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Study on the Collection and Distribution and Berth Utilization of Shekou Port

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Abstract

This paper mainly studies the collection and distribution of Shekou port and the utilization of port berths. This paper analyzes the current situation of the collection and distribution of Shekou port, and then analyzes the number of ships in port, idle cost, number of berths provided and berth utilization degree by constructing berth utilization model. Through the calculation, the optimal number of berths and the occupation degree of Shekou port are obtained. Compared with the current number of berths in Shekou port, suggestions for the development of Shekou port berths are put forward.

Keywords

Shekou Port; collection and distribution; degree of occupancy.

1. INTRODUCTION

The collection and distribution of port is an integrated transportation system of centralized and evacuated goods. Perfect port collection and distribution can alleviate the phenomenon of ship pressure and cargo pressure, and improve the radiation speed, capacity and scope of the port to the economic hinterland. At present, some container ports in our country are generally overloaded, and the actual cargo carrying capacity of the port is far beyond the designed capacity, which makes the yard berths planned according to the design capacity to be seriously challenged, and also brings great harm to the port operation companies. Therefore, the utilization degree of port berths reflects the operation of the port to a certain extent. Under the normal operation of various port systems, the port's collection and distribution capacity should be greater than or equal to the port berth capacity. Taking the existing berths of Shekou port as the research object, this paper studies the port berths by establishing the berth utilization model.

2. RESEARCH STATUS AT HOME AND ABROAD

In recent years, there are many researches on port collection and distribution and berth utilization. Domestic Zhu [1] (2020) divides the port collection and distribution into five modes, and constructs the evaluation index of port collection and distribution according to the source of port containers and port statistical data. By comparing with the world-class ports, this paper analyzes the main problems existing in the collection and distribution system of China's coastal ports, and proposes to improve the statistical system of port collection and distribution, and vigorously develop rail water intermodal transportation and water water water transportation The countermeasures and suggestions are as follows. Fang et al. [2] (2019) further studied the utilization rate of LNG berth in light and peak seasons according to the characteristics of regional LNG transportation and the current berth utilization rate. Yan [3] (2018)

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transformed the berth allocation problem of the general cargo terminal into a mathematical model, applied the heuristic algorithm to the berth analysis of the continuous Wharf on the basis of the discrete berth allocation method, and obtained that the continuous berth allocation method can effectively improve the utilization efficiency of the berth in practice. Zhou[4](2015) proposed a method to intuitively observe the service level of port berths by using AIS data, and confirmed that six indicators of port berth service level can be continuously observed and evaluated by using AIS data.Zhang [5] (2013) put forward the basis for evaluating whether the berth utilization is reasonable by optimizing the berth utilization of the bulk and general cargo wharf of Jinzhou port, analyzes the berth utilization of the bulk cargo and general cargo wharf of Jinzhou port, and judges whether the berth utilization rate of the bulk cargo and general cargo wharf of Jinzhou port is reasonable. Wu [6] (2011) took the real wharf parameters as the simulation design data values, generated the ship schedule according to the statistical laws, simulated the reasonable berth utilization rate, and compared the calculation results with the empirical value method. Ji [7] (2010) established a set of berth utilization calculation method in line with the actual application of container terminal company through case analysis, and made terminal managers realize the important role of berth utilization rate in terminal operation and management, so as to guide and standardize the optimal use of berth related resources.

Foreign scholars Neven [8] et al.(2015) improved the berth allocation model and tested the utilization rate of berths in the environment with or without water depth restriction. Yan [9] et al. (2015) proposed a new dynamic berth allocation model. Through the calculation experiment of an example generated from the actual data, the DFBAP model is more effective than the methods currently used by port management agencies. Gao [10] et al. (2014) aim to minimize the total time of ships in port. Some reasonable and necessary assumptions are put forward. Based on the hypothesis, the mathematical optimization model of BACAP is established. Bugaric [11] et al. (2012) analyzed the capacity of bulk cargo unloading River terminal, and gave the optimization process of optimal utilization rate of unloading terminal to determine the configuration and operation strategy (current and future situation) of each terminal.

3. ANALYSIS ON THE CURRENT SITUATION OF THE COLLECTION AND DISTRIBUTION SYSTEM IN SHEKOU PORT

Shekou port is located at the southern end of Shekou Peninsula, Shenzhen Special Economic Zone, on the East Bank of the Pearl River Estuary. It is the throat of the South China Sea into South China. It extends in all directions: the waterway is 3.5 nautical miles away from Hong Kong New Territories, 25 nautical miles away from Macao and Zhuhai, and is connected with Guangdong and Guangxi via the Pearl River water system; it connects with the South China highway trunk line via Shugang Avenue, connects with the Beijing Kowloon Railway through the port railway, and then connects with the national railway 30 km away from Shenzhen International Airport. The annual throughput capacity is 15 million tons, the annual container throughput capacity is 500000 TEUs, and the annual passenger flow capacity is 5 million person times.

In terms of water transportation collection and distribution, Shekou port container terminal, Pearl River coastal wharf and South China coastal important ports are closely connected through the Pearl River water system, which creates extremely excellent geographical conditions for the establishment of barge straight-line transportation network.

In terms of highway collection and distribution, the port has a direct port road connecting with Guangshen, Yanjiang, Shenshan, Guanshen expressways and Beihuan and Nanping express lines, so the port highway transportation is very convenient.

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In terms of railway collection and distribution, Nanping Railway, which is attached to the wharf, runs through the main railway lines such as Beijing Guangzhou, Beijing Kowloon, Guangzhou Meishan, Guangcheng and Guangkun, laying a solid foundation for Shekou Container Terminal to open up "sea rail combined transport" service connecting inland hinterland.

CCT / SCT gives full play to the mature waterway, land and railway collection and distribution network advantages of Shenzhen western port area, and extends the yard services of the two terminals to major ports and inland points in South China.

4. CONSTRUCTION AND CALCULATION OF PORT BERTH UTILIZATION MODEL

In the past, most countries used the empirical coefficient method to estimate. Since the 1960s, foreign countries began to explore the use of mathematical statistics and queuing theory to scientifically study and analyze the port ship waiting for berthing and so on, so as to determine the optimal number of berths. Generally speaking, the best solution is that all berths in the port can be used all the time, and the arriving ships do not need to wait for berthing. However, due to the randomness of ship arrival and the variability of ship size and cargo handling capacity, this assumption is not practical. Obviously, the construction of too many berths can reduce or even eliminate the port congestion, that is, the queuing phenomenon of ships waiting for berths. However, excessive berths will increase the investment and operating costs of port construction, and even cause waste; on the contrary, too few berths will also lead to the long queue of ships in the port, resulting in the economic loss of overstocking of ships and goods.

4.1. Construction of Berth Utilization Model

The number of ships in the port obeys the Poisson distribution. In a given time, the probability of the number of ships in the port is:

$$\mathrm{P}(n_s) = \frac{(\bar{n})^{n_s} e^{-\bar{n}}}{(n_s)!} \tag{1}$$

Where: $\bar{n}$ represents the average number of ships in the port per hour.

Idle berth cost C_1:

$$C_1 = C_b \sum_{n_s=0}^{n_b} (n_b - n_s)\, NP(n_s) \tag{2}$$

C_b: The cost per hour of idle berths;

n_b: The number of berths provided;

N : The total length of the year.

Berthing cost:

$$C_2 = C_w \sum_{n_s=n_b+1}^{\infty} (n_s - n_b)\, NP(n_s) \tag{3}$$

C_w: Hourly cost of idle ships in port.

Total cost:

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$$C_x = C_1 + C_2 \tag{4}$$

It can be concluded that the optimal (NB) is an optimal satisfying the following optimality criteria:

$$\sum_{n_s=n_b^*+1}^{\infty} p\,(n_s) < \left(1 - \frac{cw}{c_b + c_w}\right) < \sum_{n_s=n_b^*}^{\infty} P(n_s\,) \tag{5}$$

Berth occupancy degree D_0:

$$D_0 = \frac{8760n_b - \sum_{n_s=0}^{n_b-1}(8760(n_b - n_s)P(n_b))}{8760n_b} \tag{6}$$

For known $\bar{n}$, C_w and C_b, the optimal n*b can be determined by experiment and error.

4.2. Model Solving

Taking into account the novel coronavirus pneumonia outbreak in 2019, the decision was made using data from the ship's statistics at Shekou Port Container Terminal. January 1st, 2018 to January 31st, 2018. After screening the original data, we can get the number of ships arriving and berthing every day, as shown in Table 2:

According to the data in the table above, the number of vessels in port per hour:

$$\bar{n} = 3 \tag{7}$$

By observing the arrival and berthing of ships in one month, most of the ships are foreign trade ships during this period. There are 141 ships with a deadweight between 10000 tons and 50000 tons, 109 ships between 50000 tons and 100000 tons, and 38 ships with a deadweight of more than 100000 tons. Through the analysis, we can get that the deadweight tonnage of ships in January is between 10000 tons and 100000 tons. Therefore, this paper selects 50000 tonnage foreign trade container ships for research, ignoring other types of ships which account for a relatively small number.

Table 1. Arrival and berthing of ships in Shekou port in January 2018

Date	Number of berths	Date	Number of berths	Date	Number of berths
1.1	10	1.12	10	1.23	9
1.2	10	1.13	6	1.24	7
1.3	7	1.14	14	1.25	10
1.4	9	1.15	7	1.26	12
1.5	12	1.16	7	1.27	7
1.6	14	1.17	10	1.28	13
1.7	10	1.18	13	1.29	7
1.8	9	1.19	10	1.30	8
1.9	5	1.20	9	1.31	11
1.10	7	1.21	13		
1.11	5	1.22	7		

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Based on the analysis of the charging standards for berthing (Table 2) issued by the Ministry of transport of the people's Republic of China (2019), the charging standards for ships sailing on international routes are adopted.

Table 2. Parking charge standard

Project		Billing unit	Rate (RMB)
Parking fee (International)	Wharf and buoy (productive)	Billing ton ·day	0.25
	Anchorage	Billing ton · hour	0.15
	Terminal (non production)	Billing ton · day	0.05
Parking fee (domestic)	Wharf and buoy (productive)	Billing ton · day	0.08
	Terminal (non production)		0.12

Hourly cost of port restricted vessels:

$$C_w = 50000 * \left(\frac{0.25+0.05}{24} + 0.15\right) = 8125 \quad (8)$$

According to the port information released by Shekou Port Container Co., Ltd., Shekou port has 9 specialized container berths, namely $n_b = 9$.

Total time of Shekou port in one year:

$$T = 365 * 24 = 8760 \text{ hours} \quad (9)$$

For the calculation of berth idle cost:

Foreign trade:

C_b= [Labor cost * number of people + (berthing fee of wharf, buoy + anchorage type) * berth tonnage] * cost (yuan / day) (10)

Domestic trade:

C_b = [Labor cost * number of people + (berthing fee of wharf ,buoy type) * berth tonnage] * cost (yuan / day) (11)

Note: 1) the labor cost is calculated at 200 yuan per day;

2) The berths above 10000 tons usually need to be equipped with 6 loading and unloading workers.

4.2.1 optimal number of berths

According to formula (1) and (7), the n_s-p (n_s) data table is calculated, as shown in Table 3.

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Table 3. ns-P (ns) data table

ns	P(ns)	ns	P(ns)	ns	P(ns)
0	0.0000061	6	0.0254812	11	0.1143677
1	0.0000737	7	0.0436821	12	0.1143677
2	0.0004424	8	0.0655232	13	0.1055702
3	0.0017695	9	0.0873642	14	0.0904887
4	0.0053086	10	0.1048370	15	0.0723910
5	0.0127406	6	0.0254812	16	0.0542932

According to formula (8) and (10), it is calculated that $(1-\frac{Cw}{Cb+Cw})$= 0.80487.

Table 4. Data list

n_b	$\sum_{n_s=n_b^*+1}^{\infty} p(n_s)$	$\sum_{n_s=n_b^*}^{\infty} P(n_s)$
1	0.9999201254	0.9999938558
2	0.9994777430	0.9999201254
3	0.9994777430	0.9994777430
4	0.9977082134	0.9994777430
5	0.9923996246	0.99770820
6	0.9796590115	0.99239962460
7	0.9541777852	0.97965901148
8	0.9104956831	0.95417778524
9	0.8449725299	0.91049568311
10	0.7576083257	0.84497252993

According to formula (5), (7) and table 4, when n_b = 10:

$\sum_{n_s=n_b^*+1}^{\infty} P(n_s)$<0.80487< $\sum_{n_s=n_b^*}^{\infty} P(n_s)$, The optimal value NB * = 10.

When the number of container berths is 10, according to formula (2), the cost of idle berth is C_1≈8471931; According to formula (3), the cost of ship berthing is C_2≈883291, so the total cost is C_X = 9355222.

4.2.2 berth occupancy

The occupancy degree of berths reflects the occupancy degree of berths. According to the existing 9 container berths in Shekou port as the research data, through formula (6), the occupancy degree of port berth is as follows:

$$Do=\frac{8760n_b-\sum_{n_s=0}^{n_b-1}(876o(n_b-n_s)P(n_b))}{8760n_b}=1-\sum_{n_s=0}^{n_b-1}\left\{\frac{(n_b-n_s)}{n_b}P(n_s)\right\}\approx 96.43\%$$

5. CONCLUSIONS AND SUGGESTIONS

Taking Shekou port in Shenzhen as the research object, this paper analyzes the collection and distribution status of the port, and studies the container berth of Shekou port through the model construction.

1) With the rapid growth of domestic trade market demand and the gradual optimization of cargo source structure, more and more large ships enter into the domestic trade container transportation, which is not only an opportunity but also a challenge for Shekou port.

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2) According to the results of the model, the optimal number of container berths in Shekou port is 10, while there are only 9 container berths in the port. With the increase of port throughput, the berths of Shekou port will be overloaded. In terms of port construction, we should consider adding 1-3 container berths to maximize the use of port berths and efficiently handle containers.

3) The occupancy rate of berths is 96.43%, which means that the utilization rate of berths is very high, which also indicates the busy degree of berths from another angle.

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