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Study on Safe Navigation of Ships in Cecum Channel

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Abstract: In recent years, China's marine technology has made new breakthroughs and marine economy has developed rapidly. At the same time, the world's marine economy has become a new development point of the world economy. Port transportation is one of the important components of marine economy. According to relevant statistics, China's coastal port throughput has ranked the first in the world for three consecutive years. Port trade has become one of the necessary forces for China's rapid economic development. Ship navigation safety should be paid more attention to, but some areas are limited by geographical conditions. We have to build ports and wharfs in the cecum section. By introducing the characteristics, influencing factors and necessity of the cecum channel, this paper studies the optimal safe navigation control model of the cecum channel, which can provide effective reference for the safe navigation of ships in the cecum channel and make the navigation more reasonable and orderly.

1. Introduction

Since the 1990s, the layout of marine economy has been optimized and international cooperation has been expanding. According to statistics, China's marine economy has maintained a double-digit annual growth rate[1-2]. By the end of 2018, the cumulative annual growth rate has reached 7.2%. In the global port ranking of 2018, China has ten major ports ranking among the top 20 in the world. Details of the top 10 cargo throughput and container throughput ports in the world for the first half of 2017-2018 are shown in Table 1 below[3]. Its main manifestations are as follows: the scope of activities has expanded in many directions, the total economic volume has increased rapidly, the growth rate is faster than the national economic growth, and the development speed of marine industry is faster than the development of the industry as a whole.

Table 1 Ports with Global Top Ten Cargo Throughput and Container Throughput in the First Half of 2018

Rank	Port	Cargo throughput/10kt		Speed up/%	Port	Cargo throughput/10kt		Speed up/%
		January to June, 2018	January to June, 2017			January to June, 2018	January to June, 2017	
1	Zhoushan	54787	51412	6.6	Shanghai	2050.4	1960	4.6
2	Shanghai	36024	37013	2.7	Singapore	1802.1	1615	11.6
3	Singapore	31279	31032	0.8	Zhoushan	1331.2	1237	7.6
4	Tangshan	30159	28195	7.0	Shenzhen	1212.6	1187	2.2
5	Guangzhou	29866	29886	0.1	Guangzhou	1046.4	963	8.7
6	Suzhou	26233	31013	15.4	Pusan	1031.7	1011	2.1
7	Headland	26187	24782	5.7	Hongkong	991.6	1016	2.4
8	Qingdao	26042	25480	2.2	Qingdao	938.1	910	3.1
9	Tianjin	24083	25303	4.8	Tianjin	780.6	742	5.2
10	Dalian	23581	23023	2.4	Dubai	773.8	772	0.2

As a major province of marine resources and marine economy, Zhejiang Province is located in the eastern coast of China. In recent years, Zhejiang's marine economy has developed vigorously. In February 2011, the State Council formally approved the "Zhejiang Marine Economic Development Demonstration Zone Planning" and on June 30, 2011, the State Council formally approved the establishment of Zhoushan Islands New Zone in Zhejiang Province. Under the good situation of vigorously developing the marine economy in the current country, port transportation will gradually become the main force in the rapid development of Zhejiang's economy. Ports and waterways are important carriers of marine transport economy, so if we want to develop marine economy, we can not do without ports and waterways. There are five open ports and twelve second-class open ports in the main coastal ports of Zhejiang Province. There are more than 70 international routes in the province. There are 105 inland ports in Zhejiang Province. The main ports include Hangzhou Port, Jiaxing Inland Port, Huzhou Port, Shaoxing Port and Lanxi Port. Hangzhou Port is one of the main inland river hub ports in China[4].

With the development of marine economy, the port transportation volume is expanding day by day, and the number of ships in and out of ports is increasing. Whether ships can navigate safely has become a continuing concern. With the further development of port and shipping industry, many ports and wharfs will be faced with development, construction and utilization in the future[5]. Under the long-term development trend, the choice of artificial or natural, small wind and waves, convenient berthing cecum reach to build ports and wharfs will become a way of future port and wharf construction.

2. Characteristics of Cecum Channel and its Influencing Factors

2.1. Introduction of Cecum Channel

The so-called cecum channel refers to a channel which is connected with a river or offshore sea at one end and closed at the other end, as shown in Figure 1.

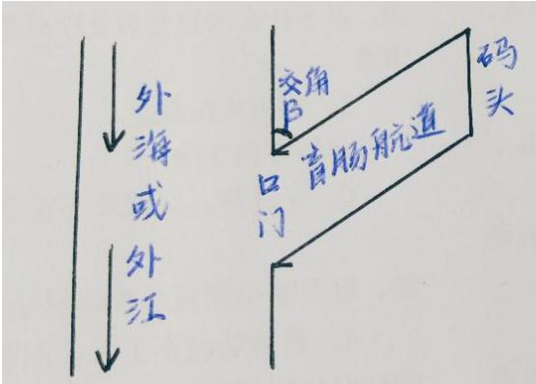

Figure 1 Cecum Channel Diagram

2.2. Kinematic Characteristics of Cecum Channel

2.2.1. Flow Characteristics of Cecum Channel

There are many typical caecal channels in China, such as the approach channel downstream of Qinhuai Xinhe Shiplock or Guichi Port in Anhui Province. One end of the channel is connected with the Yangtze River, while the other end is the port. The flow in the port is stagnant water, that is, it is formed by the introduction of Yangtze River water. The water flow in the cecum channel is greatly affected by the external river or sea water. When the external river or sea water is in high tide, the water depth of the cecum channel becomes deeper; when the external river or sea water is in ebb tide, the water depth in the cecum channel becomes shallower.

2.2.2. Sediment Transport Characteristics in Cecum Channel

There is a backflow area near the entrance of the cecum river, which is also an important cause of sediment deposition[6]. Flow at the bottom of the entrance of the cecum channel dives from the external river or sea, bringing the turbid sediment of the river or sea into the cecum channel for deposition, while the clearer sediment-deposited water gradually moves upward when it dives to a certain depth of the cecum channel, and when the current reaches or approaches the surface of the cecum channel, the flow turns. It flows outward to the sea or rivers, so the blocking sand at the entrance of the cecum channel is more serious.

2.3. Factors Affecting Flow Backflow and Sediment Deposition in Cecum Channel

2.3.1. Gate Width

Because of the difference between the current density of the offshore or the outer river and that of the cecum channel, the density current exists at the entrance of the cecum channel, and the density current is the precondition for the formation of the barrier sand. The wider the entrance of the cecum channel, the more serious the formation of the blocking sand will be. However, if the entrance is narrower, the width of the channel will be insufficient and the navigation of ships will be difficult.

2.3.2. Intersection of Export with Offshore or Offshore Rivers

The entrance angle of the cecum channel is also closely related to the formation of the barrier sand. The more vertical the intersection angle is, the greater the intersection angle is, the easier the formation of the barrier sand and the easier the siltation of the sediment. However, if the intersection angle is small, it is particularly difficult for the ship to manoeuvre at the entrance of the cecum channel, which is prone to traffic accidents[7].

2.3.3. Other Factors

Because of the narrow channel at the exit of cecum channel and the large number of navigable ships, ship motion will not only be affected by the maneuverability of the ship itself, but also be adversely affected by dynamic non-human factors such as wind and current.

3. Necessity of Optimizing Cecum Channel and its Scale

3.1. Impact on Navigation Safety of Ships

The complicated ship flow in coastal ports may lead to the disorderly passage of all kinds of ships, which greatly increases the probability of water traffic accidents. But if we can optimize the reasonable width of the entrance of the cecum channel and the reasonable intersection angle between the cecum channel and the outer sea, it can not only ensure the safety of navigation, but also reduce the formation of the entrance bar. It is necessary to study the control model of the safe navigation of ships in and out of the cecum channel.

3.2. Impact on Port Transport and Internationalization

Through the study, a more reasonable scale of cecum channel is proposed, that is, to improve the transport conditions of coastal ports, optimize the transport environment and improve the throughput of ports, in order to promote the development of coastal urban areas, thereby further improving China's comprehensive national strength and promoting the vigorous development of the internationalization process.

4. Control Model of Safe Navigation of Ships in Cecum Channel

4.1. Overview of Research on Optimization of Cecum Waterway at Home and Abroad at Present

In the study of waterway problems at home and abroad, some experts only pay attention to the flow condition, maintenance, scouring and silting of waterway unilaterally, while others only pay attention to the navigation scale of waterway unilaterally. For example, the former Soviet Union Salaliov and others used mathematical statistics theory to study the navigation environment of waterway, but the application of its results depends on statistical data; Professor Liu Mingjun, a domestic navigation expert, believes that the greater the curvature of waterway, the smaller the navigation safety index of ships; Wang Changjie, a well-known domestic waterway expert, mainly pays attention to the flushing of waterway and siltation problems.

At present, the safety and reliability of ship navigation in China's waterway area is mainly based on the relevant requirements of inland waterway navigation standards. The two-way channel width stipulated in China's inland navigation standards is as follows[8-9]:

$$B_1 = |B_1| + |B_2| + C + 2d$$

$$B_1 = |L_1 \sin a| + |b_1 \cos a|$$

$$B_2 = |L_2 \sin a| + |b_2 \cos a|$$

$$C = 0.25\,|L \sin a + b|$$

$$d = 2C$$

(B_1 is width Occupied by Shipping Vessels， L_1 is length of a upbound boat， b_1 is width of a upbound boat， a is drift angle； B_2 is width occupied by launching vessels， L_2 is length of a launching vessel， b_2 is width of a launching vessel， C is spacing between ships， L takes the larger values in L_1 and L_2 ， b takes the larger values in b_1 and b_2 ； d is the distance between the ship and the shore.)

Although the definition of channel dimension in inland navigation standard is put forward on the basis of full demonstration, it is scientific to some extent. However, there are still some shortcomings in the above formulas. First, the definition of navigation width in inland river navigation standards is limited to the use of ship size to express the navigation width of the channel. In fact, the navigation width of the channel is not only related to ship size such as ship length and ship width, but also to flow direction angle and ship size. The drift in wind flow is correlated, so the definition of navigation width is unscientific; secondly, if the accuracy calculated by relying solely on data needs to be discussed, because to avoid large errors, it is possible to get a relatively accurate degree only through a large number of actual ship tests, and no one can accurately predict the current integrity. The current situation of each navigable channel, however, still needs a lot of manpower, material and financial resources, which are inconvenient.

So for the current research situation, considering the angle range between the outlet of the cecum channel and the sea or river, the width of the entrance of the cecum channel and the safety control of the cecum channel, it is less involved to combine the sediment movement and navigation safety. It is more complicated to apply the formula of the navigation width in the inland river navigation standard to the sediment problem. The entrance of the cecum channel also has some limitations. It is a relatively new subject to consider the angle between the outlet of the cecum channel and the sea or other rivers by combining sediment movement with navigation safety. Therefore, this issue needs further study.

4.2. Research Content of Safe Navigation Model for Cecum Channel

In view of the characteristics of flow and sediment transport in the cecum channel and the safety of ship navigation, this paper proposes a reasonable angle range between the entrance width of the cecum channel and the outlet of the cecum channel and the sea or the outer river by means of numerical simulation, model test and theoretical analysis. Optimize the safe navigation control model of cecum channel. The main research contents are as follows.

4.2.1. Propose a More Reasonable Expression of the Entrance Width of the Cecum Channel

It is necessary to combine numerical simulation with physical model test to analyze the characteristics of flow and sediment transport in the cecum channel and ship motion characteristics.

4.2.2. Propose a Reasonable Angle Range Between the Outlet of the Cecum Channel and the Sea or River

It is necessary to consider ship navigation safety and minimize sediment deposition.

4.2.3. Obtain the Optimal Safe Navigation Control Model of Cecum Waterway

After determining the width of the cecum channel entrance and the reasonable angle between the channel exit and the open sea or the open river, the paper further proposes the cecum channel safe navigation control model by using the ship field theory.

5. Conclusion

Aiming at the characteristics of flow and sediment transport in cecum waterway, combined with the safety of ship navigation, the optimization of safe navigation control model in cecum waterway is realized by using the combined research method, which can provide an effective reference for safe navigation of ships in cecum waterway. This study realizes the organic combination of theoretical research, experimental technology and scientific calculation, which can provide a reference for solving other channel problems quickly and efficiently, and also lay a foundation for later research on the navigation environment of curved channel[10], cross channel and coastal navigation environment of Zhejiang.

References

[1] Research Group on World Marine Economic Development Strategy. Comparative Study on Marine Economic Development of Major Coastal Countries [J]. Statistical Research, 2007 (09): 43-47.

[2] Li Peijin, Luan Wei Xin. Preliminary study on the development level of marine economy in coastal areas of China [J]. ocean development and management, 2005 (02): 26-30.

[3] Yu Libo, Yue Lei, Zhou Jian, Wang Zhe, from 1 to October, a summary of the operation of main ports in China from October to [J]., China's port, 2018 (11): 39.

[4] Qin Qin. The main functional area of Zhejiang is planning and publishing to build a marine economic development demonstration zone [J]. port economy, 2013 (11): 63.

[5] Hu Haozhi. Analysis of the problems in port wharf construction [J]. theoretical research on urban construction (electronic version), 2019 (09): 10.

[6] Ma Xiaolin. Influence of inflow conditions on the form and movement characteristics of density currents [D]. [D]., 2015.
[7] Analysis of navigable flow conditions in the entrance area of [7] Kong Xiangyuan Chuan River tributary, [D]. [D]., 2016.
[8] Liu Baojun. Solutions to the width problem of port and waterway design [J]. Low Carbon World, 2017 (03): 223-224.
[9] Zhao Hu Gang. Study on the optimization of inland watercraft and collision avoidance model [D]., 2016.
[10] Qi Jianxiang. Study on navigation safety of ships entering and passing the cecum channel [J]. Journal of China (NATURAL SCIENCE EDITION), 2009,28 (01): 107-109.