Research on Transit Capacity of North Channel of Tianjin Port Based on Queuing Theory

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ABSTRACT

The dredging of the north channel of Tianjin Port is a key project to improve the carrying capacity of Tianjin Port. In this paper, considering the factors of ship navigation safety and channel service level, a calculation model of port channel transit capacity based on queuing theory was established, and the actual and theoretical transit capacity of the channel was obtained. It was applied to the analysis of the transit capacity of the north channel of Tianjin Port. The calculation results showed that the model can better reflect the actual situation and prove the reliability of the calculation model. At present, the transit capacity of the north channel of Tianjin Port could meet the requirements, and the theoretical transit capacity of the channel was 105 ships per day.

KEY WORDS: Channel transit capacity; queuing theory; ship navigation safety; channel service level; the north channel of Tianjin Port.

INTRODUCTION

With the continuous increase of waterway traffic volume and the large-scale development of transport ships, the restrictive effect of the entry and exit channels of coastal ports on the development of ports has become increasingly prominent (Su, 2021). More and more scholars have carried out research on the carrying capacity of port channels. Because the port navigation operation system is a typical random service system, the queuing theory is widely used in the research of the port navigation operation system because it is good at solving the optimal design and optimal control problems of the system by studying the probability characteristics of the service system in the queue.

Jagerman D et al. (2003) constructed a SHIP/G/1 queue model based on queue design. Based on this model, the queuing behavior of port ships was studied, and an approximate algorithm for the number of ships passing through was obtained. The availability of the queue model was verified by several concrete examples. Liu et al. (2008) built a practical dynamic model for evaluating saturation using queuing theory and applied it to the planning, design and expansion of the main channel of Tianjin Port. Cao et al. (2015) established a simulation model of port channel capacity using queuing theory and applied it to Changshu Port's special channel. When the berth utilization rate is closer to 100%, it is considered that it is closer to achieve its capacity. Gao et al. (2016) used the queuing theory model to calculate the maximum carrying capacity of the seaport channel, introduces the parameter n to represent the influence of LNG ships on the calculation results, and applies it to the calculation of the carrying capacity of the main channel of Ningbo - Zhoushan Port.

To sum up, scholars at home and abroad have carried out extensive research on the queuing theory modeling of the port navigation operation system, but most of the research has not integrated the two factors of ship navigation safety and channel service level. Safety is the primary consideration in the study of ship navigation issues. The channel service level reflects the operation quality of ships in the channel. It is meaningless to pursue the maximum carrying capacity unilaterally without safety and service. In this paper, the factors of ship navigation safety and channel service level had been added into the modeling of port channel capacity queuing theory, and combines the quantity and quality of channel service, so that the research conclusions have more practical reference value.

TRANSIT CAPACITY OF THE CHANNEL

Transit capacity of the channel refers to the maximum capacity of the number of representative ship types and corresponding cargo volume that can pass the channel control section in a unit time under the condition of ensuring the safety of ship navigation and certain channel service level (Nartey, 2016; Cucinotta, 2017; Jiang, 2022). It is a performance index reflecting the seaworthiness of the channel and a measure of the channel's ability to dredge ships. The analysis and calculation of the carrying capacity of the port and waterway is the basis and basis for determining the construction scale of the waterway and carrying out the waterway reconstruction and expansion project.

Guarantee and evaluation index of ship navigation safety