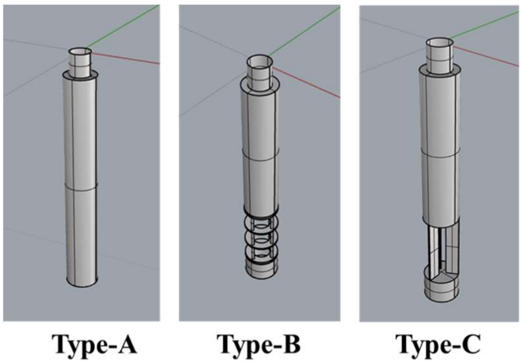

Fig. 1 New-type spar models.

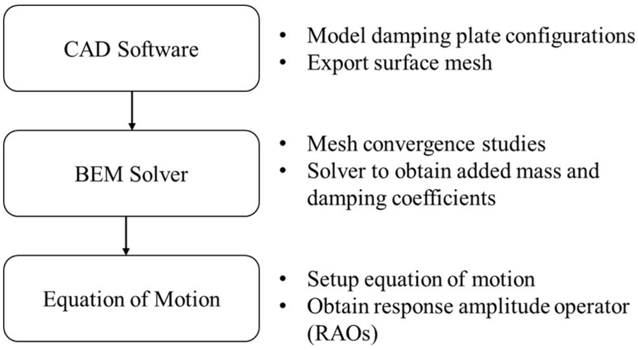

Fig. 2 Numerical simulation procedure

3. Results and discussion

The response amplitude operator in six degrees of freedom can be obtained based on the proposed method. In this paper, the heave RAO and pitch RAO are shown as demonstration. The simulation results are compared with the model scale experimental results for validation. Figure 3 shows the heave and pitch RAO results for Type-A, Type-B and Type-C spar models. There is a good correlation between the experiment and simulation results.

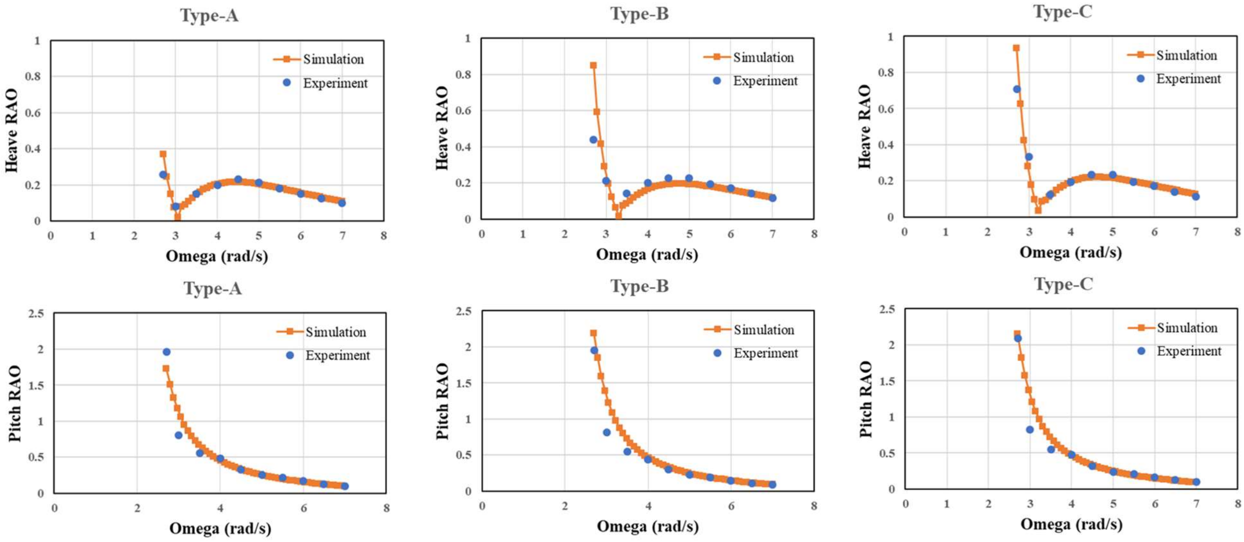

Fig. 3 Heave and Pitch RAO – Experiment vs Simulation

4. Conclusion

It is concluded from the results that the proposed numerical simulation method can predict the experimental findings. The simulation method to incorporate damping plates is validated.

References

Ishida, S. and Imai, Y., New spar design for floating offshore wind turbine with damping plates, Proceeding of the ASME 2019 38th International Conference on Ocean, Offshore and Arctic Engineering, Vol.9, 2019.