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Research on the Capacity of Port Collecting and Distributing Road based on VISSIM

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Abstract

As the economy continues to develop, the role of ports in development has become increasingly important. In recent years, due to the continuous increase in the throughput of coastal ports in my country, major ports have begun to increase the construction of deep-water berths and waterways, and the passing capacity of terminals has increased rapidly. As an important part of the land land gathering and transportation system in the port area, the port area gathering and transportation road is an important water and land transportation hub in the comprehensive transportation network, and it has gradually become an important factor restricting the development of the port. The capacity of the roads in the port area will directly affect the work efficiency of various tasks in the port area. Therefore, a calculation method that meets the actual road capacity of the port area can be proposed to solve the problems of unreasonable distribution and congestion of the roads in the port area. It can improve the service level of the collection and transportation roads in the port area.

Keywords

Port; Collection and Transportation Road; Capacity; Ramp; VISSIM.

1. Introduction

As a natural interface between the inland hinterland and marine transportation, the port plays an important role in the economic development of a country. In recent years, due to the continuous increase in the throughput of my country's coastal ports, major ports have begun to increase the construction of deep-water berths and navigation channels, and the passing capacity of the terminals has increased rapidly. As an important part of the port land collection and distribution system, the collection and distribution road in the port area is an important water and land transportation hub in the comprehensive transportation network, and has gradually become an important factor restricting the development of the port. The capacity of collection and distribution roads in the port area will directly affect the work efficiency of various tasks in the port area. Therefore, proposing a calculation method that conforms to the actual port area road capacity can solve the problems of unreasonable distribution of collection and distribution roads and congestion.

2. Characteristics of capacity of collection and distribution road in the port area

2.1 Characteristics of collection and distribution road in the port area

Port roads are important basic measures for ports that connect freight sites, storage locations, and port terminals, and provide convenience for cargo transportation, personnel entry and exit, and passage. Therefore, port roads should be distinguished from ordinary urban roads. The differences are:

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(1) The roads in the port area have lower requirements for vehicle passage, and lower standards for the number and weight of vehicles.

(2) The connection structure of roads in the port area is relatively simple, and the design of urban roads is relatively complicated. Compared with urban roads, there are fewer road intersections in the port area.

(3) The roads in the port area do not need to consider the intersection of highways and railways.

(4) The roads in the port area should ensure the speed of vehicles due to the demand for freight. Therefore, compared with urban roads, the stability of the roads in the port area should be improved.

(5) In actual use of roads in the port area, most of the vehicles that pass through are motor vehicles such as trucks and container vehicles, while the traffic of people and non-motor vehicles is rare.

2.2 Characteristics of collection and distribution vehicles in the port area

The transportation in the port area is mainly based on freight. The main function is to provide collection and distribution of port transportation. The traffic composition is mainly trucks and container vehicles, which are usually divided into passenger cars, ordinary trucks, semi-trailer trains, full-trailer trains, etc. Double-trailer trucks, trucks, tank cars and other vehicles.

2.3 Traffic characteristics of collection and distribution roads in the port area

Compared with ordinary urban road traffic, the road traffic in the port area has the following differences.

(1) The demand for road traffic in the port is mainly generated by the needs of cargo transportation. Therefore, in the traffic composition of the port area, trucks account for a relatively high proportion, and there is no fixed peak time in the port area. Generally speaking, before and after the loading and unloading of ships The traffic flow is relatively large.

(2) The road traffic in the port is always closely related to the arrival and departure of ships operating in the port.

(3) The long body length and poor power performance of large vehicles in the port area have a greater impact on the traffic capacity.

(4) Vehicles need to be parked for inspection in the port area, and the parking capacity of vehicles is outstanding.

3. Traffic flow characteristics

Although the traffic on the road is composed of individual vehicles, it exhibits the characteristics of "vehicle flow". Therefore, the fluid theory in physics can be used to study the state of road traffic, which is called traffic flow, and judging the size of traffic flow is Observe changes in traffic volume.

3.1 Definition of traffic volume

Traffic volume refers to the number of traffic entities passing through a certain place and a certain section of the road (or a certain lane of the road) in a selected time period. The unit is generally vehicle/h, or vehicle/d.

The flow rate refers to the number of vehicles per hour obtained by equivalent conversion of the number of vehicles passing through a designated place or section of a road (or a certain lane on the road) within a time period of less than 1 hour (usually 15 minutes). The unit is generally a vehicle. /h.

3.2 Expression of traffic volume

Traffic volume is a quantity that changes over time. If you want to understand the traffic intensity of a road, its expression usually requires the average value in a certain period of time as the representative traffic volume of the time period.

If we take a certain number of observation days and take vehicles/d as the unit, the expression of average daily traffic volume (ADT) is:

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$$ADT = \frac{1}{n}\sum_{i=1}^{n} Q_i \quad (1)$$

In the formula: n is the number of days to calculate the time;Qi is the number of vehicles passing through the designated place on a certain day, vehicles/d.

4. Road capacity

4.1 Definition of road capacity

Road capacity, also known as road capacity, is an index that measures the extent to which road facilities can disperse vehicles, and is a measure of road load performance. When the traffic volume on the road is close to the capacity of the road, traffic congestion will occur. At this time, all vehicles are marching in line at the same speed. Once interference occurs, it is easy to cause traffic jams. When the traffic volume on the road is less than the road capacity, the driver has a certain degree of freedom to drive forward, and has the opportunity to change the speed and overtake.

The "U.S. Traffic Capacity Manual" (HCM) stipulates the capacity of a road as the maximum hourly traffic volume that passes through a lane or a point or a uniform section on the road under a certain period of time and under road, traffic, and controlled conditions. The definition of traffic capacity in my country refers to the ability of road facilities to divert traffic flow, that is, passing through the quality point of road facilities traffic flow in a certain period of time (usually 15 minutes or 1 hour) and under normal road, traffic, control, and operation quality requirements. The capacity is also called traffic capacity or capacity for short. It is the limit value of the number of vehicles that a road facility can pass under certain conditions. According to the nature of the function, the capacity is divided into three types: basic capacity, possible capacity and design (or practical) capacity.

4.2 Road classification

Road capacity factors such as road conditions, traffic conditions, and control conditions are related to road types. At present, in our country's highway design, the road is divided into 5 grades: expressway, one, two, three, and four according to the use task, function and adaptable traffic volume. Road grades are mainly classified according to the annual average daily traffic volume (converted to passenger cars) that they can adapt to, as shown in Table 1. Gathering and distributing roads are generally dedicated port expressways or expressways connecting hinterland cities. Therefore, collection and distributing roads in port areas are considered as expressways or first-class highways.

Table 1. Road grade differentiation

Road grade	Number of lane	The amount of traffic that can be adapted
Highway	8	60000-10000
	6	45000-80000
	4	25000-55000
First-class highway	6	25000-55000
	4	15000-30000
Second-class highway	2	5000-15000
Tertiary highway	2	2000-6000
Class four highway	2	<2000
	1	<400

The vehicle conversion coefficient refers to the conversion of different types of vehicles into a unified model in order to more accurately describe the road capacity, which is convenient for calculation and analysis. However, because of the different conversion methods and different vehicle models, the values of the coefficients are quite different. Some researches believe that the road traffic composition of collection and distribution is dominated by large container vehicles, interspersed with a small

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number of small and medium-sized vehicles, and the model is relatively single, so it can be calculated by the headway method and obtained by using the data obtained from actual investigations. More detailed vehicle conversion factor. The vehicle conversion factor is shown in Table 2.

Table 2. Vehicle conversion factor

	Small car	Mid-size car	Large car
Highway	1.0	2.0	2.5-3.0

4.3 Expressway capacity calculation

4.3.1 Basic capacity

The basic capacity is also called theoretical capacity, which refers to the maximum continuous traffic flow allowed by a section of a lane in a certain period of time (usually 1h) and under ideal road, traffic and control conditions. Calculated according to the headway time distance, the calculation formula is:

$$C_B = \frac{3600}{t} \tag{2}$$

In the formula: C_B is the basic capacity of a lane,pcu/h; t is the minimum safe headway,s.

4.3.2 Maximum service traffic

$$M_{SV_i} = C_B \cdot (V/C)_i \tag{3}$$

In the formula: M_{SVi} is the maximum service traffic volume of a lane with the i-th service level, pcu/(h·ln);C_B is the basic capacity, that is, the maximum traffic volume that can be passed in a lane under ideal conditions, pcu/(h·ln); $(V/C)_i$ is the ratio of the maximum service traffic volume of the i-level service level to the basic traffic capacity.

4.3.3 Design capacity of one-way carriageway

$$C_D = M_{SV_i} \cdot N \cdot f_W \cdot f_{HV} \cdot f_p \tag{4}$$

which is

$$C_D = C_B \cdot (V/C)_i \cdot N \cdot f_W \cdot f_{HV} \cdot f_p \tag{5}$$

$$f_{HV} = \frac{1}{1 + P_j(E_j - 1)} \tag{6}$$

In the formula:C_D is the design capacity of one-way N carriageways, that is, the maximum traffic volume that can be passed under specific design conditions when i and the service level are used in one direction, veh/h;N is the number of lanes of one-way carriageway; f_w is correction coefficient of lane width and lateral clear width to capacity; f_{HV} is the correction factor for capacity of large vehicles; f_P is the correction coefficient of the driver's condition to the capacity, generally in the range of 1.00-0.90;P_j is the ratio of the number of type j models to the total traffic volume; E_j is the vehicle conversion coefficient of the j-th vehicle type converted into a standard vehicle.

4.4 Calculation of first-class highway capacity

$$C_D = C_B \cdot (V/C)_i \cdot N \cdot f_W \cdot f_{HV} \cdot f_p \cdot f_e \tag{7}$$

In the formula:f_e is the correction coefficient for lateral interference influence. Because the traffic capacity of the first-class highway is greatly affected by lateral interference, it should be considered.

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5. Basic traffic characteristics of collection and distribution roads in the port area

5.1 The composition of road traffic in the port area

The composition of the collection and distribution roads in the port area is a typical mixed traffic flow of passenger and freight. The volume of freight traffic is large. Large freight vehicles account for a relatively high proportion of the traffic composition, which is obviously different from the general road traffic composition. The passenger vehicles on the collection and distribution roads are mainly cars, mainly to ensure the passenger transportation needs of the port office staff to commute to and from get off work, the cargo owner's declaration and contact business. Truck vehicles include container trucks, large and medium-sized trucks, trailers, etc., which mainly meet the freight demand of the port area.

As a typical mixed traffic flow of passenger and freight, there are big differences in vehicle types and speeds among cars, medium trucks, container trucks, large and medium trucks, and trailers in the road traffic composition of collection and distribution. Therefore, through the mutual interference of different vehicles, the performance of the road is affected, and the traffic capacity of the road is reduced.

5.2 Influencing factors of road freight transportation in port area

Collection and distribution freight vehicles serve the collection and distribution operations of port services. Since the operating cost of ships is higher than the cost of freight vehicles, in order to shorten the loading and unloading time of ships in ports, in actual port operations, port vehicles generally arrive one after another before the ship arrives at the port.

Collection and distribution road freight traffic is affected by factors such as port types, ship arrival rules, and land collection and distribution conditions. Such as:

5.2.1 Port throughput

Port cargo throughput is the source of freight transportation in collection and distribution ports. The greater the port throughput, the greater the demand for land collection and distribution transportation.

5.2.2 Ship arrival time

The arrival time of collection and distribution freight vehicles depends largely on the arrival time of ships.

5.2.3 Proportion of ship type

The proportion of ship types affects the time distribution of port cargo loading and unloading, and the arrival of large ships at the port will generate greater demand for land collection and distribution.

5.2.4 Average load of freight vehicles

The average load of different freight vehicles will produce different freight traffic. When the average load of freight vehicles is small, it will produce a larger amount of transportation in the port.

5.2.5 Road collection and distribution conditions

The land collection and distribution system of ports includes roads and railways, and the conditions of road collection and distribution will directly affect freight traffic.

5.3 Road traffic characteristics of collection and distribution

5.3.1 There are obvious differences between traffic volume characteristics and urban traffic

In urban roads, the monthly variation characteristics of traffic volume change with the seasons, the daily variation characteristics change with working days and non-working days, and the time-varying characteristics are obvious morning and evening peaks. For collection and distribution roads, the monthly change of traffic volume is generally related to the monthly uneven coefficient of the port throughput, the daily change is related to the arrival time of the ship, and the time change is based on the characteristics of port production operations and does not present morning and evening peaks.

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5.3.2 Affected by the port production process

The cargo traffic flow of the collection and distribution roads is mainly affected by the port throughput. The size of the port, the proportion of ship types, and the time of arrival of the ships determine the characteristics of the size and time of the road cargo traffic in the collection and distribution ports. Therefore, the road traffic of the collection and distribution roads is obvious. Receiving port production operations are driven.

5.3.3 Large vehicles account for a high proportion, and the type of vehicle is related to the type of terminal

The most important feature of the collection and distribution roads is the composition of the collection and distribution roads. Large and medium-sized freight vehicles, container vehicles, and trailers account for a large proportion of the traffic composition. Moreover, the types of vehicles have a greater relationship with the types of terminals. For example, container vehicles occupy a large proportion of the roads in the container port area.

5.3.4 Simple road network interface and few road types

Gathering and distributing roads mainly meet the traffic demand of gathering and distributing roads. Generally, ports are the only starting point or end point for freight vehicles, so the road network structure is relatively simple. Moreover, the traffic composition of the collection and distribution roads is generally dominated by freight vehicles, so the road type is relatively simple, generally expressways or first-class highways.

5.3.5 The purpose of freight transportation is clear, and the route selection behavior is simple

The transportation purpose of freight vehicles on the collection and distribution roads is clear. Generally, the collection and distribution roads directly reach the destination from the port or directly reach the port from the source of the goods, so the path selection behavior is relatively simple.

6. Road traffic simulation of collection and distribution in port area

6.1 Simulation model establishment

Suppose the ramp entrance of a port area is as shown in the figure below, and use VISSIM software to construct a model of the ramp entrance of the port area.

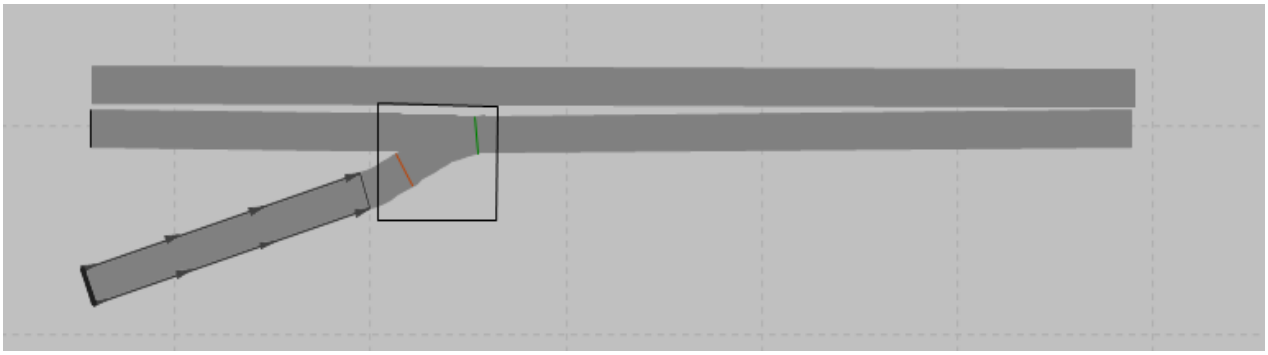

Figure 1. The ramp entrance of a port area

When building the model, a priority rule should be set up, that is, mainstream vehicles have priority over vehicles on the ramp, the minimum time neutral is 3 seconds, the minimum space neutral is 5 meters, and the maximum speed is 180 km/h.

6.2 Calibration parameters

When simulating the entrance of the collection and distribution ramp in the port area, different parameters should be calibrated for different situations, so that the simulation can better reflect the actual situation at the entrance of the collection and distribution ramp in the port area.

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6.3 Study Case

A wake-up simulation at the entrance of a collection and distribution ramp in a port area, the specific parameters are as follows:

(1) Traffic composition: according to the vehicle conversion factor, all converted into standard cars

(2) Design speed: mainstream speed: 80km/h; ramp speed: 60km/h.

(3) Traffic volume: mainstream traffic volume: 3000-3500pcu/h

ramp traffic volume: 500-1000pcu/h

The simulation results are as follows:

Table 3. The simulation results

Serial number	Mainstream traffic volume	Ramp traffic volume	Average vehicle delay		the length of queue	
			Mainstream	Ramp	Mainstream	Ramp
1	3000	1000	10.81	15.65	3.10	7.90
2	3100	900	10.18	16.43	2.37	8.83
3	3200	800	10.28	16.34	2.96	8.54
4	3300	700	8.91	15.36	2.76	3.37
5	3400	600	8.64	11.61	2.69	2.21
6	3500	500	7.05	9.76	1.30	1.74

According to the simulation results, in the different combinations of mainstream traffic volume and ramp traffic volume, the continuous increase of ramp traffic volume will not only affect the length of the ramp vehicle queue and the average vehicle delay, because of the factor of lane change. The queue length of mainstream vehicles and the average delay of vehicles will also increase. When the traffic volume on the ramp becomes larger and larger, the mainstream queue length will increase correspondingly, and the average vehicle delay will also continue to increase. When the mainstream traffic volume is much larger than the ramp traffic volume, the increase in the mainstream traffic volume will affect the corresponding reduction in the length of the vehicle queue on the ramp, and the average vehicle delay will also be correspondingly reduced.

7. Conclusion

Since the collection and distribution roads in the port area are completely different from the urban roads, when studying the collection and distribution roads, we cannot completely study it in the same way as urban roads. Compared with urban roads, trucks and container vehicles account for 90% of the total traffic composition in the collection and distribution roads in the port area. Therefore, the vehicle conversion coefficient is used to calculate the vehicles. The collection and distribution road in the port area has a simple structure and does not have too many intersections. When studying it, it can be compared with the expressway and the first-class highway according to the actual situation to obtain the corresponding capacity calculation formula. When simulating the entrance of the collection and distribution ramp in the port area, we must combine mainstream vehicles and ramp vehicles according to the actual situation to obtain the simulation results. The average delay of vehicles is obtained (because there is less pedestrian activity in the port area, the average pedestrian delay is generally not considered Delays) and vehicle queue time, so as to better reflect the actual situation of the roads in the port area.

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