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Analysis of Factors Influencing the Force of Mooring Facilities in Pontoon based on ARIANE7

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Abstract

Using ARIANE7 software, a numerical model was established with reference to a river barging terminal in Chongqing. Single factor sensitivity analysis was used to analyze the sensitivity of different factors to the mooring force at each position of the pontoon. Through the software calculation, the dynamic response analysis of the relative change law of mooring force at each position of the pontoon was carried out, and the sensitivity analysis was carried out under different conditions of simulated wind flow.

Keywords

Barging Dock; Mooring Force; ARIANE7.

1. Introduction

Mooring safety of barging quay is often related to wind, current and other factors. The dynamic factors of external environment are random and multi-directional, which makes the ship's motion response very complicated, affecting not only the safety of loading and unloading operations, but also the safety of the ship itself and the dock structure. Generally, the barge needs to be connected to the mooring post or mooring pier by a cable to limit the movement of the barge. The unbalanced distribution and magnitude of mooring force directly affect the safety of ship berthing, operation and dock structure. He Xu et al.[1]analyzed and calculated the main influencing factors of mooring force in barging quay, obtained that the influencing factors mainly include water level, current, wind load and ship factors, etc., and summarized the law of influencing factors of mooring force in barging quay. Yang Jingli[2] conducted a sensitivity analysis of the factors affecting the mooring force of the single factor down the barging wharf, providing a basis for the design and application of the barging wharf. She proposed that only four basic factors such as current, wind speed, ship tonnage and design water level should be considered. Zheng Xiaxun [3] verified the applicability of OPTIMOOR software to calculate the mooring force by comparing it with the mooring force obtained from field measurements.

2. ARIANE7 Modeling

A numerical model is established in ARIANE7 software, and basic information of the ship is input, such as ship shape size (length × width × depth × draft), longitudinal and transverse wind area of the ship, pilot hole, location of mooring piles, etc. Enter the available length, diameter and specification of the cable and chain. The initial position of the mooring system of the barge can be obtained by entering the Angle between the actual length of the cable and the horizontal plane. Create the external environment, input wind speed, wind direction, water speed, water direction and other influencing factors. ARIANE7 finds the equilibrium position by Newton algorithm under the constraint of mooring load, constant load and environmental load. Calculate the mooring force of the cable at each position in the equilibrium position. The mooring force numerical model of the barging pier is shown in Figure 1.

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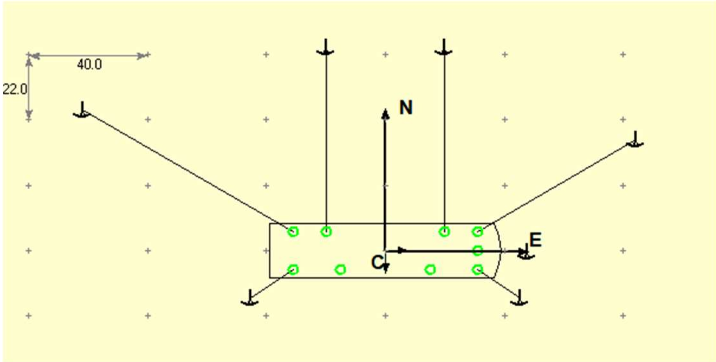

Figure 1. Numerical model of mooring force in barging quay

3. Analysis of Influencing Factors

In order to study the influence of various influencing factors on the mooring safety of ships in inland water barging terminal, a single factor analysis method was adopted. When the wind speed, wind direction, velocity and other factors remained unchanged, a barge was selected as the design ship type and ARIANE7 software was used to analyze the influencing factors of the mooring force in the barging terminal. The variation law of barging wharf with influencing factors is obtained, which provides theoretical basis for the calculation of mooring force in barging wharf design and the berthing scheme layout of ships in operation.

3.1. Influence of Wind Speed on Mooring Force

In order to study the influence of wind speed on the mooring safety of ships in inland water barging wharf and change the wind speed, five grades of strong wind (13.8m/s at the 6th level, 17.1m/s at the 7th level, 20.7m/s at the 8th level, 24.4m/s at the 9th level and 28.4m/s at the 10level) were selected for analysis. Other factors such as wind direction and velocity do not change, the water flow speed remains unchanged at 2m/s, and the water flow direction is parallel to the vertical axis of the ship. The wind is against the current.

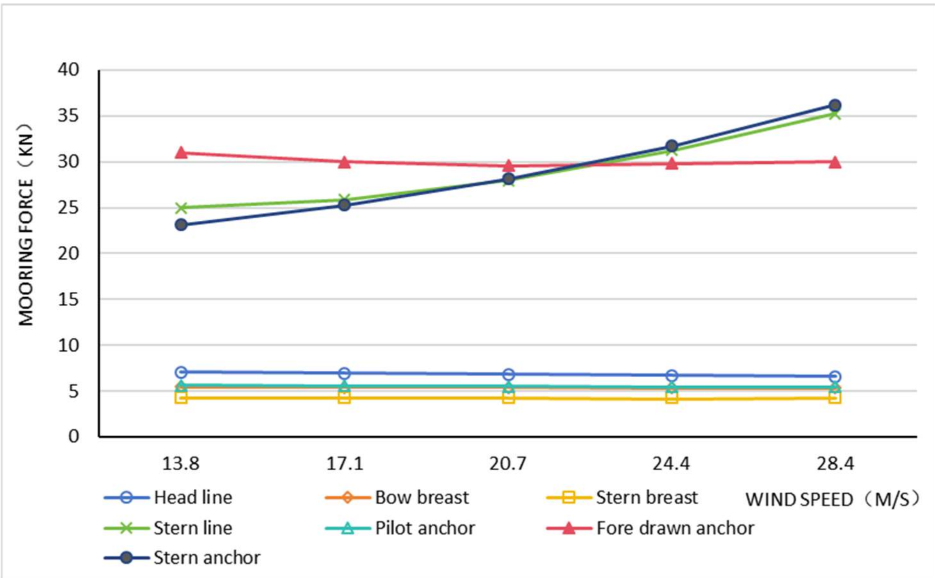

Figure 2. Tension of cable and chain under different wind speed of the barge

The figure above shows the mooring force of the barge at various positions under different wind speed conditions.

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(1) As can be seen from the above table, under the conditions of downflow + downflow wind direction, the mooring force distribution in the mooring state is unbalanced, and the mooring force is mainly provided by the bow opening anchor and the stern opening anchor and stern cable. With the increase of wind speed, both stern anchor and stern cable increase significantly, and the force of bow anchor remains stable, which is little affected by wind speed. The wind speed at 28.4m/s is the most unfavorable condition.

(2) Under the conditions of downdraft + downdraft wind, with the increase of wind speed, the change amplitude of the fore line, cross line and pilot anchor tension is not obvious, because the transverse component of the ship is not generated in the downdraft wind, so the cross line tension is maintained at a small value.

3.2. Influence of Wind Direction on Mooring Force

In order to study the influence of wind direction on the mooring safety of ships in inland water barging terminal, the wind direction and ship Angle are divided into 12 directions at 30 degrees to consider the influence of different wind direction on the mooring force. The wind direction is changed, the wind speed is 13.8m/s, the water flow direction is parallel to the vertical axis of the ship, the speed is 2m/s, and the barge is selected as the design ship type. Mooring tension is shown in the following table:

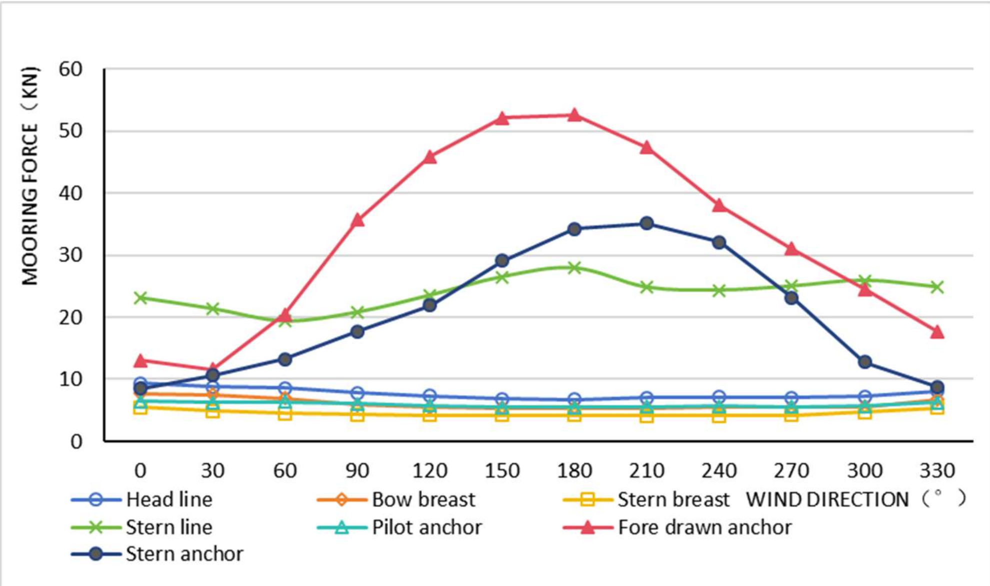

Figure 3. Tension of cable and chain under different wind direction

(1) In the case of 2m/s downstream flow, with the change of wind direction, the pilot anchor, stern cable and bow cable are always free from the force, and the mooring force is mainly provided by the bow anchor, stern cable and stern anchor. When the wind direction changes, the force of the bow open anchor changes the most. When the wind direction is between 0 degrees to 90 degrees and 270 degrees to 300 degrees, the tension is minimum, and when the wind direction is between 60 degrees to 90 degrees, the stern open anchor tension reaches the maximum. Compared with the bow open anchor tension, the change of stern open anchor tension is small, and the influence of wind direction on bow line and bow cross line stress is the least.

(2) When the pontoon is mooring, the bow and stern anchors are opened, and the stern cable mainly provides the mooring force. When the bow and stern anchors are not enough to provide mooring balance, the bow and stern lines also begin to bear part of the force, and the amplitude changes greatly with the change of direction and Angle.

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3.3. Influence of Flow Velocity on Mooring Force

Ship cable force (anchor chain force) is mainly generated by the wind pressure and current force acting on the ship, and the mooring ship is often affected by the combined action of wind flow, and the distribution of cable force (anchor chain force) is very different from that of single wind or single current. In order to analyze the influence of the flow velocity on the distribution of ship cable force, the flow velocity was divided into a grade from 0 to 2m /s for every 0.5m/s, and the wind speed was 13.8m/s for the sixth level. The direction of the flow was parallel to the vertical axis of the ship, and the direction of the wind was the same as the direction of the flow. The forces of each cable and anchor chain are shown below:

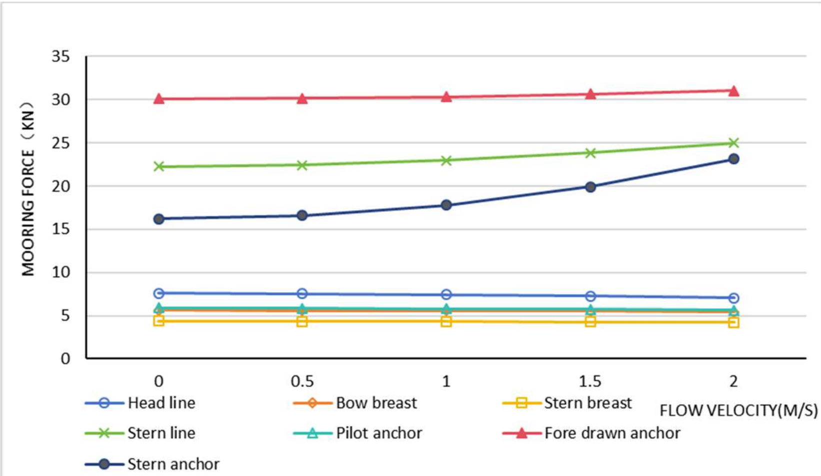

Figure 4. Tension of cable and chain under different flow speed of barge

(1) When the barge is docked, the mooring force of bow anchor, stern cable and stern anchor increases gradually with the increase of flow velocity; With the gradual increase of flow rate, the force of stern cable, bow cable and pilot anchor gradually decreases, and the distribution of mooring force is more inclined to bow anchor, stern cable and stern anchor. When the flow rate reaches 2m/s, the force of stern opening anchor, stern cable and bow opening anchor reaches the maximum, and both states are in the most unfavorable conditions.

(2) When the barge is docked, the force on the barge caused by the current speed is much less than that caused by the barge and the moored ship, and the force on the bow opening is greater when the current speed is low.

(3) Under the conditions of downwind and smooth water, the stern cable, the bow cable and the pilot anchor have not been stressed. Due to the stern opening anchor, the direction of the stern cable is closer to parallel with the flow direction and wind direction, so the stern opening anchor, the stern cable with the increase of the flow rate of anchor chain force increases the most.

3.4. Influence of Water Flow Direction on Mooring Force

Due to the complex and changeable flow conditions in the variable backwater area, there may be a certain Angle between the actual incidence direction of water flow and the ship's longitudinal axis. In order to analyze the influence of the flow incidence Angle on the ship's mooring safety, the Angle between the flow direction and the ship's longitudinal axis is considered. When changing from -15° to 15°, the distribution of cable force and cable force is analyzed with every 5° as a range. The Angle between the water flow direction and the ship's longitudinal axis is shown below:

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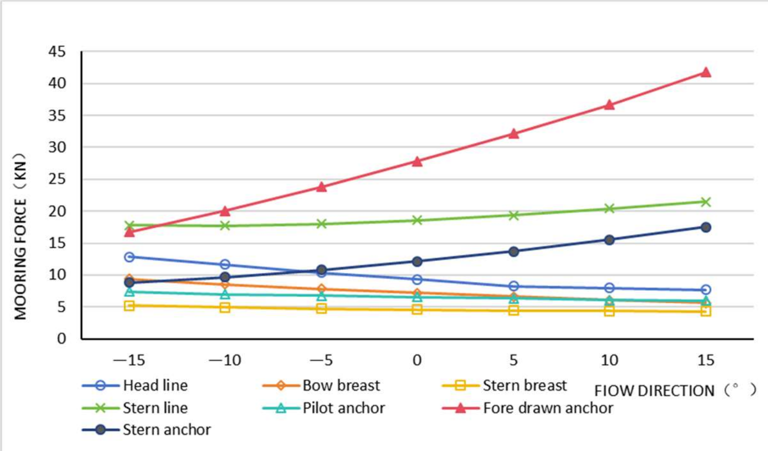

Figure 5. Tension of cable and chain under different flow direction of the barge

(1) According to the above table, when the water flow incidence Angle is different, the mooring force of the cable and anchor chain at each position is unevenly distributed when mooring the barge. When the flow direction Angle is 15°, that is, when the water flow direction points to the offshore direction, the force of each cable is small, and the mooring force is mainly provided by the anchor chain. With the bow opening anchor, the direction of the stern opening anchor is closer and closer to the flow direction, and the force is increasing.

(2) In the case of downwind, when the water flow incidence Angle changes from -15 to 15° and the water flow direction changes from shore to offshore, the forces on bow anchor, stern cable and stern anchor gradually increase, while the forces on horizontal cable and bow cable gradually decrease with the change of flow direction Angle. When only the barge is docked, the 15° water flow offshore is the most unfavorable condition for the bow opening anchor.

(3) When the barge is docked, when the flow direction Angle is 15°, the force on the bow opening anchor is still the maximum. When the flow direction Angle changes from -15° to 15°, the force of the bow, stern and horizontal cables increases gradually. When the flow direction Angle is 15°, the bow cable and bow cross cable have the greatest force. When the flow velocity is the same and the flow direction Angle is small, the difference of the cable force caused by the open wind and the downstream wind is large.

3.5. Water Depth at Wharf Front on Mooring Force

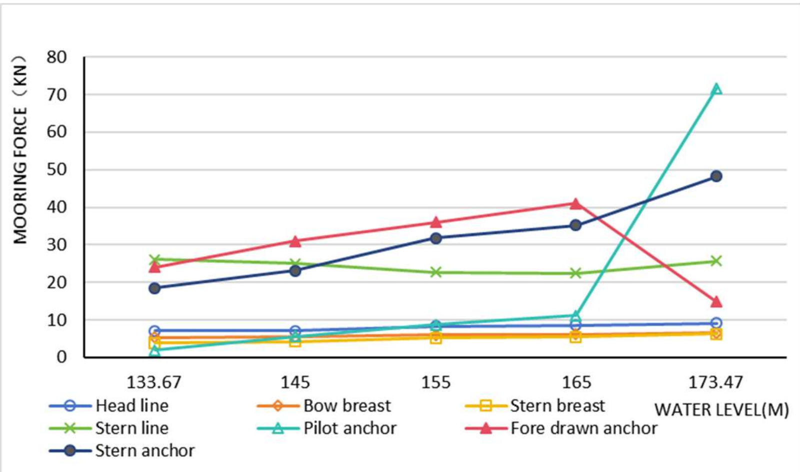

Figure 6. Tension of cable and chain at different water levels of the barge

The barging dock is generally used in the inland waterway where the water level difference is large. The influence of the water level in front of the wharf on the mooring force of the cable at

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each position cannot be ignored.The figure below shows the change of mooring force at each position as the water level changes.

(1) The figure above shows that under the conditions of downwind and smooth water, it can be seen that the distribution of mooring force of the cable and anchor chain at each position changes greatly, with the bow opening the anchor and the stern opening the anchor. The stern cable mainly provides the mooring force, while the bow cable, bow cross cable and stern cross cable have less force. When the water level reaches 165m or above, the force of the pilot anchor increases sharply when the barge is docked. The stern cable gradually decreases when the water level increases at the wharf front.

(2) Under the environment of large water level in the inner river, due to the different stress characteristics of the cables at different mooring positions, the uneven distribution of the mass of the ship's bow and stern, the difference in motion response also leads to the uneven distribution of the mooring force at different mooring positions. The increase of the water level causes the different increase of the mooring force at different positions, and the greater the mooring force, the greater the increase of the mooring force. This results in a more uneven distribution of mooring force.

4. Conclusion

In this paper, a numerical model is established by ARIANE7 software with reference to the relevant design parameters of a domestic inland waterway barge. The mooring force distribution of the cable in each position under the influence of wind flow is studied by single factor sensitivity. In this paper, only one kind of pontoon was selected for simulation calculation, but the mooring force distribution of the pontoon was different due to the different mooring layout. At present, there are few researches on mooring force and cable arrangement of pontoons, so it is possible to conduct in-depth research on multiple ship types in terms of arrangement optimization.

Acknowledgments

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