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Hydrodynamic analysis of floating platform for special purposes under complex water environment

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Abstract. This article studied a new floating offshore platform for special purposes, which was assembled by standard floating modules. By using ANSYS AQWA software, the hydrodynamic model of the platform was established. The time history responses of the platform motions and the cable tension forces were calculate under complex water environments, such as wind, wave, current and mooring. The results showed that the tension of the four cables are far less than the breaking tension of the cable, so that the cable will not break. This study can be referenced by the relevant researchers and engineers.

1. Introduction

The work studied a new type of combined marine floating platform for special purposes (Figures 1 and 2). The platform consists of standard floating body modules. The upper part adopts steel structure, laid with board, while the lower uses buoys to provide buoyancy. According to the requirements of use, they can be combined into required sizes.

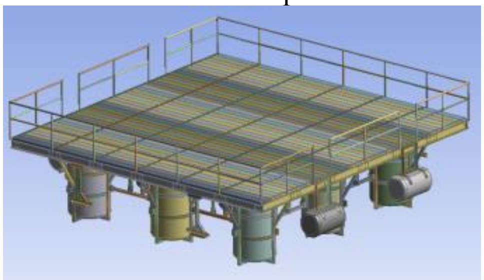

Figure 1. Axonometric drawing 1

Figure 2. Axonometric drawing 2

In order to ensure the platform with a certain degree of seakeeping, it is necessary to establish a finite element model for the new floating platform. What's more, its hydrodynamic characteristics and mooring schemes should be studied under load impact of wind, wave, current and ice[1-4].

The work studied the motion simulation of the floating platform under load impact of wind, wave and current by using ANSYS AQWA software. Firstly, the hydrodynamic model of the platform was established. Secondly, the Response Amplitude Operators (RAOs) of the platform were calculated. Finally, the time history responses of platform motion were calculated under complex water environments, such as wind, wave, current and mooring.

When it comes to the working environment, water depth is about 20m. It was designed in extreme water environment, with calculations of motion response and tension of mooring ropes, etc. The work chose the data of the wind, wave and current in the condition of five-grade sea state as the water environment simulated[5].

In this paper, the time history responses of platform motion are calculated under complex water environments, such as wind, wave, current and mooring by using ANSYS AQWA software[6].

2. Overview of environmental loads

At the beginning, the direction of wind, wave and current was the counterclockwise angle between its direction and the +X direction. Namely, the + X direction is 0 degree and the + Y direction 90 degrees. In this chapter, the work simulated the time history response of the platform under five-grade sea state, in the direction of 0, 45 and 90 degrees, respectively.

The work set five-grade sea state[5] as the harsh environment where the platform was exposed. The wind speed ranged from 22 to 27 m/s, with an average value of 24.5 m/s. In this paper, the value 24.5m/s was used in the simulation. As for wave, random spectrum can be inputted in AQWA to simulate the ocean wave environment, such as commonly used Pierson-Moskowitz spectrum (P-M spectrum) in engineering. The required parameters of the spectrum include wave frequency interval, significant wave height and average period. Table 1. shows the relevant parameters of the irregular wave spectrum in each sea conditions.

Table 1. Parameters of P-M Wave Spectrum of Different Sea State[5,7]

Grade of sea state	Significant wave height (m)	Lower limit of angular frequency (rad/s)	Upper limit of angular frequency (rad/s)	Average period (s)
2	0.5978	1.222	3.225	6.3
3	1.144	0.8836	2.331	7.5
4	1.841	0.697	1.838	8.8
5	3.612	0.4973	1.312	10
6	6	0.3746	0.9883	12.4

The velocity of water flow used 0.85m/s, like the condition of once-in-a-decade in the South China Sea without typhoon, consuming of linear distribution along with water depth, according to *DNV OFFSHORE STANDARDDNV-OS-E301*. Considering the most dangerous situation, directions of wind, wave and current are assumed of the same direction.

3. Mooring state

With regard to the floating platform, the common practice in engineering is that in the four corners of the platform, there will be one, two or three cables, moored under water. Since the floating platform for the research is relatively small in size, with length and width of 6m, in the initial mooring scheme, it is preferable to use tension cable made of fiber composite material. According to the cable data provided by Zhejiang Sixiong Wire & Cable Co., Ltd., the work initially adopted eight strands of polypropylene monofilament as the mooring rope, with the density of 0.91g/cm3 and the elongation at break 17% to 21%. In this chapter, the cable diameter was 64mm; fracture force 488kN. Besides, a mooring line was defined at each of the four corners of the platform, mooring at the seabed.

In AQWA, the cable was simplified to linear elastic cable, regardless of its wet weight. For linear elastic cable, we only have to set its tensile stiffness, float connection point, fixed point position under water and cable length. The tensile stiffness of a linear elastic cable is calculated as follows.

$$\text{Tensile stiffness} = \frac{\text{Fracture force}}{\text{Elongation at break}}$$

Because the elongation at break was the average data 19%, the tensile stiffness is 2568.4 kN/m after calculation according to the above equation.

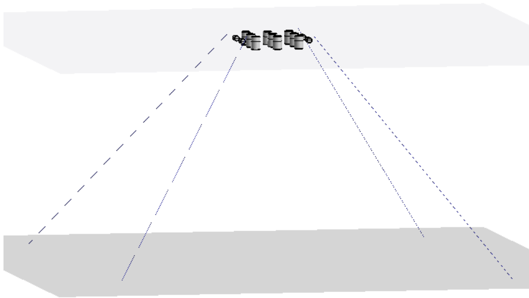

Figure 3. The Mooring State

The contact angle between tension cables and seabed is from 30° to 45° in general. The plan with angle of 45 degrees is settled in order to decrease the cost as much as possible, as is shown in Figure 3. Geometrical information, such as position of contact points and fixed points and length, is shown in Table 2.

Table 2. Geometrical Information of Mooring Cable

Number of mooring cable	Coordinate of contact points (m)	Coordinate of fixed points (m)	The straight-line distance between contact points and fixed points (m)	The length of cable (m)
1	3,3,0.6	18,18,-20	29.57	29.5
2	3,-3,0.6	18,-18,-20	29.57	29.5
3	-3,3,0.6	-18,18,-20	29.57	29.5
4	-3,-3,0.6	-18,-18,-20	29.57	29.5

4. Results of time historyresponse

The directions of wind, wave and current are settled as positive x, and simulative time are settled as 600 seconds. The response with time of translational and shaking motions of platform and tension of each cable are calculated. Time history curves of the degrees of freedom of platform in directions of X, Y, Z, Rx, Ry, Rz are shown in Figure 4 and Figure 5 respectively.

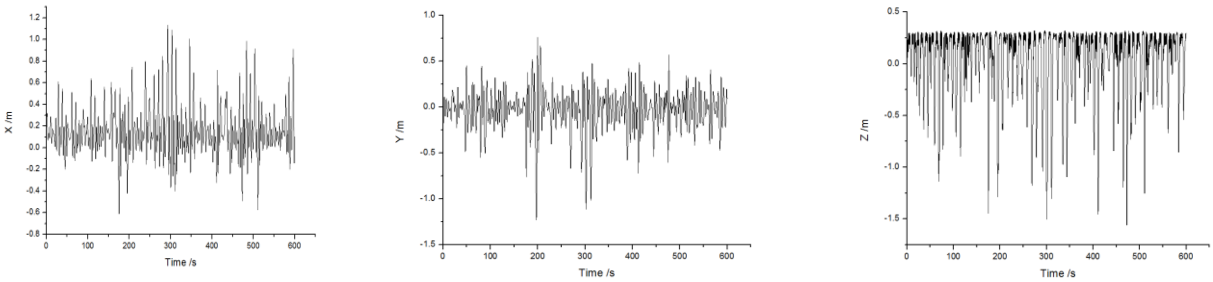

Figure 4. Time History Curves of Degrees of Freedom of Platform in Directions of X, Y, Z

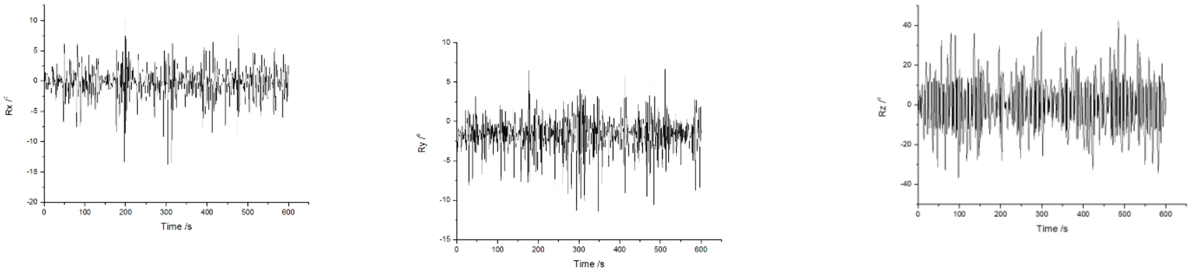

Figure 5. Time history curves of degrees of freedom of platform in directions of Rx, Ry, Rz

From Table 3, it can be learnt that response peak of platform in directions of X and Rz is larger, and shaking of Rx and Ry is obvious. Figure 6 shows tension time history curve of four cables, and Table 4 is the tension peak of four cables.

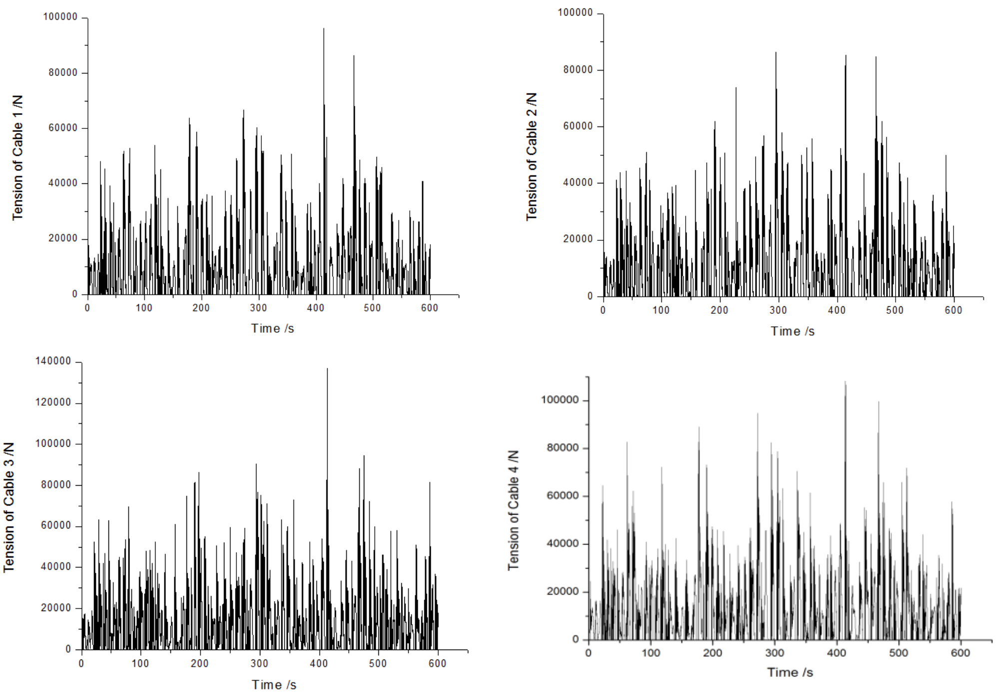

Figure 6. Time History Curves of the Tension of the Four Cables

Table 3. Response Peak of Degree of Freedom of Platform

	X	Y	Z	Rx	Ry	Rz
Minimum	-0.61	-1.23	-1.56	-16.24	-11.38	-36.80
Maximum	1.13	0.76	0.32	10.22	6.78	42.34

Table 4. Tension Peak of Four Cables

Tension peak (kN)	Cable 1	Cable 2	Cable 3	Cable 4	Fracture tension
	96.28	86.37	137.10	108.24	481

5. Conclusion

The time history responses of platform motion are calculated under complex water environments, such as wind, wave, current and mooring, by using ANSYS AQWA software.

The design environment adopted the wind and wave in five-grade sea state, as well as the water flow of once-in-a-decade in the South China Sea. After calculating the time history response of the platform, it comes to the conclusion that the platform has the largest translational motion response in the direction of load. Horizontal and vertical shaking amplitudes are between 14.42 and 20.04 degrees, with great first roll Rz amplitude, reaching 58.166 degrees. It is mainly due to the fact that the cable is not tensioned enough to provide sufficient restoring force. What's more, the tension of the four cables are far less than the breaking tension of the cable, so that the cable will not break. In order to maintain higher stability in the environmental load, it is vital to conduct optimal design on the cable system.

References

[1] Chen Peng, Ma Jun, Huang Jinhao, Li Yanqing, Xue Qingyu. Hydrodynamic Analysis and Mooring System Calculation for Semi-submersible Platform. Ship & Ocean Engineering, 2013,42(3), 44-47.

[2] Li Ya-nan, Tang Wen-xian, Zhang Jian, Su Shi-jie;Wang Kui. Research of Optimizing Mooring Line Length Methods of Semi-submersible Platform Based on Mooring System [J]. Ship Engineering, 2014(3):115-118.

[3] Ueno M. Hydrodynamic derivatives and motion response of a submersible surface ship in unbounded water. Ocean Engineering, 2010. 37(10): 879-890

[4] Murray J, Tahar A, Yang C K. Hydrodynamics of Dry Tree Semisubmersibles. Proceedings of the Eeventeenth International Offshore and Polar Engineering Conference, Lisbon, Portugal, 2007, 1-6 July.

[5] Faltinsen, O. M. "Sea loads on ships and offshore structures." New York, NY (United States); Cambridge University Press, 1990.

[6] Liu Zhen, Huang Weiping. Dynamic response analysis ofS-Spar platformbased on AQWA. Journal of Ship Mechanics, 2016, 20(z1): 48-56.

[7] Yan Li. Key Technologies of Ship Motion Simulation Base on Sea State. Doctoral dissertation, Shanghai Jiao Tong University, 2009.