Research on Parking Problems and Demand based on Parking Generation Rate Model in the Old Town of Hefei

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Abstract. Due to its comprehensive urban functions, high population density, and unreasonable parking space planning, the old town of Hefei is facing a serious problem of uneven distribution of parking spaces. This paper analyzed the current parking situation in the old town of Hefei through the survey results of the current parking situation in the old town. Then, based on the parking generation rate model, considering the impact of price factors and parking service levels on parking demand, a parking generation-prediction model was established to predict the parking demand in the old town of Hefei and the parking demand of each traffic district was obtained. The results show that the contradiction between the supply and demand of parking in the old town of Hefei is still prominent in the future.

Keywords: Urban Traffic; Parking Space; Demand Forecasting; Old Town.

1. Introduction

In recent years, with the continuous improvement of people's living standards, the number of motor vehicles in my country has grown rapidly, but at the same time, the development of urban parking lots (spots) has been seriously lagging. The contradiction between urban parking supply and demand has become increasingly prominent, and the problem of parking difficulties in urban areas has become more and more serious. The more prominent and to a certain extent restrict the development of social economy and urban transportation, especially in the old town. Due to the lack of consideration of the construction of motorized parking spaces in buildings and residential areas in early urban planning, the supply of parking spaces has become tighter. Therefore, the planning of urban parking facilities has become one of the necessary measures to alleviate traffic problems and promote the smooth operation of traffic organization. The premise of parking facility planning is parking demand forecasting.

This article researches the parking status and parking demand prediction in the old town of Hefei. By analyzing the parking status to master the parking characteristics, determine the parking demand prediction method in Hefei based on the parking generation prediction method and predict the parking demand in the short term. Reasonably formulate parking facilities construction plans and parking management systems to provide a theoretical basis.

2. The Current Parking Problems in the Old Town of Hefei

2.1 Rapid Growth in the Number of Motor Vehicles

In recent years, Hefei's economic development has attracted national attention. The booming economy and the increase in per capita income have made motor vehicles no longer a luxury. At the same time, with the development of the traditional automobile industry, the continuous improvement and promotion of various technologies, the rapid product update, the price of cars is also decreasing, the penetration rate of cars is getting higher and higher, and the number of motor vehicles in Hefei has shown a continuous increase. Especially in the past ten years, motor vehicles have grown at an average annual growth rate of 200,000. According to statistics, as of 2021, the number of motor vehicles in the Hefei urban area is 1.495 million, of which about 1.42 million are cars. According to the results of the preliminary survey of parking facilities, the total number of parking spaces in Hefei is only 1.295 million, and the current shortage of parking spaces is about 267,000. It is estimated that

by the end of 2021, the number of cars in Hefei City will be about 1.7 million, and the demand for parking spaces will be about 1.87 million.

2.2 Historical Reasons

The buildings in the old town are mostly early buildings with low floor area ratios and very dense, very close to each other. Various reasons have caused the shortage of land resources in the old town so that there is very little land that can be used for the construction of parking facilities. Although the old town no longer assumes the functions of the administrative center of Hefei, it is still the commercial, economic, and cultural center of Hefei. Many commercial, medical, cultural, entertainment, and educational facilities are gathered, which attracts a lot of external traffic to the old town.

2.3 Low Utilization Rate of Parking Resources and Low Parking Space Turnover Rate

According to the relevant provisions of the "Urban Road Traffic Planning and Design Code", the turnover rate of each parking space in urban public parking lots should be maintained 3-7 times a day. The average turnover rate per parking space in the city center should be greater than this range. According to relevant survey data, the average daily turnover rate of public parking lots in the First Ring Road of Hefei is about 2.3 times, which fully illustrates the insufficient utilization of public parking lots in the old city of Hefei.

2.4 Unreasonable Urban Planning

In the early days, people mainly used bicycles and buses as the means of travel. It did not anticipate the rapid increase in the number of cars and did not pay attention to the parking problem of motor vehicles. In the pre-urban planning, the number of parking spaces for various building parking lots is low, which is far from meeting the sudden increase in the number of motor vehicles in the later period and the subsequent parking demand. In addition, in order to save costs during construction, the developers of some projects have privately reduced the number of parking spaces and diverted the planned parking spaces for other uses. At the same time, due to ineffective supervision and lack of relevant laws and regulations to punish related projects, this has caused a serious shortage of parking spaces in many buildings, especially in the old town.

3. Parking Demand Forecasting in the Old Town of Hefei

3.1 Parking Demand Prediction Model

The more common parking prediction models include the parking incidence model, regression analysis model, motor vehicle OD prediction method, traffic volume-parking demand model, etc. In this section, a parking demand forecast model is established based on the parking generation rate model. The model takes into account the price factors and the impact of parking service levels on parking demand. The parking lot turnover rate and utilization rate are introduced into the model so that the actual application can be directly derived. Calculated as follows:

$$y = \mu \delta \beta \sum_{i=1}^n \frac{\alpha_i R_i}{\rho_i \gamma_i} \quad (1)$$

Among them, y represents the parking demand during peak hours in the planned area; α_i represents the generation rate of public parking for similar land use; R_i represents the number of employees per unit; ρ_i represents the average parking space turnover rate during peak hours of similar land use (when taking 1); γ_i indicates the average parking space utilization rate during peak hours for land use of a similar nature; μ indicates the parking supply-demand ratio in the planned

area; δ indicates the impact rate of the parking lot service level; β indicates the growth rate of motor vehicles.

3.2 The Result of Forecasting

3.2.1 Parameter Calibration

(1) Floor area of different types of land

The area of various types of land in the old urban area of Hefei is shown in Table 1.

Table 1. Floor area of different types of land

Land type	Area(m ²)
Commercial land	5.692 e5
Residential land	2.155 e7
Office land	3.900 e5
Entertainment	1.833 e5
School	4.523 e5
Hospital	1.199 e5

(2) Average space turnover rate during peak hours

The average space turnover rate during peak hours refers to the average number of vehicles parked in each parking space during peak hours. Its value is the ratio of the cumulative parking number of the parking lot during the peak time to the total number of parking spaces in the parking lot.

(3) Average space utilization rate during peak hours

The average space utilization rate during peak hours refers to the ratio of the number of spaces used in the parking lot to the total number of spaces during the peak time. The calculation method is as follows:

$$\gamma = \frac{\sum t_i}{CT} (i = 1, 2, 3, 4, \dots, n) \quad (2)$$

t_i represents the parking time of each vehicle in the peak period, C is the total number of parking spaces in the parking lot, and T is the length of the peak period.

For each type of land, select three to four representative buildings for on-site investigation, and then take the average value to obtain the peak-time space turnover rate and average space utilization rate of each type of land as shown in the Table 2.

Table 2. Parking generation rate, Parking space turnover rate, Average space utilization rate during the peak hour

Type of land	Parking generation rate	Peak space turnover rate	Peak space utilization rate
Business	1.32	1.20	0.90
Residential	0.40	1.12	0.98
Office	0.65	1.00	1.00
School	0.36	2.30	0.95
Hospital	2.54	1.50	0.96
Others	1.22	1.26	0.70

(4) The impact rate of parking lot service level

The service level of the parking lot is proportional to the parking demand, that is, the higher the service level of the parking lot, the greater the value. The current parking facilities in the old town of Hefei are insufficient, and there is still a big gap between the actual parking demand. The problem of parking difficulties during peak hours is even more prominent, and the public's parking experience is not good. Moreover, the current urban smart parking system developed by Hefei Urban Park is not perfect. Therefore, the impact rate of the parking lot service level is taken as 85%.

(5) Motor vehicle growth rate

The growth of motor vehicles is the most direct cause of the increase in parking demand. The growth rate of motor vehicles is the ratio of the number of vehicles in the forecast year to the number of vehicles in the base year. The number of motor vehicles in the forecast year can be obtained by fitting and forecasting the data over the years. The result is shown in Figure 1.

Fig 1. Polynomial Fitting Curve of Motor Vehicle Ownership

(6) The influence rate of price factors

The number of motor vehicles in the Hefei urban area is growing rapidly, with an average annual growth of 200,000 vehicles. This puts a lot of pressure on the city's static traffic and there is a shortage of parking spaces. In general, Hefei is in a state of restricted parking. The rigidity of parking demand is relatively strong. The price of parking does not have a strong impact on parking demand, so it is taken as 90%.

3.2.2 Analysis of Prediction Results

Substituting the above parameters into the parking demand prediction model, the parking demand in the old city of Hefei from 2022 to 2025 is calculated. The results are shown in Table 3.

Table 3. Forecast results of parking demand in the old city of Hefei from 2022 to 2025

Year	Forecasting results
2022	33202
2023	37268
2024	41022
2025	47580

To further analyze the relationship between the current parking supply and demand in the old city of Hefei, the old city of Hefei is divided into traffic districts, and the parking demand in each traffic district is predicted. Combining the field survey and the land use planning of the old city, the old city of Hefei is divided into 17 traffic districts. The comparison analysis of the current parking supply and demand forecast results of each district is shown in Figure 2.

It can be seen from Figure 2 that, except for the small difference between the supply and demand of the traffic community 4, the current supply parking spaces of the other traffic communities are far less than the demand parking spaces, and the parking space gap is huge.

To alleviate the parking pressure in the main urban area and curb excessive parking demand, parking measures must be taken, including increasing parking fees and controlling demand. Specifically, combining with the renovation of the old town, strictly implementing the standard of

equipment construction, building a three-dimensional parking garage and underground parking with a small area, staggered use existing parking facilities, moderately increase the supply scale of on-street parking at night, establish a parking information system to increase the utilization rate of parking spaces.

Fig 2. Comparison chart of the current situation and forecasting results

4. Summary

This paper took the parking problem in the old town of Hefei as the research object. Through field investigation, questionnaire survey, system analysis, and other methods, the following contents have been completed. First, based on the field survey, the characteristics of parking behaviors in the old town of Hefei were studied and analyzed, and the main parking problems are summarized. Second, based on land use planning and survey data, the parking demand-supply forecast model was used to predict the overall parking demand of the old town in short term. And the old town was divided into 17 traffic districts. The parking demand of each traffic district was clarified. The results show that the contradiction between parking supply and demand in the old town of Hefei will still be prominent in the future, and parking control strategies need to be adopted to reduce the adverse impact caused by excessive parking demand. Third, the research results provide a reference for further research on the parking problem in the old town of Hefei and lay a theoretical foundation of parking planning and management of the old town of Hefei in the future.

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