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Dynamic Response of Tension Leg Platform Based on Partial Linear Factors in Offshore Engineering

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Abstract: With the advancement of science and technology and the infinite development and exploration of the ocean, compared with land engineering construction projects, a new type of engineering construction emerges as the times require, "Ocean Engineering". Marine engineering refers to new construction, reconstruction and expansion projects with the purpose of developing and protecting marine resources, and the main body of the project is located on the seaward side of the coastline. The research purpose of this paper is the dynamic response of tension leg platform in marine engineering based on linear factors. In the experiment, the basic parameters of the tension-leg platform are set, and the wave load algorithm of the tension-leg platform is used to investigate and analyze the dynamic response statistics of the tension-leg platform under different waves.

1. Introduction

The development of marine engineering is of great significance to the development of our country, so great attention should be paid to the prevention and control of marine environmental pollution. The construction of marine engineering is an important driving force to promote the development of my country's marine economy. However, with the increasing trend of incremental, technological and diversified marine engineering, there are more and more researches on tension-leg platforms in marine engineering, and it is urgent in the future development process. It is necessary to solve the development problem of tension leg platform in offshore engineering construction.

The deep-sea floating platform represented by the tension leg platform will be further widely used in the development of marine engineering. Uffelen L studied underwater acoustics, one of the major focus areas of the University of Rhode Island's Department of Ocean Engineering, the first ocean engineering program in the United States. The program offers bachelor's, master's and

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doctoral degrees. Degree in Ocean Engineering. Based on the Narragansett Bay campus, these programs provide a living laboratory for student learning. Some of the key features of the plan are an acoustic tank, a 100-foot wave tank. A new regional-class ship is expected. At the graduate level, students are actively involved in research focusing on areas such as acoustic oceanography, propagation modelling, acoustic localization and navigation, geoacoustic inversion, marine mammal acoustics, marine acoustic instrumentation and transducers [2]. Djebarri S presents a design approach for permanent magnet generators for fixed-pitch tidal turbines in the context of marine renewable energy. In the case of underwater turbines, fixed-pitch tidal turbines can be very attractive and interesting to reduce maintenance operations by avoiding the use of such complex electromechanical systems for blade pitching. In this technical case, one of the main control challenges is ensuring power confinement at high power flow speeds. This control mode can be achieved using generator field weakening. In this context, a novel system design approach is proposed to optimize the generator design while taking into account the tidal turbine power constraints at high tidal velocities [3]. Rationally develop and utilize marine resources, comply with my country's sustainable development strategy, and promote the long-term and stable development of the marine economy.

According to the research background and significance of the subject, this paper studies the general situation of the development of the tension-leg platform and the dynamic response of the tension-leg platform, including the basic overview of the structure and wave load of the tension-leg platform. In the experiment, the basic parameters of the tension-leg platform are set, and the wave load algorithm of the tension-leg platform is used to investigate and analyze the dynamic response statistics of the tension-leg platform under different waves.

2. Research on Dynamic Response of Tension Leg Platform Based on Partial Linear Factors in Offshore Engineering

2.1. Research Background and Significance

The indirect or direct marine environmental ecological damage and the economic loss of our country brought about by the rapid development of marine engineering construction projects are huge. There are many pollution accidents caused by marine engineering at home and abroad. We should re-examine the existing relevant legal system while developing marine engineering projects. While studying the legal system of pollution prevention and control in my country's marine engineering construction, on the one hand, it will help to promote the work process of my country's marine environmental pollution prevention and control; Reflection of guiding ideology. It will help to promote the construction of marine ecological civilization and lay a good foundation for the realization of a powerful marine country. The negative effect brought by the vigorous development of marine engineering construction is the occurrence of accidents that marine engineering pollutes the marine environment. Due to the lack of legal system in the prevention and control of marine engineering pollution in our country, once such a huge construction project has a big accident, it will bring huge economic losses. Therefore, it is necessary to fundamentally reduce the probability of accidents in order to promote the stable development of my country's marine economy. Through the research of this paper, on the one hand, it will help to fill the legal loopholes in the field of marine environmental pollution prevention and control, and improve the legal system related to the marine environment; Coordinate pollution control and improve the effectiveness and systematicness of pollution prevention and control in my country's marine engineering construction. Increase the public's attention to the marine environment, and further promote the implementation of laws and regulations on the prevention and control of marine engineering pollution.

2.2. Development Overview of Tension Leg Platform

ETLP is optimized from the traditional tension leg platform structure, which reduces the distance between the four columns of the platform, so that the connection point between the bottom floating body and the column is no longer located at the outermost edge of the tension leg structure. This design was first proposed by ABB. It cleverly reduces the size of the deck, so that the platform has a smaller waterline surface area, making it cheaper to build, and also reduces the moment of inertia of the tension leg platform, improving the economic performance of the platform and the survivability of severe sea conditions. . Sea Star TLP and MOSESTLP are both mini TLPs, which are significantly smaller than traditional tension leg platforms. They are designed and developed by Atlantia and MODEC respectively. The difference between Sea Star TLP and the traditional tension leg platform is no longer set with four uprights. A cylindrical column connects the upper and lower parts of the platform, called the central column, and the three floating bodies at the bottom radiate outward at a 120-degree angle to each other, the end is connected with the tension leg structure. Although the MOSESTLP retains the four columns connecting the upper and lower parts of the platform like the traditional tension leg platform, the distance between the columns is greatly reduced, which reduces the water plane of the platform, reduces the effect of wave force, reduces the construction cost of the platform, and improves the operation safety performance.

2.3. Research on Dynamic Response of Tension Leg Platform Based on Sub-linear Factors

(1) Theoretical basis of tension leg platform

The dimensional potential flow theory is based on the potential flow theory. According to the four conditions of the free surface dynamic condition, the bottom condition, the object surface condition and the infinite distance boundary condition, the corresponding velocity potential can be obtained, and then substituted into Bernoulli's formula Get the surface pressure value of the object. The following Green's function method solves the velocity potential that satisfies the conditions according to the fixed solution conditions of the fluid. Common methods for solving boundary problems include: boundary integration method, three-dimensional watershed meshing method (finite element finite difference) and Green's function method. The Green's function method can solve the wave load of any shape of floating body structure and ship structure, and has its own unique advantages. Compared with solving on a two-dimensional surface, the calculation accuracy of Green's function is improved in a three-dimensional watershed, while ensuring that the three-dimensional grid points do not intersect the object surface. In the linear range, if the Green's function is properly selected, the integration can also be performed at the interface between the fluid and the solid. When Morrison's theory calculates the wave force of small-scale member structures, a semi-empirical formula based on the flow theory is usually used—the Morrison formula.

(2) Basic overview of wave loads

When the water is stationary in the gravitational field, the free surface must be horizontal. Under a certain disturbance, the free surface of the water will deviate from the original equilibrium position, but due to the action of gravity, the surface of the water can return to equilibrium; but due to inertia, The water level deviates from its equilibrium position and gravity is restored; this reciprocating motion propagates over the entire free surface in the form of waves, waves.

Engineering Background of Wave Loading Wave is a very common natural phenomenon that occurs alternately in time and space between the highest and lowest water surface on the sea surface, and has a certain energy. In order to be able to determine the effect of wave loads on marine structures, it is necessary to determine the wave-related design elements, that is, the maximum wave conditions that marine structures may encounter during service. However, because the waves in nature are obviously irregular in both time and space, in order to express this feature as much as possible, related wave calculation theory methods have been gradually developed.

3. Investigation and Research on Dynamic Response of Tension Leg Platform Based on Partial Linear Factors in Offshore Engineering

3.1. Basic Parameters of the Tension Leg Platform

The tension leg platform studied in this paper adopts the traditional type of structure, and the main structural parameters of the tension leg platform are shown in Table 1:

Table 1. Main parameters of the tension leg platform

The parameter name	Numeric value	Unit
Operating draft	2000	m
Platform draft	35	m
Total water mix on the platform	28471.9	t
Total platform weight	18547	t
The column is long	55	m
Column diameter	18	m
Column span	60	m

3.2. Calculation of Wave Load of Tension Leg platform

The wave load calculation method of the tension leg platform measures the numerical value of the wave dynamic response. In the formula, F is the wave force per unit length of the small-scale member perpendicular to its axis direction; F_D is the drag force; F_1 is the inertial force. The specific formula is as follows:

$$F = F_D + F_1 \tag{1}$$

$$F_D = 1/2\rho_w C_d A|u - x|(u - x) \tag{2}$$

$$F_1 = \rho_w V(C_m u - C_a x) \tag{3}$$

4. Analysis and Research on Dynamic Response of Tension Leg Platform Based on Partial Linear Factors in Offshore Engineering

4.1. Statistics and Analysis of Motion Response of Tension Leg Platform

Statistics on the motion response of the tension leg platform under different waves are shown in Table 2 and Figure 1:

Table 2. Statistics of the motion response value of different wave downward tension leg platform

Envirment Angle	180	190	200
Mean	91.28	88.32	83.21
Wave-freq rms	5.364	5.124	5.008
High-frq rms	2.142	2.105	2.041
Low-freq rms	4.845	4.674	4.518
Min	98.512	97.251	96.214
Max	76.241	75.944	73.142

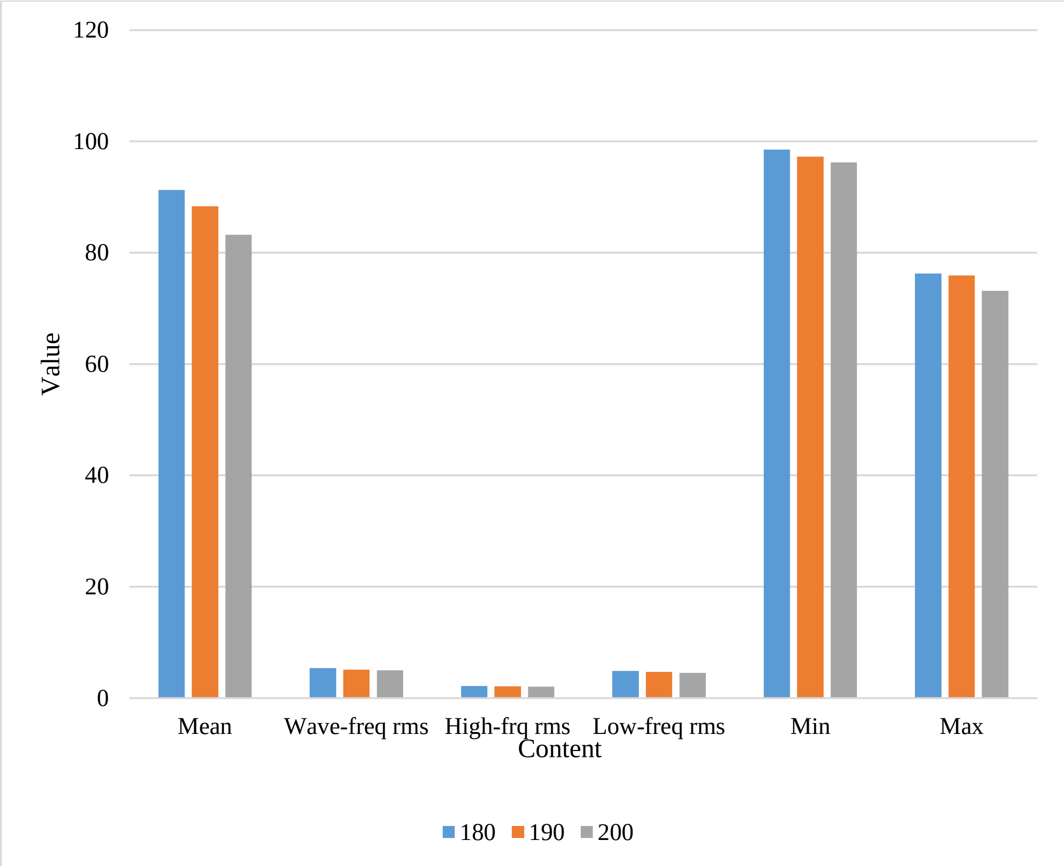

Figure 1. Data diagram of the motion response value of the tension leg platform

From the table, it can be found that the maximum X-direction displacement of the tension leg platform occurs at 180°, which is 91.28m, indicating that the movement of the tension leg platform in the plane has a strong compliance.

4.2. Statistics of Dynamic Response of Tension Leg Platform in Different Waves

The statistics of the dynamic response of the tension leg platform to the tension tendon in different waves are shown in Table 3 and Figure 2:

Table 3. Statistics of the force response values of each tendon in different wave downward tension legs

Envirment Angle	180	190	200
Mean	18600000	19100000	19900000
Wave-freq rms	1220000	1340000	1420000
High-frq rms	953000	947000	938000
Low-freq rms	513000	507000	491000
Max	21000000	24100000	26800000

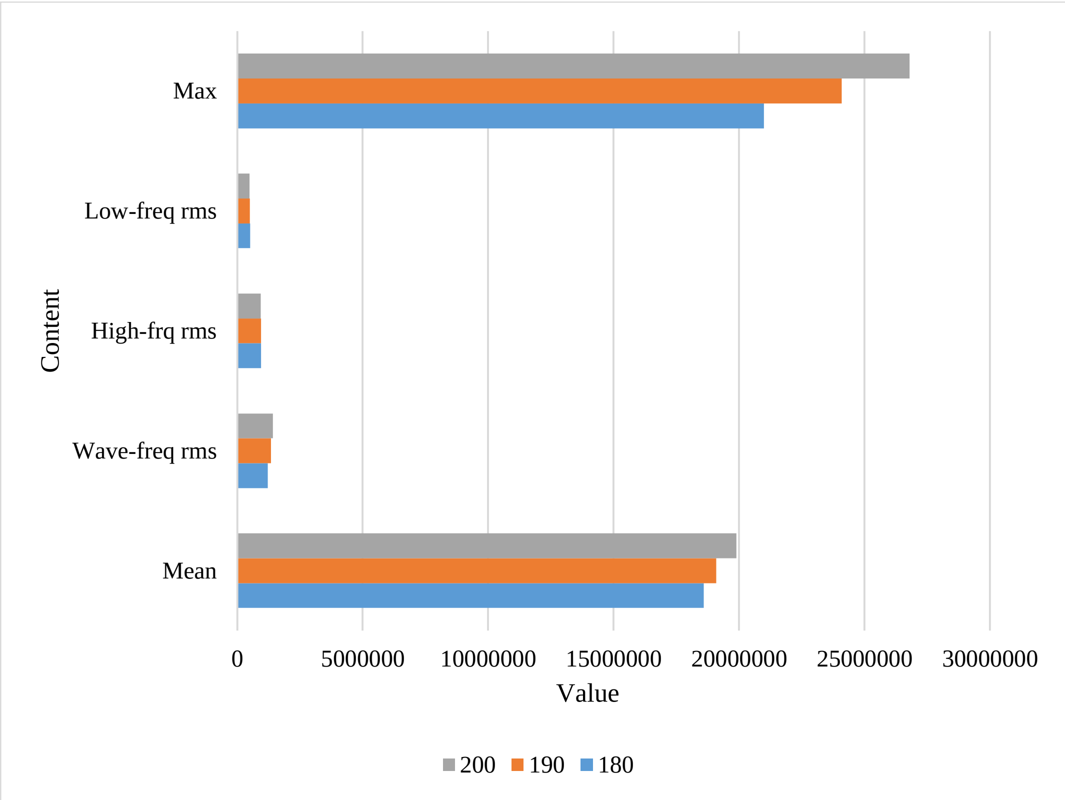

Figure 2. Data diagram of the force response value of each tendon of the tension leg

The data shows that the tendons that experience the most tension vary depending on the orientation of the environment. When the environmental load direction is 200°, the load borne by the tendon increases, at this time 26800000, which meets the specification requirements for the tendon of the tension leg platform under the condition of self-storage. Since the main body of the tension leg platform is in the form of left-right and front-back symmetry, this paper only calculates the motion response of the platform in the range of 180° to 200°. For other environmental directions, the motion response values are similar to the values in this interval, but the position of the tendon under maximum tension is different.

5. Conclusion

In this paper, based on the study of the dynamic response of the tension leg platform in marine engineering based on the linear factors, combined with the dynamic response of the tension leg platform and the position of the tendon, the dynamic response and displacement characteristics of the platform after local failure are studied by numerical analysis. Under the influence of asymmetric factors such as the location of tendon destruction and the direction of wave action, the TLP arcuate response after local tendon destruction has a longitudinal height. Return tension and supertonic concentrations represent the total reserve level of remaining tendon tension and an arbitrary level of remaining tendon tension level, respectively. If the systemic tension deviation is large and the substandard deviation after local tendon rupture is small, the TLP has good strength and vice versa.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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