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Research on Urban Road-Network Capacity Based on Traffic Big Data

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Abstract

Accurate and reliable urban road network capacity directly affects the adaptability and effectiveness of urban traffic planning and traffic management. At present, the research on road network capacity is based on theoretical models deduced from formulas, among which the time-space consumption method is the most widely used. However, the determination of various correction parameters by time-space consumption method needs on-site investigation and investigation, which is huge in workload and difficult to realize, so calculated road-network capacity has a large deviation. According to the flow-density-speed relationship and statistical methods, the work obtained the equations of road network capacity and real-time data such as the traffic density and road network speed using traffic big data. Besides, maximum road network capacity was obtained based on the capacity-density-speed function. The calculation method was applied to the actual urban road network to derive the time-varying graph of the capacity, density, and speed.

Keywords

Traffic big data; Road network capacity; Capacity-density-speed function; Statistics.

1. INTRODUCTION

The number of cars in China is increasing year by year with the continuous development of the social economy. The density and capacity of the existing urban road network can no longer meet the normal traffic of vehicles in the morning and evening peaks at present. Urban traffic planning in built urban areas needs to be changed from the traditional "four-stage" method to refined traffic planning and design and traffic demand management [2]. Therefore, the calculation of urban road-network capacity and related traffic flow characteristics such as the road network density and road network speed is the basis of fine traffic planning and traffic management decision-making. Therefore, the accuracy of road network capacity calculation directly affects urban traffic planning and traffic demand management.

At present, the methods for studying road network capacity mainly include the linear programming method [1], time-space consumption method [2], cut set method [3], traffic distribution simulation method [4], and supply analysis method [5]. Although all the above methods have their theoretical methods and calculation models, the calculated road network capacity is far from the actual one due to the defects of these models and the difficulty of calibrating various parameters, with its significance lost. The calculation of urban road network capacity and parameter calibration can be realized through the big data platform and Internet multi-source data with the development and application of big data and Internet multi-source

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data. The calculated results are true and reliable and can serve fine urban traffic planning and design and traffic management. In recent years, Ma Yingying [6], Xu Jianming [7], Rathore M M [8], Fan S S [9], Tsai J [10], Huang Tinghui [11], Duan Zongtao [12], Chen Zhaozheng [13] and others have done relevant research using the traffic Big data.

Road network capacity analysis has gone through three development stages, namely maximum network flow theory, microscopic traffic flow model, and the macroscopic fundamental diagram (MFD)based on the road network [14] (see Table 1).

Table 1 Development course of research on road network capacity

Method classification	Research object	Research idea	Representative research results
Based on the maximum network flow theory	Road sections, intersections, and simple road networks	Traffic capacity analysis, graph theory, etc	[15-18]
Based on the microscopic traffic flow model	Maximum road network capacity	User equilibrium traffic distribution, route selection model, and sensitivity analysis	[19-23]
Based on the road network MFD method	Theoretical road-network capacity	Variational theory, and the theoretical curve of MFD of road network homogeneity	[24-28]
	Actual road-network capacity	Qualitative empirical analysis and traffic simulation	[29-30]
		Relationship between trip completion and the number of existing vehicles, and expansion of trajectory data	[31-34]

Urban road network capacity is not a simple superposition of the capacity of each road section. As there are intersections and interchanges connected between each road section, traffic delays exist at these nodes, especially at plane intersections. Therefore, the node types at the nodes should be reduced (see Fig. 1).

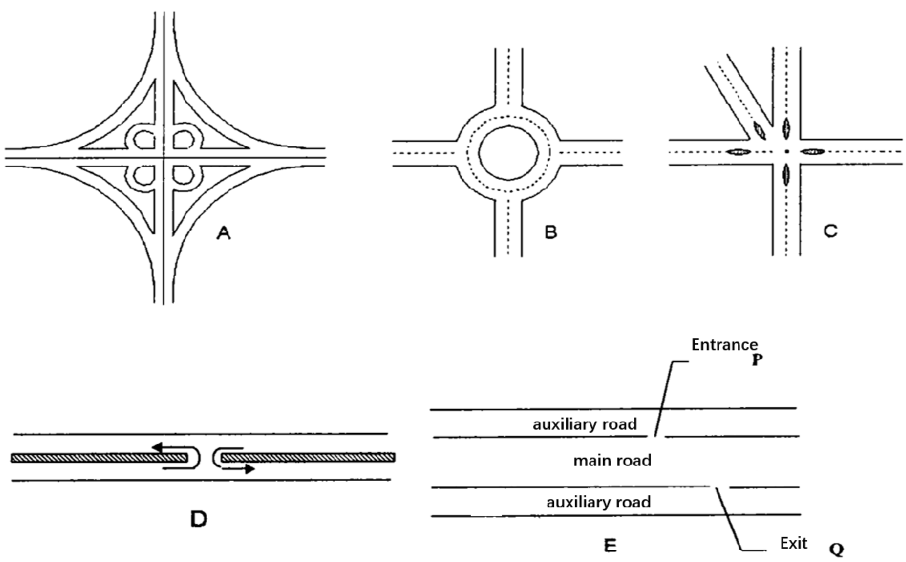

Figure 1. Road-node type

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Based on the flow-density-speed function of road sections [9], the work deduced the equation of the relationship among optimum flow, density, and speed. The road network capacity-density-speed function was established to obtain the theoretical equation for calculating road network capacity. Finally, the "peak graph"[5] of road network capacity and optimal road network traffic density and that of the road network traffic density and optimal road network speed are obtained through the average optimal traffic density and the average optimal road network speed obtained through big data platform. There is a peak-value correspondence problem between road network capacity and road network traffic density (the actual number of vehicles given by the network). The two are the same when the road is smooth, and vice versa. The peak value is the required road network capacity at this time.

2. ROAD NETWORK CAPACITY

Road network capacity is a concept extended from traffic capacity [24]. According to the constraint conditions, research on road network capacity can be divided into two categories: narrow road network capacity and generalized road network capacity.

Narrow road network capacity: The maximum flow of people and vehicles that may pass through the urban road network per unit time.

Generalized road network capacity: The number of travelers and travel traffic individuals that may be accommodated in the urban road network under various constraints in a certain period [25].

Road network capacity is the maximum number of vehicles that the whole urban road network can serve in calibrated time as the research object, which is defined as follows. Travelers follow Wordrop's first principle (optimal for users optimum) [26] to freely and reasonably choose the path with the lowest travel cost (generalized cost) and the means of transportation. Road network capacity corresponds to the maximum number of vehicles that the urban road network can serve when road network distribution is reasonable and the road network density and speed are optimal under the actual road traffic conditions. The urban road network is in the optimal running state at this time. The road network capacity has temporal and spatial characteristics. Different time windows correspond to different optimal capacities, and different cross-sections correspond to different optimal capacities. Therefore, road network capacity should be a function of time and space.

Based on the total traffic benefit, the maximum capacity in one day is adopted as the measurement index of road network capacity. It is difficult to describe the optimal state of the whole road network by traffic flow. If the road network capacity index is replaced by the average optimal traffic flow density and the average road network speed index, the maximum capacity is

$$\mathrm{C}_{\max}=K_m\times V_m\times T\times L \tag{1}$$

where $\mathrm{C}_{\max}$ is the maximum total road network capacity, pcu.km; k_m the average optimal traffic density under the corresponding maximum road network capacity, pcu/km; v_m the average road network speed under the corresponding maximum road network capacity, km/h; T the time length taken to calculate the maximum road network capacity, h; L the total length of all motor vehicle lanes in the road network, km.

3. CAPACITY-DENSITY-SPEED FUNCTION

According to the traffic flow theory, the three parameters of road section traffic flow are flow, density, and speed. The work analyzed the relationship among the three major parameters of

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traffic flow in the road section. The sample was analyzed by the least squares method to obtain the relationship between the sample and the parameters. Then the relationship among road network capacity, road network density, and road network speed was derived. Finally, the optimal density and speed of the road network were obtained using traffic big data to directly calibrate road network capacity.

3.1. Flow-density-speed function of road sections

Traffic flow can be regarded as a particle fluid composed of vehicles (means of transportation) in the traffic flow theory [27]. Like other fluids, traffic flow, density, and speed are the three major elements describing the basic characteristics of traffic flow, and they are interrelated and mutually restricted. The relationship among them is as follows.

$$Q = K \cdot V \tag{2}$$

where Q is flow, pcu/h; K the density, pcu/km; V the speed, km/h.

The relationship between speed and density is deduced from the Greenshields model (linear model).

Assume a linear relationship:

$$V = aK + b \tag{3}$$

When K=K_j, V=0; when K=0, V=V_f.

$$\begin{cases} 0 = a \cdot k_j + b \\ V_f = a \cdot 0 + b \end{cases} \tag{4}$$

Eq. (4) is used to obtain $a = \frac{V_f}{K_j}$ and b=V_f. The results are substituted into Eq. (3) to obtain

$$V = V_f - \frac{V_f}{K_j} \cdot K = V_f\,(1 - \frac{K}{K_j}) \tag{5}$$

Eq. (5) is substituted into Eq. (3) to obtain

$$K = K_j(1 - \frac{V}{V_f}) \tag{6}$$

Eq. (5) is substituted into Eq. (2) to obtain

$$Q = V_f(K - \frac{K^2}{K_j}) \tag{7}$$

Eq. (6) is substituted into Eq. (2) to obtain

$$Q = K_j(V - \frac{V^2}{V_f}) \tag{8}$$

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According to Eq. (6), the relationship between flow Q and density K is quadratic parabola. When K=0 and Q=0, the curve passes through the origin of the coordinates. The relationship between flow Q and speed V is also quadratic parabola. When V=0 and Q=0, the curve passes through the origin of the coordinates. Therefore, there is the following relationship:

$$\frac{dQ}{dK} = 0 \text{ and } K=\frac{1}{2}K_j=K_m \tag{9}$$

$$\frac{dQ}{dV} = 0 \text{ and } V=\frac{1}{2}V_f=V_m \tag{10}$$

Eqs. (9) and (10) are substituted into Eq. (2) to obtain

$$Q_m=\frac{1}{4}V_f \cdot K_j \tag{11}$$

When $K<K_m$, the traffic flow density is less than the optimal traffic flow density. Traffic flow is free-driving, and the average speed is high. The traffic volume does not reach the maximum, the density and traffic volume increase.

When $K= K_m$, the traffic density is close to or equal to the optimal traffic density. Traffic flow has a car-following phenomenon, and the speed is limited. All kinds of vehicles are close to a certain speed and run at the same speed, and the traffic volume reaches the maximum.

When $K>K_m$, the traffic density is greater than the optimal density, and the traffic is in a congested state. As the traffic density increases gradually, the speed and traffic volume decrease simultaneously. The traffic is blocked, or even vehicles are stopped.

3.2. Road-network capacity-density-speed function

The flow-density-speed function of road sections shows that road-section flow depends on the traffic density, and the speed and the traffic density are linear. When the road section traffic density is optimal, road section flow reaches the maximum, and the corresponding traffic capacity is also the maximum. The optimal traffic density of each section is different in a road network of an urban area due to intersections and jammed road sections (see Fig. 2). Therefore, a model can be established to divide roads in the road network into n road section units, and each road section unit has its corresponding optimal traffic density and maximum traffic flow.

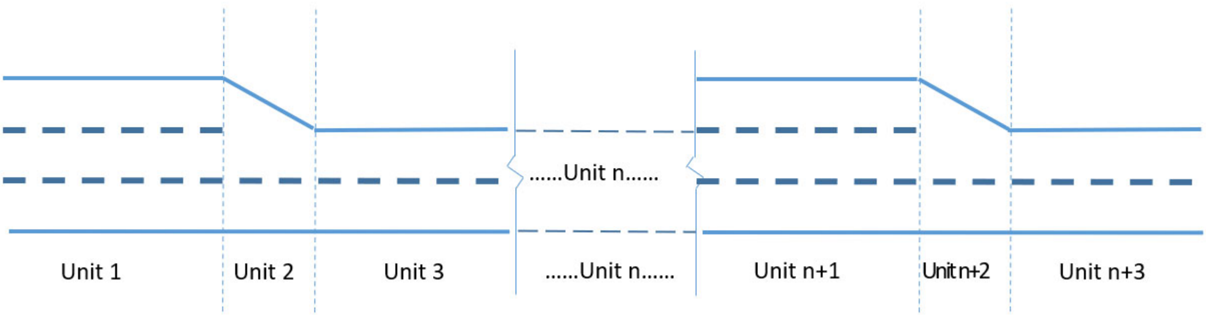

Figure 2. Road section unit division

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The calculation model of the whole road network capacity is established on this basis (see Fig. 2). Eq. (1) shows that road network capacity $C_{max}=K_m \times V_m \times L \times T$, and the capacity of each road section unit is $C_i=K_{mi} \times V_{mi} \times L_i \times T$. Assuming that the whole road network is in a certain period, the calculation equation of road network capacity is as follows.

$$C_{max}=\sum_{i=1}^{n} k_{mi} \times v_{mi} \times l_i \times t \tag{12}$$

According to Eq. (12), whole road network capacity can be obtained by the optimal traffic density of each road section unit, the corresponding traffic speed, and the length of road sections. If the sample data of each vehicle in each road section is observed, optimal traffic density K_m, corresponding traffic speed V_m, free flow speed V_f, and jam density K_j of each road section can be obtained with the least square method as follows:

Based on the Greenshields model (linear model), $V = \alpha + \beta K$, and the least square method is used.

Assuming $M=\sum_{i=1}^{n}(V_i-v_i)^2$ $\because V_i= \alpha_i + \beta_i K_i \therefore M=\sum_{i=1}^{n}(\alpha_i + \beta_i K_i-v_i)^2$

$$\begin{cases} \frac{\partial M}{\partial \alpha_i} = 2\sum_{i=1}^{n}(\alpha_i + \beta_i k_i - v_i) = 0 \\ \frac{\partial M}{\partial \beta} = 2\sum_{i=1}^{n}(\beta_i k_i - \beta_i v_i - \alpha_i k_i) = 0 \end{cases} \tag{13}$$

$$\Rightarrow \alpha_i=\frac{1}{n}\sum_{i=1}^{n} v_i - \beta_i \frac{1}{n}\sum_{i=1}^{n} k_i \tag{14}$$

Eq. (14) is substituted into Eq. (13) to obtain

$$2\sum_{i=1}^{n}\left(\frac{1}{n}\sum_{i=1}^{n} v_i - \beta_i \frac{1}{n}\sum_{i=1}^{n} k_i + \beta_i k_i - v_i\right)= 0$$
$$\Rightarrow \frac{1}{n}\sum_{i=1}^{n} k_i \cdot \sum_{i=1}^{n} v_i - \beta_i \frac{1}{n}\left(\sum_{i=1}^{n} k_i\right)^2+\beta_i \sum_{i=1}^{n} k_i{}^2-\sum_{i=1}^{n} k_i\, v_i = 0$$
$$\Rightarrow \beta_i = \frac{n\sum_{i=1}^{n} k_i v_i-\sum_{i=1}^{n} k_i \sum_{i=1}^{n} v_i}{n\sum_{i=1}^{n} k_i^2-(\sum_{i=1}^{n} k_i)2} \tag{15}$$

Based on Eqs. (5), (6), (14), and (15),

$$v_{mi}= \frac{1}{2} v_{fi} = \frac{1}{2}\alpha_i, \tag{16}$$

$$k_{mi}= \frac{\alpha_i}{\beta_i} \tag{17}$$

Eqs. (16) and (17) are substituted into Eq. (12) to obtain road network capacity.

$$C_{max}=\sum_{i=1}^{n} \frac{\alpha_i}{\beta_i} \times \frac{1}{2}\alpha_i \times l_i \times t \tag{18}$$

a_i and β_i of each road section unit can be easily obtained through big data analysis and fitting, and whole road network capacity can be obtained according to Eq. (18).

4. CALCULATION OF ROAD NETWORK CAPACITY BASED ON TRAFFIC BIG DATA

Parameters k_m and v_m of each road section unit are calibrated to obtain the maximum whole road network capacity. Then Eq. 17 is used to get road network capacity. If the traditional method of collecting data on the spot is used, the workload is too huge to achieve it. The development of big data and informatization has provided new opportunities and scientific means for urban transportation research [28]. Profound changes occur to the transportation system and are mainly manifested in the development of information collected from single data sources to multi-department data integration, data analysis from traditional data processing to deep mining of big data, decision support from basic data statistics to intelligent decision support, and information release from passive query service to comprehensive, active and personalized service [29]. Therefore, it is necessary to avoid the distortion and confusion of the calibration of the network traffic speed function based on the difference and connection of the traffic flow speed between time and space. The traffic operation status should be defined to calibrate the parameters of the network traffic speed function based on the traffic big data platform.

Parallel collection of traffic big data can obtain the time and space of vehicles through the synchronous transmission of moving vehicle traffic information cards (uniformly installed by DMV) and GPS real-time information collection (mobile phones and vehicle networking) [30]. Besides, the real-time speed of traffic flow can be obtained through calculations. The traffic flow density can be extracted from the macroscopic fundamental diagram of the traffic flow density corresponding to different traffic states to obtain the "time axis diagram" of traffic flow density and traffic flow speed in the road network. The "bimodal diagram" of the traffic benefit index can be obtained after standardizing the two indices and superimposing them into one diagram. There is a peak-value correspondence problem between the traffic benefit and traffic density (the actual number of vehicles given by the network).The two are the same when the road is smooth, and vice versa. The corresponding peak value in the bimodal diagram is the required road network capacity at this time.

5. EXAMPLE APPLICATION

According to the deduction of the theoretical equation and calibration of big data parameters, the maximum capacity of road sections and road networks can be obtained. Data came from Guangzhou Municipal Transportation Bureau. The optimal cross-section flow of each road section was calculated by taking seven main roads in Guangzhou as examples, and the 24-h data of road sections were collected on June 22, 2021 (Tuesday) for calculations.

The seven main roads are Linjiang Avenue, Huangpu Middle Avenue, Huacheng Avenue, Xingang West Road, Gongye North Avenue, the middle section of Guangzhou Avenue, and Liede Avenue. Linjiang Avenue and Huacheng Avenue are two-way six lanes. Xingang West Road, Liede Avenue, and Gongye North Avenue are two-way eight lanes. The middle sections of Guangzhou Avenue and Huangpu Avenue are two-way 10 lanes. The lane width of 7 main roads is 3.5 m, and those of the other 5 main roads are all 3.25 m except for Liede Avenue and Huangpu Middle Avenue. The optimal cross-section capacity of each road section is calculated. The 24-h time-varying diagrams of the traffic density, traffic speed, and cross-section capacity of road sections are given below by taking the middle section of Guangzhou Avenue (from south to north) and Linjiang Avenue (from west to east) as examples.

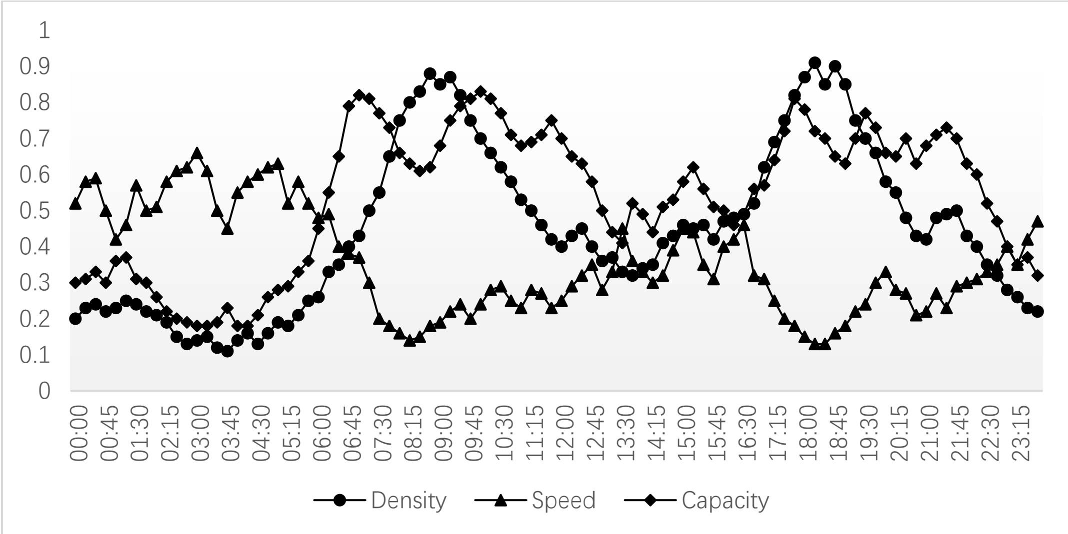

Figure 3. 24-h Time-varying diagram of traffic parameters in Guangzhou Middle Avenue (from south to north)

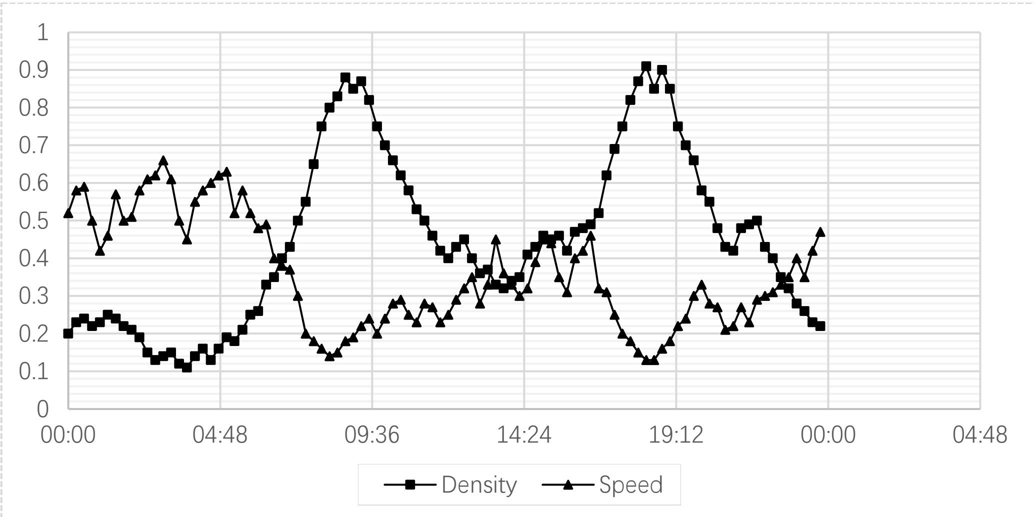

Figure 4. 24-h Density-speed correlation trend of Guangzhou Middle Avenue (from south to north)

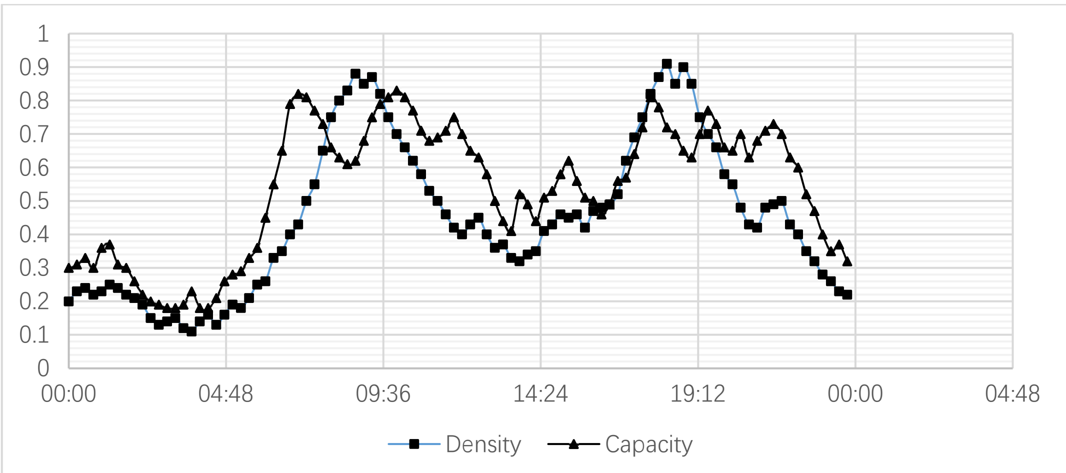

Figure 5. 24-h Density-capacity correlation trend of Guangzhou Middle Avenue (from south to north)

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Fig. 3 shows the 24-h change trend of the traffic density, traffic speed, and cross-section capacity of Guangzhou Avenue. The traffic density of Guangzhou Avenue (from south to north) reaches the maximum at 8:45 and 18:30, and reaches the minimum at around 3:30. The changing trend of the traffic flow speed shows that the traffic flow speed reaches its maximum at around 3:00 am. When the traffic flow speed is free flow speed Vf of road sections, the cross-section capacity of road sections reaches its maximum at 6:45, 9:45, 17:30, and 19:30, respectively. Fig. 5 shows the 24-h Density-speed correlation trend of Guangzhou Middle Avenue (from south to north).

The trends of parameters 4.1-4.3 are combined to obtain conclusions consistent with the traffic flow characteristics: when the traffic flow speed reaches maximum value V_f for a speed-density relationship, the corresponding traffic flow density is the minimum. That is, the speed peak corresponds to density trough. When the traffic flow speed reaches optimal traffic flow speed V_m, the corresponding traffic flow density reaches optimal traffic flow density K_m. When the traffic flow speed reaches the minimum value, the corresponding traffic flow density is the jam density, that is, speed trough corresponds to the density peak. When the traffic density is minimum, the corresponding road section capacity is minimum; when the traffic density is optimal, the corresponding road section capacity is maximum.

Optimal traffic speed V_m and optimal traffic density K_m of road sections obtained by Fig. 4 are substituted into Eqs. 2.15, 2.16, and 2.17 to derive parameters α and β and the cross-section capacity of road sections. The parameters of the seven main roads are listed (see Table 2).

Table 2 Calculation of traffic flow parameters of each main road

Road name	Optimal density K_m,	Optimal speed V_m,	Free flow speed V_f,	Number of lanes	Width of lanes,	Parameter α	Parameter β
	pcu/km	km/h	km/h	Nos.	m		
Linjiang Avenue (from west to east)	32.6	35.7	52.3	3	3.25	52.3	1.60429
Huangpu Middle Avenue (from west to east)	78.3	38.4	65.6	5	3.5	65.6	0.83780
Huacheng Avenue (from east to west)	42.2	32.1	58.6	3	3.25	58.6	1.38863
Xingang West Road (from west to east)	44.8	34.6	55.9	4	3.25	55.9	1.24777
Gongye North Avenue (from south to north)	39.5	36.5	53.1	4	3.25	53.1	1.34430
Middle section of Guangzhou Avenue (from south to north)	68.9	33.4	64.8	5	3.25	64.8	0.94049
Liede Avenue (from south to north)	62.7	37.2	61.1	4	3.5	61.1	0.97448

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Table 3 Calculation of maximum cross-section flow of each main road

Road name	Linjiang Avenue (from west to east)	Huangpu Middle Avenue (from west to east)	Huacheng Avenue (from east to west)	Xingang West Road (from west to east)	Gongye North Avenue (from south to north)	Middle section of Guangzhou Avenue (from south to north)	Liede Avenue (from south to north)
Maximum cross-section flow, pcu/h	1,163.8	3,006.7	1,354.6	1,550.1	1,441.8	2,301.3	2,332.4
Number of lanes, m	3	5	3	4	4	5	4

Tables 2 and 3 show that the more lanes are, the greater the maximum cross-section flow is. The cross-section flow of 5one-way lanes is significantly larger than that of 4 and 3 lanes. However, the influencing factors of the cross-section flow of road sections do not completely depend on the number of lanes. For example, the middle section of Guangzhou Avenue and Huangpu Middle Avenue are both 5 lanes. However, flow on Huangpu Avenue is much larger than that in the middle section of Guangzhou Avenue, which is closely related to the number of signalized intersections of road sections, roadside influence, and interference. The cross-section flow of Xingang West Road, Gongye North Avenue, and Liede Avenue with 4 lanes is also quite different because both Xingang West Road and Gongye North Avenue have bus lanes and the impact on flow is self-evident.

The work calculated the cross-section flow of road sections and the road network capacity of six districts in Guangzhou through big data. Similarly, 24-h road network data were collected on June 22, 2021 (Tuesday).

The six districts are the road networks of Liwan District, Yuexiu District, Tianhe District, Haizhu District 1#, Haizhu District 2#, and University Town. LiwanDistrict road network is surrounded by Nan'an Road, Huangsha Avenue, Renmin Road, and Dongfeng West Road, with an area of 6.75 km^2.Yuexiu District road network is surrounded by Jiefang North Road, Jiefang Middle Road, Yanjiang Middle Road, Huanshi Middle Road, and Yuexiu North Road, with an area of 5.13 km^2. Tianhe District road network is surrounded by Guangzhou Middle Avenue, Guang Yuan Expressway, South China Expressway, and Linjiang Avenue, with an area of 16.42 km^2.Haizhu District 1# road network is surrounded by Guangzhou South Avenue, Binjiang Road, and Gongye Avenue, with an area of 20.78 km^2.Haizhu District 2# road network is surrounded by Jianghai Avenue, Xinjiao Middle Road, Keyun Road, and Yuejiang Road, with an area of 12.36 km^2. The area of University Town road network is 15.83 km^2.

Table 4. Traffic parameters of road network in each district

Road network name	Average optimal density K_m,	Average optimal speed V_m,	Average free flow speed V_f,	Density standard deviation n	Total road area,	Total length of lanes,
	pcu/km	km/h	km/h		km^2	km
Liwan District road network	253.7	30.6	54.47	0.812	0.91125	276.14
Yuexiu District road network	197.4	28.8	52.13	0.784	0.72333	222.56
Tianhe District road network	266.3	27.1	49.59	0.816	2.15102	642.10
Haizhu District 1#road network	290.2	33.7	56.95	0.709	2.55594	751.75
Haizhu District 2#road network	321.6	32.3	57.17	0.718	1.59444	490.60
University Town road network	276.7	37.4	61.71	0.633	0.98146	286.14

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Table 5. Calculation of road network capacity in each district

Road network name	Liwan District road network	Yuexiu District road network	Tianhe District road network	Haizhu District 1#road network	Haizhu District 2#road network	University Town road network
Maximum road network flow, pcu/km	779,530	496,195	1,643,202	2,526,423	1,763,378	1,010,629

Tables 4 and 5 show that Haizhu District 1# has maximum road network capacity, while Yuexiu District has minimum road network capacity. There is a direct connection between road network capacity and the total length of lanes in the district, which shows a positive correlation. However, the influencing factors of road network capacity also include road grade, the number of intersections with good signals, road bottlenecks, etc. For example, the total lane length of University Town road network is close to that of Liwan District road network, but the road network capacity of University Town is significantly larger than that of Liwan District. As University Town road network belongs to a newly-built district, the road grade and road network rationality in the district are higher than those of Liwan District road network. Therefore, road network capacity is significantly higher than that of Liwan District.

The higher the average optimal speed is, the larger the road network capacity is. The average optimal speed reflects the rationality of the regional road network, the more reasonable the road network structure, the higher the optimal average speed. The density standard deviation reflects the road network utilization rate. The higher the road network utilization rate is, the lower the density standard deviation is [31]. If the density standard deviation is higher, structural problems will occur in the road-network utilization rate in the district and are usually manifested in part of congested roads and other unblocked roads. Besides, the densities of each road section is quite different. Therefore, it is reasonable and efficient to use traffic big data to obtain the average optimal density and the average optimal speed of the road network to calibrate road network capacity, which avoids the tedious calculation and the difficulty in measuring data of traditional methods [35-36].

6. CONCLUSION

According to the Greenshields model (linear model), the work deduced the flow-density-speed relationship and obtained the capacity equation of the whole road network with a statistical method. Obtaining optimal density K_m and optimal speed V_m of the whole road network is challenging with traditional methods, but they can be easily obtained through traffic big data. At present, traffic big data has been widely used in various traffic management platforms and Internet software, so it is feasible to obtain real-time traffic data and parameters such as traffic density and road network speed using traffic big data.

According to the capacity-density-speed function, maximum road network capacity was obtained by traffic big data. The calculation method was applied to the actual urban road network to obtain the density-speed correlation chart, density-capacity correlation chart, and time-varying diagram of capacity-density-speed. The relationship among the capacity, density, and speed accorded with the Greenshields model (linear model) in actual traffic operation.

As the basic layer of traffic planning and decision management, road network capacity calculation is very complex. At present, the mainstream research on road network capacity is based on theoretical models deduced from equations, among which the time-space consumption method is the most widely used. However, the determination of various correction parameters by time-space consumption method needs on-site investigation and investigation,

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which is huge in workload and difficult to realize, so calculated road network capacity has a large deviation [32].

The acquisition of traffic big data makes traffic planning and traffic analysis simple and accurate with the development of the Internet and big data. Traffic flow theory was applied to the whole road network. The whole road network capacity could be calculated with the average optimal density and the average optimal speed of the road network. It considered instantaneous flow and the temporal and spatial characteristics of the whole road network and avoided the tedious correction calculation brought by various nodes in the road network. However, when the current road network capacity in some districts was not the maximum, the maximum road network capacity needed to be fitted and predicted according to big data, and some errors might occur with the actual situation. Therefore, the work is more suitable for calculating road network capacity in the district where urban traffic flow is saturated.

Using traffic big data to calibrate the maximum road network capacity is of progressive significance, which can avoid tedious traffic parameter investigation and correction of various parameters in the traditional calculation process. Real-time and dynamic data are directly provided by the big data platform [33], which can obtain important traffic parameters such as the maximum capacity, the optimal speed, and the optimal density of the road network. The above-mentioned three traffic parameters are the basic data of many traffic predictions and planning.

Accurate and fast access to these data can improve the fineness of traffic forecasting and planning as well as the accuracy of formulating traffic policies and measures. Therefore, the method can be used to optimize the urban traffic structure and formulate corresponding traffic policies and measures for built urban areas, especially urban areas where the traffic volume is already greater than the maximum road network capacity. It can also be used for a series of studies such as refined traffic planning and parking lot capacity prediction.

7. DECLARATION OF CONFLICTING INTERESTS

The authors declared that there was no conflict of interest in the paper.

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