Calculating method of container terminal through capacity based on unit shoreline

Gu Xiaofeng

Engineering Research Center of Container Supply Chain Technology, Ministry of Education, Shanghai Maritime University, Shanghai 201306, P. R. China

Huang Youfang

Engineering Research Center of Container Supply Chain Technology, Ministry of Education, Shanghai Maritime University, Shanghai 201306, P. R. China

Yan Wei

Engineering Research Center of Container Supply Chain Technology, Ministry of Education, Shanghai Maritime University, Shanghai 201306, P. R. China

Abstract
Due to the development of China's economy and trade, marine transport, especially container transportation has been a dominant mode of transportation. Problem of sea port berths works overload is increasingly crucial lately. To solve this problem, container terminal through capacity must be determined to meet the essential requirements. In accordance with the proposed berth layout, this paper compares two calculating methods of hectometer coastline throughput capacity based on fuzzy comprehensive evaluation and berth throughput capacity. Eventually one method is chosen to determine the container terminal through capacity.
Key words: CONTAINER TERMINAL, BERTH LAYOUT, CONTAINER TERMINAL THROUGH CAPACITY

Introduction

With the advancement in networking and multimedia technologies enables the distribution and sharing of multimedia content widely. In the meantime, piracy becomes increasingly rampant as the customers can easily duplicate and redistribute the received multimedia content to a large audience. Insuring the copyrighted multimedia content is appropriately used has become increasingly critical [1].

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Marine transport has occupied the leading position of freightage for its lower price.

Compared with the traditional transportation methods, container transportation has obvious advantages in the field of loading and unloading efficiency, labor intensity, transport quality of goods, etc. The mass benefit container transportation generated pushes modern container transportation to upsurge, which is also the sign of the transportation modernization. Being the important hinge of container transportation, port directly affects velocity of circulation and efficiency of goods. Berth ability [1] and terminal operation efficiency should be lifted to improve the port competitiveness. To solve the problem of sea port berths works overload, container terminal through capacity will be the first to consider, and ensure the actual throughput[2] is less than berth throughput capacity.

Li er al [3] research on categorization of terminal through capacity. Clustering methodology is first used to divide terminal into three classes. Take the hectometer coastline throughput capacity of the terminal as the evaluation index, analyze and obtain the eigen interval of the hectometer coastline throughput capacity of container terminal based on flexible berthing way, which will to some extent assist the construction of the port planning. Peng C.S.[4] proposes that the way of check and ratification for the container terminal through capacity exist problems. Since random factors influencing container terminal through capacity is studied through deterministic method, which differs from actual operations of the port. Parameters of terminal through capacity vary differently, but most of our attention is focused on length of the coastline, ship loading and unloading equipments and performance, etc. Exactly check and ratify the terminal through capacity can effectively avoid resource waste and lift the terminal through capacity according to the ideal pattern. Fan er al [5] lay emphasis on the comparison of calculating methods of berth throughput capacity in Chinese mainland, Hong Kong and Korea. Compared with Chinese calculating methods, results of Korean are close to actual throughput. Annual operation days of berth and the effective availability of berth should also be taken into main statistical indicators of the port to improve the value of the parameters.

Container terminal through capacity restricts container throughput of the port, and competitions among ports are also around terminal through capacity. The research content of this paper is based on the container terminal, the length of which is 1800 meters. Dock apron is set for sex berths; berth layout is calculated according to the accumulation of single berth length. This paper compares two calculating methods [6] of hectometer coastline throughput capacity based on fuzzy comprehensive evaluation and berth throughput capacity and finally ascertains the container terminal through capacity.

Berth layouts

Berth length must meet the requirements of berthing maneuver and system. For common purpose of terminal, single berth length can be determined according to formula 1.

$$L_b = L + 2d \qquad (1)$$

Affluence length d should be left between two berths. Berth affluence length will be different on the basis of berth length. Values of berth affluence length are shown below in Table 1.

Table 1. Values of berth affluence length d of different ship types

Type of ship	berth affluence length(m)
5000DWT	14
10000DWT	15
30000DWT	30
50000DWT	30
100000DWT	30

In accordance of berth layout and highest utilization principles, the following berth layout plan is obtained.

From left to right, six berths are allocated for two ships of 100000DWT（8000TEU）, two ships of 50000DWT, one ship of 10000DWT（700TEU）and one ship of 5000DWT（350TEU）, the total berth length is represented by L.

$$L = 30 + 346 + 30 + 346 + 30 + 293 + 30 + 293 + 30 + 141 + 15 + 121 + 14 = 1719 \text{（m）}$$

Determination of container terminal through capacity

Berth throughput capacity and hectometer coastline throughput capacity are considered to determine container terminal through capacity in this paper. Berth throughput capacity is calculated based on the Code for Design of General Layout of Sea Ports. While hectometer coastline throughput capacity can combine container terminal elements of business environment, management level, storage condition[7], terminal gate and port condition, etc. Fuzzy comprehensive evaluation is used to determine terminal index and selection and correction factor of hectometer coastline throughput capacity can also be achieved. Eventually ascertain container terminal through capacity.

Table 2. Calculation of through capacity

Subject	Parameters for through capacity calculation							through capacity Pt(TEU)
	Annual operation days of berth, Ty（d）	Effective availability of berth Ap(%)	Loading and unloading volume of single container vessel Q(TEU)	working hours of loading and unloading t_g (h)	auxiliary operating hours t_f（h）	hours of day and night td（h）	Designed ship efficiency p(TEU/h)	
5000DWT	330	60	250	24	4	24	64.13	150412
10000DWT	330	60	600	24	4	24	64.13	118800
30000DWT	330	60	1500	24	4	24	96.19	363782
50000DWT	330	60	2700	24	4	24	96.19	400082
100000DWT	330	60	3500	24	4	24	128.25	531536

Result of Berth comprehensive throughput capacity approximately equal to 2.13 million TEU calculated as below.

$531536 * 2 + 400082 * 2 + 118800 + 150412 = 2132448$（TEU）

B. Prediction for hectometer coastline throughput capacity

Hectometer coastline throughput capacity of container terminal can be calculated according to the following formula:

$$P_t = \eta * n * P * K_1 * T_y * t_g * A_p * (1 - K_2) * (1 - K_3) \quad (2)$$

P_t——Hectometer coastline throughput capacity of container terminal（TEU）；

η——Correction factor of hectometer coastline throughput capacity, which is determined by terminal business environment, management level, storage condition, terminal gate and port condition, generally select from 0.5 to 1.0. Expert evaluation method is used to determine η in this paper.

n——Numbers of container bridges for hectometer coastline

P——Designed ship efficiency of container bridge for container terminal（Unit /hour）, selected as 25.

T_y——Annual operation days of terminal, in accordance with historic hydrology and meteorological data, generally choose from 330 to 350 days, determined as 330 days in this paper.

t_g——Hours of day and night, generally choose 24 days, and no less than 22 hours. determined as 24 hours in this paper.

A_p——Cardinal number for crane utilization(%), specific value is shown in Table 3.

K_1——Convert coefficient for standard container, specific value is shown in Table 3.

K_2——Interference factor for concurrent operation of Crane(%), specific value is shown in Table 3.

K_3——Restow rate of terminals handling (%), including switching hatch, and specific value is shown in Table 3.

A. Prediction for berth throughput capacity

Table 3. Parameter specification

Terminal level	A type	B type	C type	D type	E type
Cardinal number for crane utilization Ap	0.6	0.6	0.65	0.7	0.7
Convert coefficient K1	1.4-1.6	1.4-1.7	1.5-1.7	1.5-1.7	1.6-1.8
Interference factor K2（%）	0-1	1-3	2-4	3-4	3-5
Restow rate	0-3	1-5	2-6	3-7	3-8

K3（%）					

C. Correction factor for hectometer coastline throughput capacity

Expert evaluation method is used to ascertain correction factor for hectometer coastline throughput capacity of container terminal.

$$\eta = 0.2 * B_1 + 0.2 * B_2 + 0.15 * B_3 + 0.2 * B_4 + 0.1 * B_5 + 0.15 * B_6 \qquad (3)$$

B_1 to B_6 indicate the influence factor of hectometer coastline throughput capacity in the formula (3), that is, business environment, management level, storage condition, terminal gate and port condition. The proportions assigned for B_1 to B_6 are 0.2, 0.2, 0.15, 0.2, 0.1, and 0.15 in accordance with the sequence. The evaluation criterion is distributed into five classes, very poor, poor, common, good and excellent, recorded as 100%,90%,75%,60% and 50%.

D. Determine the terminal indexes via fuzzy comprehensive evaluation method

Branches of the fuzzy comprehensive evaluation method are shown below, principle elements of which are natural conditions U1 and management and design U2. Along with the principle line, evaluation method can be divided into 3 facets. Expert assessment is combined with the professional standard to determine the weight and with the fuzzy judgment matrix, we can reach the final result of comprehensive assessment.

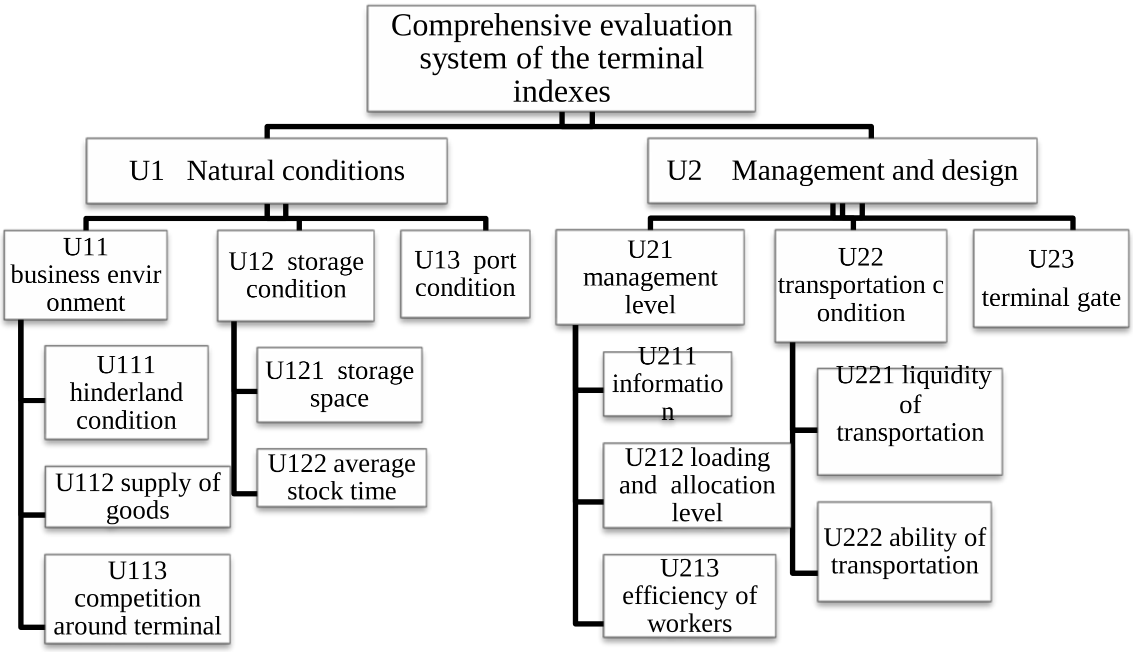

Figure 1. Comprehensive evaluation system of the terminal

The Weight of the indexes are assigned as follow.

U=(0.5，0.5)

U1=（0.4，0.3，0.3）

U2=（0.4，0.4，0.2）

U11=（0.4，0.3，0.3）

U12=（0.6，0.4）

U21=（0.2，0.5，0.3）

U22=（0.6，0.4）

The fuzzy judgment matrix is obtained as follows.

Table 1. Fuzzy judgment matrix

Element	A	B	C	D	E
hinderland condition	0.90	0.60	0.75	0.754	0.624

supply of goods	0.87	0.57	0.742	0.787	0.687
competition around terminal	0.80	0.63	0.757	0.739	0.598
storage space	0.54	0.75	0.764	0.897	0.749
average stock time	0.63	0.69	0.739	0.903	0.753
port condition	0.75	0.90	0.75	0.75	0.60
Information	0.639	0.905	0.752	0.998	0.893
Loading and unloading and loading level	0.605	0.876	0.784	0.985	0.904
efficiency of workers	0.587	0.889	0.756	0.974	0.885
liquidity of transportation	0.748	0.874	0.736	0.721	0.743
ability of transportation	0.739	0.923	0.758	0.756	0.707
terminal gate	0.75	0.9	0.75	0.90	0.90

The final comprehensive Index is 0.716, 0.81, 0.755, 0.833, 0.745 according to the calculation and the order is determined as D,B,C,E,A. The fourth scheme is selected as the selection indicator in this paper. Designed business environment of the container terminal is described as follows. The area of hinder land is not broad, supply of goods is ordinary, and there are casual competitions around terminal. Due to storage condition, the area of storage can greatly meet the requirements of berths. The average stock time of container in the yard is basically 5 to 8 days. For the port condition, clearance rate of the container inventories is ordinary. With regard to management level, information, loading and allocation reaches the high level, and workers can accomplish the mission effectively. As for transportation condition, collecting and distributing system and ability of transportation are ordinary. For terminal gate, the traffic is good, so container truck can pass the gate smoothly.

Substituting into formula 3,

$$\eta = 0.2 * B_1 + 0.2 * B_2 + 0.15 * B_3 + 0.2 * B_4 + 0.1 * B_5 + 0.15 * B_6 = 0.2 * 0.75 + 0.2 * 1.0 + 0.15 * 0.9 + 0.2 * 0.75 + 0.1 * 0.9 + 0.15 * 0.75 = 0.83$$

Substituting into formula 2,

$$P_t = \eta * n * P * K_1 * T_y * t_g * A_p * (1 - K_2) * (1 - K_3) = 0.83 * 1.0 * 25 * 1.5 * 330 * 24 * 0.7 * (1 - 0.03) * (1 - 0.05) = 159011.28$$

So hectometer coastline throughput capacity is close to 2.86 million TEU.
159011.28*18=2862203.04(TEU)

E. Determine the terminal capacity

Compared with berth throughput capacity, the result of hectometer coastline throughput capacity is much bigger, which complies with the trend of terminal development. Container terminal through capacity is finally determined as 2.86 million TEU.

Conclusions

In recent years, boost to the economy leads to the flourishing export, which makes throughput of professional container terminal increase swiftly, and ocean shipping is the major mode of transportation. While the original throughout of terminal cannot catch the pace of the development of terminal, so it occurs that terminal works overload. Due to the impact of the transportation technology of container, operation technique of the new terminal and application of production management Methodology on the terminal through capacity, the original calculation method is relatively conservative. Hectometer coastline throughput capacity based on fuzzy comprehensive evaluation, which complies with the trend of terminal development, is finally selected in this paper.

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References

1. Yavuz B. Türkoğulları, Z. Caner Taşkın, Necati Aras, İ. Kuban Altınel. (2014) Optimal berth allocation and time-invariant quay crane assignment in container terminals. *European Journal of Operational Research*, 235(1), p.p.88-101.
2. Wang, Z.M., He, X.M. (2004) On the Reasonable Throughput Capacity of Container Terminals. *Port & Waterway Engineering*, 3, p.p.16-20.
3. Li,G.X., Guo Z.J, Song X.Q. (2011) Classification Study of Port Throughput Capacity Based on Clustering Analysis, *Port Engineering Technology*, 48(3), p.p.7-9.
4. Peng C.S. (2009) Existing problem in container port through capacity verification method, *Comprehensive transportation*, 7, p.p.55-58.
5. Fan H.M., Dong G.S.,Tan, C.F. (2009) Comparative Analysis of Calculation of Throughput Capacity of Berths at Container Terminals between China and Public of Korea, *China Harbour Engineering*, 3, p.p.5-9.
6. Chen B.G., Shi G. (2009) An Approach to Berth Throughput Capacity Calculation for Container Trunk Line Port, *Port Operation*, 6, p.p.38-39.
7. Héctor J. Carlo, Iris F.A. Vis, Kees Jan Roodbergen. (2014) Storage yard operations in container terminals: Literature overview, trends, and research directions, *European Journal of Operational Research*, 235(2), p.p. 412-430.