Research on the Construction Scale of Modern Land Port Multi-Modal Transport Reloading Area

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Abstract. It is of great significance to rationally determine the construction scale of land port multi-modal transport reloading area for scientifically guiding construction, improving construction efficiency and saving construction investment. The multi-modal transport reloading area of land port contains multiple functional modules, such as railway loading and unloading line, container yards, and truck parking areas. The influencing factors of the construction scale of each functional module are different, so the construction scale measurement model of each functional module is given. According to the actual situation of each land port, the parameter values of the influencing factors of each functional module are determined, and the construction scale of each functional module can be obtained according to the scale measurement model, and then the construction scale of the multi-modal transportation replacement area of the land port can be determined. Example results show that the minimum length of railway loading and unloading lines, the number of railway loading and unloading lines, and the size of container yard calculation model have a good matching degree, which can meet the needs of cargo loading and unloading of various transportation modes. Through the quantitative prediction of the construction scale of the multi-modal transportation reloading zone, it provides scientific guidance for the subsequent construction of the land port multi-modal transportation reloading zone.

Keywords: land port, multi-modal transport reloading area, railway loading and unloading line, container yard

1 INTRODUCTION

Land port is an important part of logistics hub, which has three major characteristics: transportation hub, open port and logistics hub. It undertakes the functions of collection and distribution, transshipment, processing and distribution of goods, and plays an important role in promoting regional economic development and integrating into the global industrial chain and supply chain. The core functions of land port mainly include railway container center station, customs supervision area, container yard, international transit area, multi-modal transport reloading area, road freight station, warehouse, distribution area, railway special line, etc.

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Domestic and foreign scholars have done a lot of research on the location and positioning of land ports. Back SW et al. analyzed the relevant influencing factors of logistics comprehensive location selection [1]. Poitevint D mainly elaborated on the relevant issues related to the change of logistics location by information system [2]. Peker I et al. took Turkey as an example and studied related issues of logistics center location based on ANP/BOCR [3]. Xupei took the management mode of GZ international land port "administrative committee + company" as an example, to optimize the management mode of "administrative committee + company" in land port [4]. Ge Xiaofang proposed to establish an inland port of container port operating in the mode of combined transport of public railways, and studied the location of inland port of container port under the mode of combined transport of public railways [5]. Li Zehao took the land-port national logistics hub in Hengyang city as the research object, and conducted in-depth and systematic research on its site selection [6].

However, there are few research results on the construction scale of land port and internal functional area. In order to solve the current problems such as inconsistent infrastructure standards and planning of the land port multi-modal transport reloading area, and provide scientific guidance for the subsequent construction of the land port multi-modal transport reloading area, this paper carries out standardized and modular design from the aspects of functional configuration, construction scale, information construction, etc., by studying each functional module of the land port multi-modal transport reloading area. This paper provides an effective reference for the subsequent planning, design and construction of the multi-modal transport reloading area of the land port to ensure that it can efficiently meet the needs of logistics circulation and better serve the construction of logistics facilities. Taking Qingdao and LQ land ports as examples, the construction scale of each module in multi-modal transport reloading area is verified.

2 CONSTRUCTION REQUIREMENTS

2.1 Definition

Land port, relying on railway or highway land transportation, a trade and logistics hub will be set up in inland port cities to provide goods distribution and port services [7].

Multi-modal transport reloading area, the logistics park provides enough space for the transfer of goods, and the corresponding facilities and equipment are configured to realize the safe and efficient transport function of various modes of goods transportation.

Railway loading and unloading line, railway line used for all kinds of cargo handling vehicles [8].

Container yard, it is an area used for handover, storage and storage of containers for transfer, providing basic services such as cargo collection, box maintenance and cleaning [9].

2.2 Multi-Modal Transport Reloading Area Construction Requirements

The construction of multi-modal transport reloading area shall meet the following requirements: The park should generally have the conditions for multi-modal transport reloading, ensure sufficient land for public and railway combined transport, and have the corresponding infrastructure equipment and facilities; The configuration of reloading equipment should improve the level of mechanized operation, and when handling container cargo, emptying, packing, empty container management and other operations are required, corresponding reloading facilities and sites should be equipped; Reasonable organization of multi-modal transport modes, as far as possible to avoid the horizontal crossing between different modes of transport lines; Loading and unloading operations should not occupy the road area, should not interfere with the operation of other modes of transport, should not affect the passage of other vehicles; The multi-modal transport reloading area mainly includes storage yard, warehouse, parking lot and other ancillary facilities for reloading, which should be integrated with other functional area facilities. Railway loading and unloading lines shall meet the requirements of loading and unloading technology, plane layout and railway operation organization.

2.3 Container Yard Construction Requirements

Container yard construction should meet the following requirements: The width of the main road of the container yard should be determined according to the operation and operation requirements of transport vehicles and yard machinery, and should not be less than 15m; Heavy container yard containers should be stacked in the same direction as the door, box spacing should be 0.4m; The empty container yard should make full use of the park site and should be located at the rear of the park. When the rail type container gantry crane is used in yard operation, the gauge should be 24m~50m, and the container trailer channel should be left, and the width of the single lane should not be less than 3.5m. When a wheeled container gantry crane is used in the yard operation, there should be a container trailer channel between the hips, the width should not be less than 3.5m, and the adjacent lanes should be arranged in pairs. When container straddle trucks are used in storage yard operation, there should be a straddle truck channel between two rows of containers with a width of 1.5m; When the container front crane and container forklift are used, the working channel in the yard should not be less than 15m; The space of the container yard should be reasonably arranged according to different technological arrangements, and the location and code should be marked.

2.4 Parking Area Construction Requirements

The construction of the parking area shall meet the following requirements: The parking mode and driving route of the parking area shall be selected according to the parking lot, road and traffic organization of the park; Parking areas should be centrally arranged or set up separately in different working areas. Self-owned vehicles and external vehicles in the park should be parked separately. The parking area shall be arranged near the loading and unloading yard; The general layout of the parking area, fire spacing,

fire access, safety evacuation, safety lighting, fire water supply and electrical building standards shall meet the requirements of GB 50067.

2.5 Information Construction Requirements

Information construction should include the following contents: data center construction, hardware facilities, network infrastructure, information security, data management, software systems, etc. Data centers are the foundation and core of land port information construction, and should be planned, designed, constructed, operated and maintained in accordance with relevant national norms and standards to ensure the safe, reliable, efficient and green operation of data centers. Hardware facilities are an important part of the information construction of the land port. All kinds of hardware equipment should be rationally configured according to the business process and functional requirements to realize the information collection, transmission, processing and display of the land port. Network infrastructure is the key support for the construction of land port formalization. Planning, design, construction, operation and maintenance should be carried out in accordance with relevant national norms and standards to ensure the coverage, connectivity, speed and quality of network infrastructure. Information security is an important guarantee for the information construction of land ports. Planning, design, construction, operation and maintenance should be carried out in accordance with relevant national laws, regulations and standards to ensure the confidentiality, integrity and availability of information resources at land ports. Data management is the core content of the information construction of land ports. Planning, design, construction, operation and maintenance should be carried out in accordance with relevant national norms and standards to ensure the quality, value and sharing of data resources of land ports. The software system is an important carrier of the information construction of the land port, which should be planned, designed, constructed, operated and maintained in accordance with the relevant national norms and standards to ensure the perfect function, convenient operation and quality service of the software system.

3 CONSTRUCTION SCALE CALCULATION MODEL

3.1 Minimum Length of Railway Loading and Unloading Line

The minimum length of railway loading and unloading lines can be calculated according to the relevant requirements of JTS 166-2020 by referring to the following formula:

$$L_R = \frac{Q_t K_{Bt} L}{T_{yk} G_t C K_L} \tag{1}$$

In formula: L_R——Minimum length of railway loading and unloading line(m); Q_t——Annual freight handling capacity of railway in the park(t); K_{Bt}——The unbalanced coefficient of train arrival in the park, it is determined according to the statistical data of train arrival number and tonnage of loading and unloading vehicles; L——Average vehicle length(m); T_{yk}——Annual operation days of railway loading and unloading

line (d); G_t——Average vehicle load (t); C——Number of daily train deliveries (times), it should be determined according to the service function of the park, the annual volume, the efficiency of loading and unloading vehicles, and the organization of railway transport; K_L——Utilization coefficient of loading and unloading line.

3.2 Number of Railway Loading and Unloading Lines

The number of railway loading and unloading lines can be calculated by reference to the following formula:

$$m = \frac{Ct_e}{1440K_L - t_f} \tag{2}$$

In formula: m——Number of railway loading and unloading lines (pieces); C——Number of daily train deliveries (times), it should be determined according to the service function of the park, the annual volume, the efficiency of loading and unloading vehicles, and the organization of railway transport; t_e——Time taken by each train to load and unload goods (min); K_L——Utilization coefficient of loading and unloading line; t_f——Other operations occupy loading and unloading time.

3.3 Container Yard Area

Container yard area can be calculated by reference to the following formula:

$$S_{dc} = \frac{Q_{dc}K_{Bt}t_{dc}}{T_{yk}GN_1A_s} \cdot E \tag{3}$$

In formula: S_{dc}——Container yard area(ten thousand m^2); Q_{dc}——Annual cargo handling capacity of container yard(ten thousand t); K_{Bt}——Unbalance coefficient of container yard; t_{dc}——Average storage period of container yard (d); T_{yk}——Annual working days of container yard(d); G——Average weight of goods per container (t/TEU); N_1——Number of layers of equipment in container yard; A_s——Capacity utilization rate of container yard(%); E——Area of each container plane(m^2).

3.4 Parking Area

The parking area is determined according to the vertical parking of the parking lot, and the parking area is calculated using the following formula:

$$S_P = \frac{Q_pK_{Bt}}{G_t\gamma} \cdot k \cdot S_t \tag{4}$$

In formula: S_P——Parking area(ten thousand m^2); Q_p——Average daily cargo handling capacity (ten thousand t); K_{Bt}——Average coefficient; G_t——Cargo capacity per vehicle (t); γ——Vehicle integrity rate; k——Percentage of parked vehicles(%); S_t——Unit parking area(m^2/car).

4 CASE STUDY

4.1 A Land Port in Qingdao

A land port in Qingdao is a construction project invested by enterprises. The project constructs two railway loading and unloading lines, with a single railway loading and unloading line length of 851 meters and a container yard area of about 60,000 m^2.

According to the minimum length of railway loading and unloading line calculation formula:

$$L_{\mathrm{R}} = \frac{Q_t K_{Bt} L}{T_{yk} G_t C K_L} \tag{5}$$

In formula: L_R——Minimum length of railway loading and unloading line (m); Q_t——Annual freight handling capacity of railway in the park (t), the value is 600,000 tons based on the actual situation; K_{Bt}——The unbalanced coefficient of train arrival in the park, it is determined according to the statistical data of train arrival number and tonnage of loading and unloading vehicles, and the value is 1.3 according to the actual situation; L——Average vehicle length (m), the value is 14 m based on actual conditions; T_{yk}——Annual operation days of railway loading and unloading line (d), the value can be 365 days based on actual conditions; G_t——Average vehicle load (t), the value can be 65 tons based on actual conditions; C——Number of daily train deliveries (times), it should be determined according to the service function of the park, the annual volume, the efficiency of loading and unloading vehicles, and the organization of railway transport, and the value is 2 times according to the actual situation; K_L——Utilization coefficient of loading and unloading line (%), the value can be 30% based on actual conditions At present, there are three main standards for the length of railway loading and unloading lines, 1050 meters, 850 meters and 880 meters. According to the values of the above parameters, it can be calculated that the minimum length of the railway loading and unloading line is 767 meters, and the standard value is 850 meters.

According to the formula of the number of railway loading and unloading lines:

$$m = \frac{C t_{\mathrm{e}}}{1440 K_L - t_f} \tag{6}$$

In formula: m——Number of railway loading and unloading lines (pieces); C——Number of daily train deliveries (times), it should be determined according to the service function of the park, the annual volume, the efficiency of loading and unloading vehicles, and the organization of railway transport, and the value shall be 2 times according to the actual situation; t_{e}——Time taken by each train to load and unload goods (min), the value can be 210 mins based on actual conditions; K_L——Utilization coefficient of loading and unloading line is 30% according to the actual situation; t_f——Other operations occupy loading and unloading time, the value is 180 mins based on actual conditions. According to the values of the above parameters, the number of railway loading and unloading lines can be calculated as 1.67, which is rounded to 2.

According to the calculation formula of container yard area:

$$S_{\mathrm{dc}} = \frac{Q_{dc} K_{Bt} t_{dc}}{T_{yk} G N_1 A_s} \cdot \mathrm{E} \tag{7}$$

In formula: S_{dc}——Container yard area(ten thousand m^2); Q_{dc}——Annual cargo handling capacity of container yard (ten thousand t), based on actual conditions, the value is 400,000 t; K_{Bt}——Unbalance coefficient of container yard is 1.4 according to the actual situation; t_{dc}——Average storage period of container yard (d), and the value shall be 15 days according to the actual situation; T_{yk}——Annual working days of container yard (d), and the value shall be 365 days according to the actual situation; G——Average weight of goods per container (t/TEU), the value is 20/TEU based on actual conditions; N_1——Number of layers of equipment in container yard, and the value is 3 layers based on the actual situation; A_s——Capacity utilization rate of container yard (%), and the value shall be 65% according to the actual situation; E——Area of each container plane (m^2), and the value shall be 26 m^2 according to the actual situation. Based on the values of the above parameters, it can be calculated that the area required for the container yard is 15,300 m^2.

According to the parking area calculation formula:

$$S_P = \frac{Q_p K_{Bt}}{G_t \gamma} \cdot k \cdot S_t \tag{8}$$

In formula: S_P——Parking area(ten thousand m^2); Q_p——Average daily cargo handling capacity (ten thousand t), the value is 1,600 tons according to the actual situation; K_{Bt}——Average coefficient, the value is 1.1 according to the actual situation; G_t——Cargo capacity per vehicle (t), and the value shall be 30 ton according to the actual situation; γ——Vehicle integrity rate (%), the value is 100% according to the actual situation; k——Percentage of parked vehicles (%), the value is 25% based on the actual situation; S_t——Unit parking area (m^2/car), the value is 55 m^2 according to the actual situation. According to the values of the above parameters, it can be calculated that the parking area needs to be 829 square meters

4.2 Other Land Port

A land port in LQ is a construction project invested by enterprises, and the project has built a container yard of 15,000 square meters. The annual cargo handling capacity of the yard is 554,400 tons, the unbalanced coefficient of the yard is 1.2, the average storage period of the goods is 5 days, the annual working days of the yard are 350 days, the average weight of each container is 10 tons per TEU, the number of stacking floors of the yard is 4, the capacity utilization rate of the yard is 60%, and the box area per plane is 40 square meters. Substituting the above parameters into Formula (3), it can be calculated that the container yard area demand is 15,800 square meters, which is basically consistent with the container yard area of LQ dry port (15,000 square meters), and the existing container yard of LQ dry port can basically meet the operation needs.

5 CONCLUSIONS

5.1 Conclusions

For the land port in Qingdao, the minimum length of railway loading and unloading line calculated by the calculation model of the minimum length of railway loading and unloading line is consistent with the length of a single railway loading and unloading line in the land port (851 meters), and the matching degree of the calculation model of the minimum length of railway loading and unloading line is good. The number of railway loading and unloading lines calculated according to the calculation model of the number of railway loading and unloading lines is consistent with the number of railway loading and unloading lines in the land port (2), which can meet the needs of railway cargo loading and unloading, and the calculation model of the number of railway loading and unloading lines has a good matching degree. According to the calculation model of container yard area, the area of container yard calculated is much smaller than that of the land port (60,000 square meter). The existing scale of container yard in the land port can meet the operation needs. Therefore, it is necessary to further expand the business market, increase the storage of container yard, and improve the utilization rate of container yard area.

Reasonable planning of the land port, giving full play to the role of the land port in urban economy, society, industry, residents consumption and other aspects, has an important role in promoting the transformation of the logistics industry development mode and the development of other industries. By studying the construction scale of modern land port multi-modal transport reloading area and establishing prediction models including minimum length of railway loading and unloading line, number of railway loading and unloading line, area of container yard and area of parking area, the construction scale of multi-modal transport reloading area is quantitatively predicted, which provides scientific guidance for the subsequent construction of land port multi-modal transport reloading area and ensures that it can meet the needs of logistics circulation efficiently. Better serve the construction of logistics infrastructure.

5.2 Shortcomings and Prospects

The freight handling capacity of multi-modal transport reloading area is an important variable to determine the construction scale of each functional module, and the freight handling capacity is greatly influenced by the world economy, supply and demand, the conditions of land ports and the external environment of land ports, so the construction scale of each functional module is greatly influenced by the supply and demand and external environment. On the one hand, the underestimation of freight handling capacity leads to the small construction scale, which is not enough to support the future land port business operation and restricts the development of land ports. On the other hand, we are blindly optimistic about the freight handling capacity, resulting in the extensive development of "staking the land", which leads to the high vacancy rate of the park, resulting in the waste of land resources and increased construction investment. Therefore, when determining the construction scale of each functional module, we should

fully study the freight handling capacity, fully consider the changes of regional economic development and logistics demand, and provide scientific basis and data support for the construction scale of each functional module.

REFERENCES

1. Back, Sun-Woo, and Kyung-Sik Kang, "A Study on the logistics complex site selection factor," Journal of the Korea Safety Management & Science 17(4), 287-295 (2015).
2. Poitevint D, "Information Systems Alter Logistics Site Selection. Information, Organization and Information Systems Design," Springer US, 195-201 (2015).
3. Peker, Iskender, et al, "Logistics center site selection by ANP/BOCR analysis: A case study of Turkey," Journal of Intelligent & Fuzzy Systems 30(4), 2383-2396 (2016).
4. Xu Pei, "Research on the optimization of 'Management Committee + Company' management Mode of international land ports - taking GZ International Land Port as an example," Gansu: Lanzhou University (2022).
5. Ge Xiaofang, "Study on the location of inland port of container port under the mode of international transportation," Liaoning: Dalian Maritime University (2022).
6. Li Zehao, "Research on site selection and development strategies of Hengyang Land-Port National Logistics Hub," Hunan: Hunan University of Technology (2023).
7. "Index for classification and evaluation of dry ports," T/CADZ 0002-2023 (2023).
8. "Parameters requirements of logistics facilities and equipments," GB/T 39660-2020 (2020).
9. "Container yard: definition, function and detailed explanation," 20 March 2024, https://container-xchange.cn/blog/container-depot/