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Optimization of berth length of LNG terminal

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Abstract. Based on the multimodal transport mode of LNG container, it is suitable for transportation, storage and land, and it can realize safe, high efficiency and convenient transportation, and meet the needs of modern LNG transportation. This paper discusses the change trend of LNG terminal berth length which has been built in recent years. The research progress of berth length optimization method of LNG terminal in China is described. The comparison analysis is made with the berth length optimization method of open oil and gas terminal, and some suggestions are put forward.

1 Construction status and utilization of LNG terminal facilities

By the end of 2020, 22 LNG receiving and unloading berths have been built and put into operation in China, and 22 LNG receiving stations have been built and put into operation in China, with a receiving capacity of 90.35 million tons / year. The supporting storage tanks of each large LNG terminal berth are mainly 2-4 160000 m3 tanks, which are generally small in scale. The capacity of storage and transportation system is insufficient, and the capacity of peak shaving and cross regional regulation is limited. At present, the construction of several LNG terminals has been gradually optimized.

2 Change trend of berth length of LNG terminal

Although the construction of LNG terminal in China started late, it has developed rapidly. With the accumulation of LNG terminal construction experience in China, the design level of terminal is also improving. At present, the change trend of the ratio of berth length to ship length of LNG terminal is shown in Figure 1, in which the berth length is calculated to the outer edge of the outermost mooring structure.

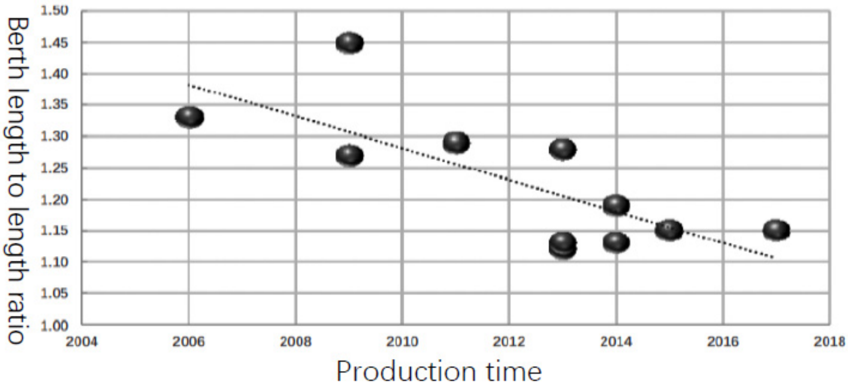

Figure 1. Change trend of berth length to length ratio of LNG terminal

As can be seen from Figure 1, with the development of large-scale ships, the berth length of China's LNG terminal does not increase but decreases, and the ratio of berth length to captain shows a downward trend. To sum up, the overall length of LNG terminal berth has a trend of shortening, but due to different terminal construction conditions, the length of berths of the same scale is slightly different.

3 Optimization and determination of berth length of LNG terminal

The length of berth and reasonable arrangement of mooring pier play an important role in balancing the mooring force of berthing ship, improving the loading and unloading efficiency of wharf and reducing the project cost. According to the code for design of LNG terminals issued by the Ministry of transport, the berth length of

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LNG terminals should meet the requirements of safe berthing, unberthing and mooring operation of ships, which is determined by simulation test, but should not be less than one time of the designed captain; in the feasibility study stage, it can be estimated as 1.0 ~ 1.2 times of the designed captain. [1] However, the code does not give a specific reference method or description to determine the berth length. In conclusion, combined with the research progress of berth length optimization of LNG terminal in China, this paper analyzes and evaluates the test methods and optimization objectives, and puts forward the recommended value and optimization method of berth length in LNG terminal design, which can be used as reference for similar projects.

3.1 Engineering background

In this paper, a LNG terminal with the largest design ship type of 138000m3 is selected. The length of berth is 400m, the top elevation of wharf surface is 7.5m, and the bottom elevation of wharf apron is - 14.5m. The main cables are 40 mm diameter steel cables, symmetrically arranged in the form of 3 / 3 / 2. The plane layout and mooring mode of the wharf are shown in Figure 2.

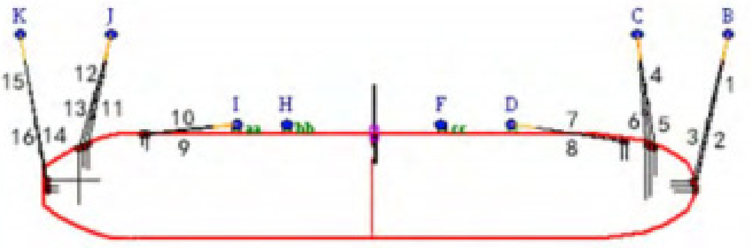

Figure 2. Wharf layout and mooring method

In this study, the mooring force software optimal is used for numerical simulation. Referring to the research results at home and abroad [2], the optimal berth length of LNG yard head is comprehensively analyzed by using the three indexes which are closely related to mooring safety and wharf operation, namely, the nonuniformity coefficient of mooring force, the maximum mooring force intensity ratio and the amount of ship movement.

In this study, the change of simulated berth length only considers the position movement of fore and aft mooring piers along the longitudinal axis of the ship, and the berth lengths are selected as 1.08, 1.1, 1.2, 1.3, 1.4 and 1.5 times the length of the ship respectively. These six kinds of berth lengths basically cover all the berth lengths recommended by the above domestic and foreign codes.

3.2 the strength ratio of mooring force of each cable under different berth lengths

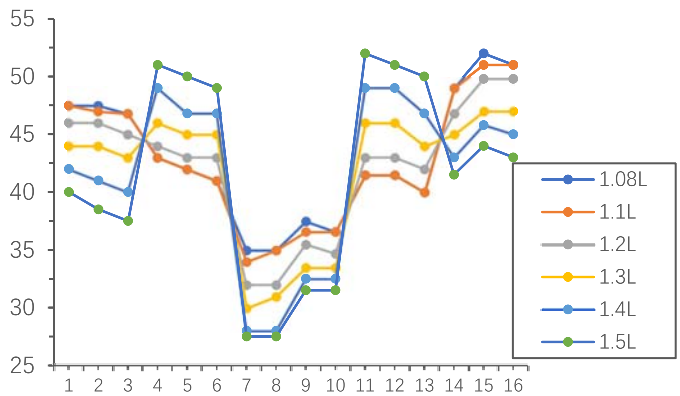

Figure 3. The strength ratio of mooring force of each cable under different berth length

The project is under the action of transverse environmental load, as shown in Figure 3, the transverse cable will bear a large part of the transverse force, and its stress is large, so it should be arranged perpendicular to the longitudinal axis of the ship as far as possible. The reverse cable mainly bears the longitudinal force, so the smaller the angle between the reverse cable and the longitudinal axis of the ship, the better. For bow and stern lines, foreign codes consider that they are only produced to adapt to different types of ship mooring, while Chinese codes consider that an important role of bow and stern lines is to assist reverse lines and transverse lines to restrain the movement of moored ships [3-5]. In view of this project, the fore and aft lines of each berth length are stressed greatly, and the restraint effect on the mooring ship can not be ignored. It can be seen from the output results of the mooring force intensity ratio of each rope under different berth lengths that the mooring force distribution of the whole mooring system is quite complex. The following analysis is based on these complex data.

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3.3 variation of mooring force nonuniformity coefficient with berth length

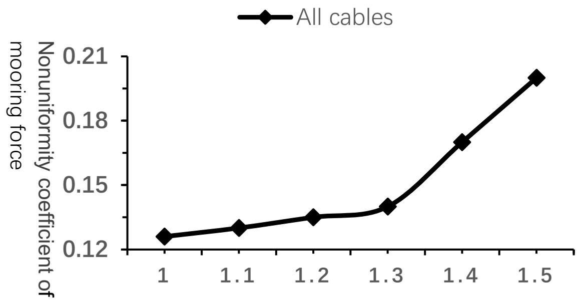

Figure 4. Variation curve of nonuniformity coefficient of mooring force with berth length

The nonuniformity coefficient of mooring force refers to the ratio of standard deviation and mean value of tension of all cables. As shown in Figure 4, the non-uniform coefficient of mooring force is positively correlated with the length of berth, that is to say, the shorter the berth is, the more uniform the cable force is [6]. This is because, under the action of transverse environmental load, when the berth length is reduced, the bow and stern cables can better share the transverse force, thus changing the distribution of transverse external force on each cable and balancing the force on the cable.

3.4 variation of maximum mooring force strength ratio with berth length

According to the requirements of the mooring equipment guide, the maximum mooring force strength ratio of the rope should not exceed 55% [7]. When the length of the berth is large, the transverse force shared by the bow and stern cables is small, and the longitudinal force is large, which leads to a significant increase in the force on the transverse cables; when the length of the berth is small, the bow and stern cables share a large part of the transverse force, which leads to a large force on the bow and stern cables. The direct manifestation of these two situations is that if the berth length is too large or too small, the maximum mooring force strength ratio of the moored ship will increase significantly, which is very easy to cause the breaking of individual cables in practical engineering, so special attention should be paid to it.

3.5 variation of ship motion with berth length

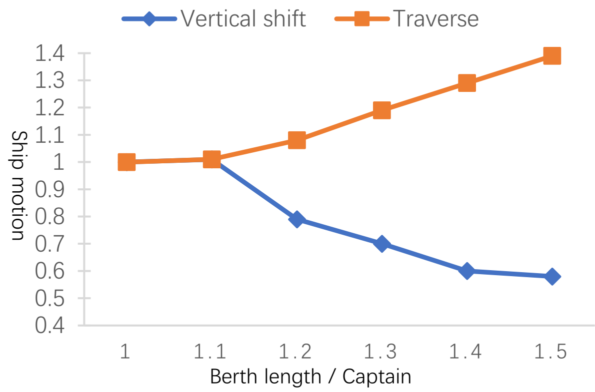

Figure 5. Curve of ship's transverse and longitudinal displacement with berth length

When the length of the berth is reduced, because the angle between the bow and stern lines and the longitudinal axis of the ship is larger, the lateral stiffness of the mooring system composed of the ship and the lines is larger, and the longitudinal stiffness is smaller, which makes the horizontal binding force of the lines on the ship larger and the longitudinal binding force smaller. The transverse movement of the ship is effectively controlled, but at the same time, the longitudinal movement is also increased. As we know, the influence of ship motion on the efficiency of terminal handling is very large [8-9], so it is also an important part of the mooring problem.

4 Conclusion

Through the analysis of the above three indexes, it can be seen that shortening the berth length can effectively balance the cable tension and reduce the transverse displacement of the mooring ship. But at the same time, it may cause individual lines to bear too much force and

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increase the longitudinal displacement of the moored ship. To sum up, it is reasonable to reduce the berth length appropriately. For this project, the recommended berth length is about 1.2 times the length of the ship. At this time, the combination of the three indexes is optimal, which is also in line with the so-called short berth concept.

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