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Motor Vehicles Parking Index for Middle School

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Abstract:

In order to resolve the problem that current parking index of Middle School is not clear, by investigating the present parking situation of Fuzhou Middle school, got the conclusion that the decisive factors of parking index of Middle Schools are urban motorization level, school location, the scale and composition of school teachers and students. Parking index's computation model was introduced and the correction coefficient model of parking index, the correction coefficient and steps to determine the value of the parking index was put forward. The model was verified by using measured data in Fuzhou and the recommendations parking index was gave.

Key words： parking index;middle school;location condition; correction coefficient

1 Introduction

In recent years, as teachers choose to move outside, the number of cars increases and social interaction becomes more and more frequent at school, parking problems become more and

more serious in middle school. At the same time, as the ceaseless improvement of living standard and the acceleration of urbanization, more and more parents help their children select a school to read, carry their children to school, which make parking problems more outstanding. Teaching and administrative staff and students study and live on the campus, their activity are relatively independent and frequent with outside. The parking facility on campus is one important part of city parking facilities; its functions are terminal parking (self-owned parking) and social parking which gives consideration to travel process. The formation and accumulation that lack of middle school parking space, is due to the low standard of parking index in the process of city building, and the underestimation of development of vehicle quantity. Facing important opportunity of current urban development and important transition of transportation development, it is the key to solve middle school parking problems that grasp the vehicle development and urban construction characteristics, further strengthen and deepen the middle school parking index system, and improve construction of parking facilities.

There are much research have done about parking index. Institute of Transportation Engineers[1-2] studied the parking demand and parking index for all types of building based on a large survey in USA.Goyal et al[3] presented a linear programming model for determining the optimum allocation of existing car parking facilities for different classes of users within a closed community.Young et al.[4] developed model groupings by relating their main objectives: choice, allocation and interaction models.Wong et al[5] described the parking demand models for private cars and goods vehicles developed as part of a parking demand study.Ma[6] analyzed the demand of the parking influences factors,list building motor vehicle construct revision of standard calculate formula.Ibeas et al[7] used multiple linear regression and geographically weighted regression models for estimating parking demand in areas with paid short stay parking systems.Li et al[8] combined with analysis of location condition attributes, established parking index method based on the parking function division and location conditions.Boamah[9]designed an economic model of parking behavior to consider the relationship between costs and benefits in meeting parking demands of the range of users on an urban university campus.Stasko et al[10]analyzed the impact of carsharing on parking demand in a university setting using a member survey and parking permit sales data.

2 Main influence factors of middle school parking index

2.1 City motorization level

Motorization is the process of increasing of motor vehicles' quantity. Motorization has different performances in different countries, regions, cities, and different development stages. The differences are mainly due to the different means of mainstream motorization. Fuzhou is in a period of rapid urbanization, and because of the economic growth, land using extends to three-dimensional direction and horizontal direction, intensive land use are common and types are complex. However, the parking space are limited in city, so the supply of parking facilities will slow down, but this period is still the main stage of parking facilities development.

Middle school parking primarily depends on the building parking space, and the parking index directly determines the supply number of building parking space. The supply of parking space is great while the level of urbanization is high. As the important part of city building parking, middle school parking also needs to consider city motorization level factors.

2.2 School location

Traffic location refers to the geographical high frequency (or high probability) place of traffic phenomena. In the city, the different functions and properties of land using make up the urban productivity layout and structure system. In such a system, the land using of different locations proceeds different properties and frequencies of social, economic and cultural activities, and shows different parking demand. Because of the different location of middle school, there are great space distribution differences caused by different parking demand.

Different location that middle school located has different economic strength, and this will influence parking index in a certain extent. In different geographical position of a city, if don't consider locations' differences in a certain time and only consider economic strength influence to parking index in peak time, the relationship between the economic strength and parking index are as follows:

(1) The economic strength in downtown is strongest, the demand of parking space is highest, and parking index should be the highest.

(2) The economic strength in the edge of downtown is stronger, the demand of parking space is higher, and parking index should be the higher.

(3) The economic strength in suburb is weak, the demand of parking space is low, and parking index should be the low.

2.3 Scale and composition of middle school

In recent years, with increase enrollment and expansion of middle school, teachers and students' scale is also on the rise, and parking demand should be also improved. The number of teachers in a certain extent directly reflects the school parking demand situation. On the other hand, in order to ensure the safety of the children travel, some families use private cars to pick up their children. When going school and after school, there is a great impact on the dynamic traffic around school. The situation will aggravate with the process of urban development and the increase of vehicle population.

In addition, because of rich education resource, some middle schools often hold some education meetings, visit, competitions and other activities. All of these need more parking resource to meet outside parking demand.

3 Calculation model of middle school parking index

The key of middle school parking index is to determine the parking demand of middle school. The demand and user of parking are relatively fixed in middle school, mostly use for the school staffs parking and parents temporary stop to pick up their children.

3.1 Middle school parking demand calculation

At present, for single use of land, parking demand is mainly analyzed by the single factor analysis method. One of the most representative methods is Technical Council Committee (ITE) method[2]. For all kinds of buildings' parking demand and parking index, ITE carry out detailed and continuous research. For decades, ITE published "Parking Generation" according to the accumulation of large-scale sample data. Its parking demand formula is:

$$P = f(S) \qquad (1)$$

Where: P=building parking demand;S=land use index which best relates with building (such as building area, number of jobs, number of seats); $f(*)$=regression equation.

According to formula(1), the calculation of middle school parking demand mainly considers the number of students. The investigation of Fuzhou middle school parking situation shows that motor vehicles parking of middle school consist of school staffs parking and outside parking, so Formula (1) is revised to get the formula of middle school peak hour parking demand:

$$P_0 = W_1 \times L \times \alpha + W_2 \times M \times \beta \quad (2)$$

Where: P_0=motor vehicles parking demand in peak hour of middle school;W_1=building area;L=average number of teachers and students per building area; α =percentage of motor vehicles that parents use to pick up students and teachers use to travel among all the teachers and students in peak hour;W_2=using area;M=the number of attracted motor vehicles in peak hour per area; β =percentage of non taxi among the attracted motor vehicles.

3.2 Correction factor of middle school parking index

With the development of social economy, urban education facilities improve in all aspects. But due to the limitation of land and building in downtown, parking space often can't satisfy school staffs' parking demand. For the middle schools that have high teaching level, when after school, the demand of parking space is increase to a high value. The parents often park on the side of the road to wait for students, and this will cause adverse effect to urban traffic. According to the main influence factors of middle school parking index, put forward the correction model:

$$P = Y_1 \times Y_2 \times Y_3 \times P_0 \quad (3)$$

Where: P=correction middle school building parking space in peak hour;Y_1=city motorization level influence coefficient;Y_2=school location influence coefficient;Y_3=scale and composition of middle school influence coefficient.

（1）quantization of city motorization level influence factor

The increase of motor vehicle quantities improves city motorization level, and inevitably leads to the explosion of parking demand. At the same time, the increase of parking space supply will further stimulate the increase of motor vehicles, especially family cars. And vice versa, both present a kind of relationship that mutual promotion and interdependent, as shown in Fig.1[11].

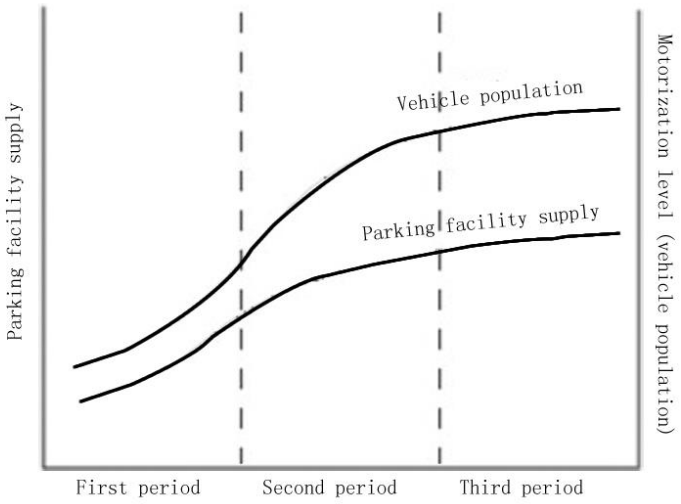

Fig.1 Relationship between motorization level and parking facility supply

According to the statistics of motorization level of Fuzhou and parking facilities supply condition in recent years, the motorization degree of Gulou downtown is highest, and parking facilities supply is stable, that is, in the end of the second phase in Fig.1. Fig.1 shows that the relationship between motorization level and parking space supply is fixed in the period, and motorization level influence coefficient is 0.95-1.0.

The motorization level and parking facilities supply of edge of downtown grows rapidly such as Cangshan, that is in the early of second phase in Fig.1. The relationship between motorization level and parking space supply distance gradually in the period, and motorization level influence coefficient is 0.90-0.95.

The motorization level and parking facilities supply of suburb grows rapidly such as Fuzhou university town, that is, in the end of first phase in Fig.1. The motorization level influence coefficient is 0.85-0.90.

（2）quantization of school location influence factor

Due to the limitation of land and building in downtown, campus parking space in downtown is far lower than the edge of downtown and suburb campus parking space. Many middle school build new campus in the edge of downtown or suburb for the limit of land use in downtown, and the new campus isn’t convenient in transportation, the proportion of school staffs that choose to drive private car and parents pick up their children by car is greatly increased. Therefore, all these factors should be taken into account when determining the influence coefficient of middle school parking index, so as to attract the development of the edge of downtown and suburb.

According to parking sample survey of 5 middle schools in downtown, edge of downtown and suburb in Fuzhou, school location influence factor in downtown is 0.9-1.0 for the limitation of land use; school location influence factor in the edge of downtown is 1.1-1.2 for the development of new town; school location influence factor in suburb is 1.2-1.3 because the land use is enough when building new campus.

（3）scale and composition of middle school influence factor

According to parking sample survey of 15 middle schools in Fuzhou, the proportion of school staffs that choose to drive private car and parents pick up their children by car is high when the scale of the middle school is big and education resources is rich. Middle schools in downtown have rich education resource and often hold some education meetings, visit, competitions and other activities. But for the limitation of their scale, the influence factor is 0.9-1.0; the edge of downtown's influence factor is 0.9-1.0 for the large scale of middle school; the suburb's influence factor is 0.8-0.9 for the small scale of middle school.

The recommended value of coefficient is shown in Tab.1.

Tab.1 The recommended value of coefficient

	Downtown	Edge of downtown	suburb
city motorization level influence coefficient Y_1	0.95-1.0	0.9-0.95	0.85-0.9
school location influence coefficient Y_2	0.9-1.0	1.1-1.2	1.2-1.3
scale and composition of middle school influence coefficient Y_3	0.9-1.0	0.9-1.0	0.8-0.9

3.3 Relation between parking supply and demand

Generally, the downtown will try to meet the parking demand, and then take a series of parking policy and management to control and adjust parking demand. So introduce parking policy and management parameter, in addition, consider the using characteristic of the parking facilities, the relation between parking facilities supply and demand can express as follow [12]:

$$P_x = \frac{P \times a}{t \times b} \qquad (4)$$

Where: P_x=theory supply scale of parking demand (standard parking space);P=correction parking demand in peak hour of middle school;a=parking policy and management parameter;t=parking turnover ratio in peak hour(packing space/h);b=average parking space

occupancy.

3.4 Steps of parking index determination

After correlation test, analyze survey results of middle school parking demand survey samples; calculate maximum, minimum and average parking producing rate, and other important indexes. Considering different location of middle school, the number of school staffs and students and other factors, its parking demand is also different and the data is discrete. As a control index to directly determine parking supply, the value of parking index should take different parking producing rate into account. Then use above formula to calculate parking index of different location.

4 Suggestion for middle school parking index in Fuzhou

According to the interaction mechanism of parking demand and supply, in a certain parking demand, parking supply satisfaction will stimulate more potential demand and require more parking supply, and a large number of parking facilities will bring a series of problems; but if parking supply is at a low level, and not with the effective management measures, will lead to violate parking that parking on the road. It not only affects the traffic flow, but also impacts on development of regional economy. Therefore, the parking index recommended value should not contain the supply and cause excessive supply shortage. Middle school parking demand should keep moderate scale, match with demand management and realize the low levels of parking supply and demand balance.

Base on the survey and analysis of middle school parking demand in Fuzhou, fully take examples from revised experience of Shenzhen, Nanjing, Hangzhou and other city parking index, put forward middle school parking index recommended value in Fuzhou.

4.1 Middle school parking demand calculation in peak hour of Fuzhou

First collate survey data and the necessary data in Formula（2）, such as land area, building area, the number of teachers and students, parking numbers in peak hour, then calculate motor vehicles parking demand P_0 in peak hour of school. The specific representative school samples' calculation results show in Tab.2.

Tab.2 Motor vehicles parking demand P_0 in peak hour of school

Middle School	W_1*L	α	W_2* M	β	P_0
Fuzhou No.19 Middle School (Downtown)	3991	0.0164	24	1.00	90
Fuzhou No.3 Middle School (Edge of downtown)	2171	0.0087	8	1.00	27
Fuzhou No.10 Middle School (Suburb)	4299	0.0059	7	1.00	32

4.2 Middle school correction parking demand calculation in peak hour of Fuzhou

Base on Formula（3）, analyze the location type of school samples, then get city motorization level influence coefficient, school location influence coefficient, scale and composition of middle school influence coefficient from Tab.1, and calculate motor vehicles correction parking demand P in peak hour of school. The result shows in Tab.3.

Tab.3 Motor vehicles correction parking demand P in peak hour of school

Middle School	P_0	Y_1	Y_2	Y_3	P
Fuzhou No.19 Middle School (Downtown)	90	0.95-1.0	0.9-1.0	0.9-1.0	69-90
Fuzhou No.3 Middle School (Edge of downtown)	27	0.9-0.95	1.1-1.2	0.9-1.0	24-31
Fuzhou No.10 Middle School (Suburb)	32	0.85-0.9	1.2-1.3	0.8-0.9	26-34

4.3 Middle school parking theoretical demand calculation of Fuzhou

According to Formula (4), analyze the theory parking supply scale of different location of school. According to parking survey of 5 middle schools in downtown, edge of downtown and suburb of Fuzhou in peak hours (7:00-8:00, 16:30-17:30), the average parking turnover ratio of downtown is 6.32/h, the average parking turnover ratio of edge of downtown is 5.13/h, and the average parking turnover ratio of suburb is 3.86/h.

According to parking survey of 5 middle schools in downtown, edge of downtown and suburb

of Fuzhou during 12 hours (6:00-18:00), the average parking space occupancy of downtown is 0.85, the average parking space occupancy of edge of downtown is 0.81, and the average parking space occupancy of suburb is 0.73.

Without consideration of parking policy and management, calculate middle school parking supply theoretical scale, and the results show in Tab.4.

Tab.4 Theory supply scale motor vehicles parking demand PX of school

Name of Middle School in Fuzhou	*P*	*a*	*t*	*b*	P_x (packing space/100 students)
No.19 Middle School (Downtown)	69-90	1.0	6.32	0.85	0.62-0.81
No.3 Middle School (Edge of downtown)	24-31	1.0	5.13	0.81	0.41-0.53
No.10 Middle School (Suburb)	26-34	1.0	3.86	0.73	0.37-0.48

4.4 Middle school parking index recommended value in Fuzhou

Base on the influence factors of middle school parking index, current situation of Fuzhou, land use arrangement of urban master planning and the demand and distribution of middle school parking in Fuzhou, the middle school parking index recommended value in Fuzhou are proposed as Tab.5.

Tab.5 Motor vehicles parking index recommended value of Middle School in Fuzhou

School location	Motor vehicles parking index recommended value （packing space/100 students）
Downtown	0.70-0.80
Edge of downtown	0.45-0.55
Suburb	0.40-0.50

5 Conclusion

This paper aims at the middle school parking problems in Fuzhou, combines with the parking investigation of middle schools' current situation in Fuzhou, and analyzes the main influence

factors of parking index. By proposing a model, revise the middle school parking index model, clarify the steps to determine the parking index value, and give middle school parking index recommended value of different location in Fuzhou. Because the influence factors of parking demand are wide and samples are limited, the proposed correction model needs to adjust, improve and develop in the practice.

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