Calculation of a new type of column stabilized floating platform's anchor chain force

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Abstract: In this paper, using aqwa software column stability type new platform for the modeling and analysis, first by using the method of frequency domain, the added mass of the floating platform and potential flow radiation damping and shaking RAOs curve, and then calculate the platform using the time domain analysis of cable force, in this paper, for the subsequent platform structure intensity laid a foundation.

1. The introduction

The new type of column stabilized floating platform is the latest product developed in recent years. It integrates the advantages of various ocean platforms and ocean buoys. It is a new tool to protect China's ocean safety and strengthen ocean monitoring.Due to the floating platform itself has no power system, most of the time depends on the anchor chain fixed in the seabed, so in addition to wave force, the influence of the anchor chain force is also not negligible.In this paper, the anchor chain force is solved, which lays a foundation for the subsequent safety check.

2. The relation of linear system of floating platform

The irregular movement and stress of the floating platform are caused by the irregular wave action.As a transmitter, the floating platform converts the irregular wave input into motion y(t).y(t) can represent roll φ(t), pitchθ(t), heave Z(t) and force F(t), etc.

If irregular wind and wave is a stationary normal random process, then the floating platform is a linear time-constant system under the action of irregular wind and wave, so the movement process of floating platform under irregular wind and wave becomes the corresponding problem of studying the output to input of linear system.

2.1 Frequency domain analysis

Frequency domain analysis method is a method to explore the dynamic characteristics of ship under wave action by using frequency response in frequency domain.The frequency response is the steady-state value of the ship's response to sinusoidal input at different frequencies.If the mathematical expression of the input wave is sine function: $\xi = \xi_0 e^{iwt}$, The output stable value can also be expressed as a sine function $Y = Y_0 e^{i(\omega t+\delta)}$.In this case, the frequency response is expressed as a function of their ratio:

$$H(iw) = \frac{Y(iw)}{\xi(iw)} = \frac{Y_0}{\xi_0} e^{i\delta} \tag{1}$$

In the formula: $Y_0 / \xi_0 =|H(i\omega)|$ represents the amplitude ratio of the output to the input, also known as the amplitude-frequency characteristic, This squared $|H(i\omega)|$2 is called the amplitude response operator, Abbreviated as RAO; $\delta = \arg[H(i\omega)]$ represents the phase frequency characteristic, which means the phase difference between sinusoidal output and sinusoidal input.

Therefore, the frequency response function *H(iω)* can be regarded as the transfer function in

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frequency domain analysis, which is an important characteristic of the ship's own system. If the frequency response function of the system is known, the linear response of the system under any external conditions can be calculated.

For the irregular disturbance of wind wave, the spectral density function is the most convenient expression of input and output. In a linear system, the output spectral density $S_y(\omega)$ can be expressed as the multiplier of the input spectral density $S_\xi(\omega)$ and the amplitude response operator RAO, namely

$$S_y(\omega) = S_\xi(\omega) \,|\, H(i\omega) \,|^2 \tag{2}$$

2.2 Time domain analysis

Time domain analysis is a method to describe ship dynamic characteristics under wave action by using impulse response in time domain. This method can obtain the time course of ship's motion under the action of irregular waves. The numerical motion of the floating body can be determined by a given moment.

This method introduces a unit pulse $\delta(t_0)$ acting on the system, which generates an impulse response function of $h(t-t_0)$ size. For a ship, the impulse response function is equivalent to the response of the ship after a short sudden action, from the moment when the disturbance ends to the process of restoring the static equilibrium, which is the dynamic characteristics.

If $\tau = t - t_0$, then the unit impulse $\delta(t_0) = \delta(t-\tau)$ has an impulse response of $h(t-t_0) = h(\tau)$. According to the principle of linear superposition, the input can be regarded as the sum of many pulses, in which case the pulse is the wave surface elevation $\xi(t_0) = \xi(t-\tau)$. After deduction, the output y(t) of the linear system at □ is:

$$y(t) = \int_{-\infty}^{\infty} \xi(t-\tau) h(\tau) d\tau \tag{3}$$

2.3 Frequency domain versus time domain

In frequency domain analysis, the dynamic characteristics of floating body are expressed by frequency response function. In time domain analysis, impulse response function $h(\tau)$ is used to express its dynamic characteristics. Both $H(\omega)$ and $h(\tau)$ reflect the dynamic characteristics of the system itself, and the relationship between them can be determined by Fourier change, namely:

$$H(w) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} h(\tau) \; e^{-iwt} d\tau \tag{4}$$

$$h(\tau) = \int_{-\infty}^{+\infty} H(\omega) e^{i\omega t} dw \tag{5}$$

3. Analysis of hydrodynamic response in frequency domain of floating platform

The hydrodynamic analysis model is shown in Figure 1. Hydrodynamic frequency domain analysis and time-domain analysis under mooring state are respectively conducted.

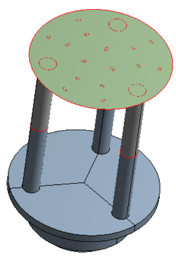


Fig. 1 Hydrodynamic model of floating platform

3.1 Additional mass and potential flow radiation damping

The curve of the relationship between the additional mass in X and Y directions and wave frequency is shown in FIG. 2. When the wave frequency is 2.13rad /s, the added mass is the maximum. The curves of radiative damping in X and Y directions with wave frequency are shown in FIG. 3. The curves of the two directions coincide with each other in the same degree, and the radiation damping reaches its maximum when the wave frequency is 2.38rad /s.

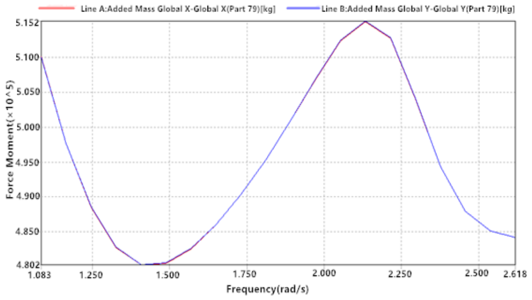


Fig. 2 The relation curve of additional mass

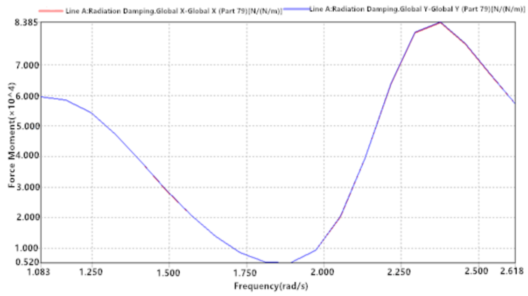


Fig. 3 Radiative damping curve

3.2 The curve of the RAOs

The floating platform studied in this paper has certain symmetry, and the Ry degree of freedom response under the direction of 0° and 180° can only be studied to explain the lateral rocking performance of the platform. Fig.4 shows RAOs curves of 0° and 180° floating platform shaking. When the wave frequency is 2.29 rad/s, the amplitude of lateral oscillation is the largest.

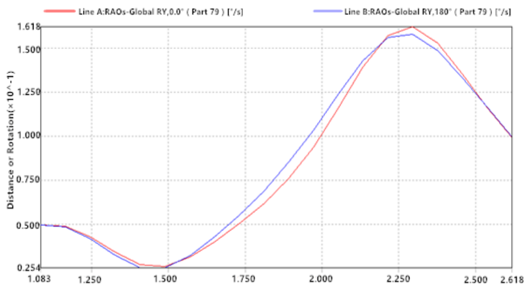


Fig. 4 Raos curve of horizontal shaking

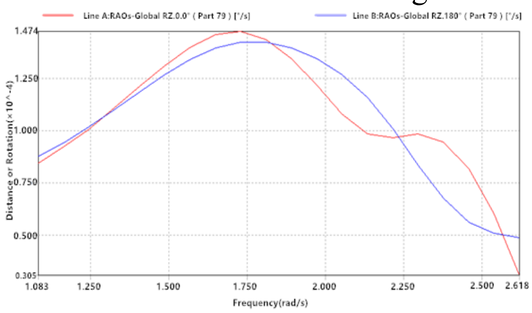


Fig. 5 Raos curve of head swing

RAOs curves of 0° and 180° bow of the floating platform are shown in FIG. 5. When the wave frequency is 1.73rad /s, the amplitude of yaw is the largest.

4. Hydrodynamic response analysis of floating platform in time domain

4.1 Marine environmental parameters

The working environment of the floating platform is located in the shallow sea of the South China Sea. Under the environment of water depth of 60m, the structure and overall design of the floating platform are required to meet the relevant specification requirements in different Marine environments. In order to ensure the safety of the floating platform, the most severe sea conditions should be adopted in the checking environment. Therefore, the environmental conditions in the time domain analysis adopt the Marine environmental parameters under the extreme sea state that occurs once in a century. The specific wind, wave and current conditions are shown in Table 1.

Table 1 Wind and wave flow parameters in Marine environment

	Return period	
	1year	100years
wind speed$v$(m/s)	16.4	39.0
Current Speed$v$(m/s)	0.3	0.93
Meaningful wave heightHs(m)	7.0	13.8
Peak periodTp(s)	12.1	16.1
spectrum	P-M	

4.2 Design of mooring system

In the system design of the platform, the cable section parameters initially selected are: diameter D is 0.1 (m), relaxation length is 55m, self weight is 150kg/m, and axial stiffness is 600ea/kn. The mooring scheme is shown in Figure 6, where θ= 21°. After the two cables meet directly under the platform, they are moored on the 60m deep seabed.

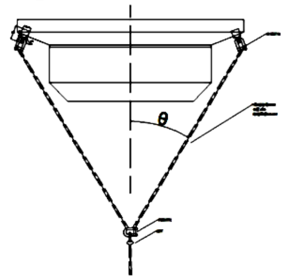
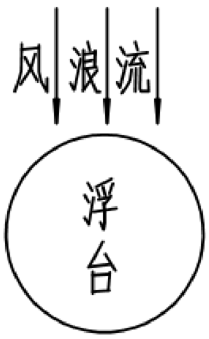


Fig. 6 Mooring scheme design

4.3 Hydrodynamic time domain analysis

Since the most dangerous working conditions are to be checked in this paper, the working conditions with wind, wave and current pointing in the same direction are selected, as shown in Figure 7.



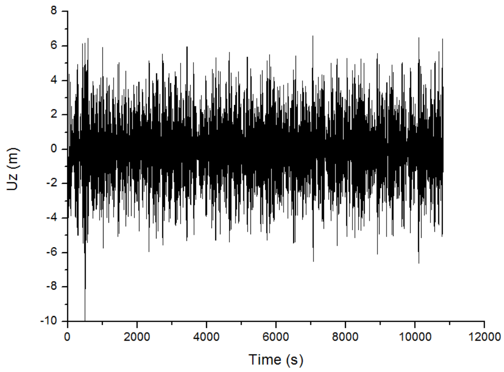
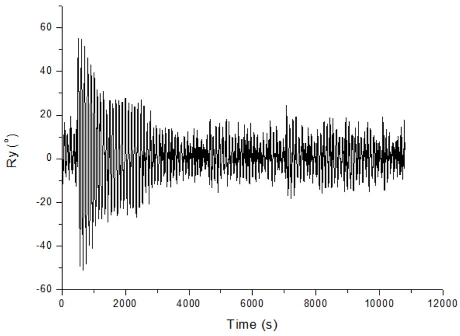


Fig. 7 Wind wave current load direction

Fig. 8 Time history curve of heave

According to the hydrodynamic analysis, calculate the movement of the positioning system for 3 hours (step size 0.1s, total 108000 steps) under the given environmental load. Finally, the time history motion response of the platform and the change curve of anchor chain tension can be calculated.

The time history curve of heave is shown in Figure 8. The time history curve of longitudinal shaking is shown in Figure 9



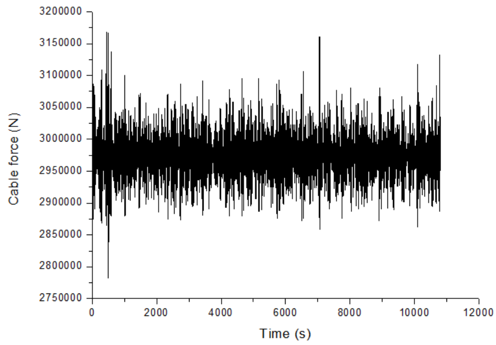


Fig. 9 Time history curve of longitudinal shaking

Fig. 10 Time history curve of cable tension

The time history curve of cable tension is shown in Figure 10.

After calculation, the maximum heave amplitude of the platform is 10.0m, the maximum swing amplitude is 55.1 °, and the maximum cable tension is 3.18mn. It can be seen from the maximum shaking amplitude that the shaking of the floating platform is large, so it should be considered to apply anchor chain force from multiple angles.

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