Original Research Article

Research on the Construction Index of Parking Lots of Large Commercial Complexes around Transportation Hubs

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Abstract: Based on the construction regulations and plans of large -scale commercialcomplexes near rail hubs in various cities in Jiangsu Province and the understanding of parking construction standardsin Wuxi City, this paper analyzes the provisions of parking construction indicators and integrates other large-scale commercial complexes adjacent to the hub. The parking demand and the distribution of berths during the operation period were investigated and compared horizontally. Taking the Baolong 2BC plot in Wuxi City as an example, a forecasting method of berth demand for large-scale commercial complexes near the rail hub was proposed, and it was concluded that it is suitable for the surrounding of the rail hub. General method for determining the allocation index of commercial complexes.

Keywords: Dommercial complex; Rail transit; Transportation hub; Parking lot; Construction index.

1. Introduction

Large commercial complexes have a rich and diverse range of business formats, and the actual berth requirements vary among different large commercial complexes. The situation of large commercial complexes near rail transit hubs is more complex, and it is obviously unreasonable to use general construction indicators to calculate berth requirements based on building area. This article investigates and horizontally compares the parking demand and distribution of parking spaces during the operation period of other large commercial complexes. Taking the Baolong 2BC plot in Wuxi City as a case study, a prediction method for the demand for parking spaces in large commercial complexes near rail hubs is proposed, and a general method for determining the allocation indicators of commercial complexes around rail hubs is summarized.

2. Case Analysis

The Baolong 2BC plot studied in this study is located in Xinwu District, Wuxi City, Jiangsu Province. The plot is developed into a large-scale commercial complex. The plot is adjacent to Lijiang Road in the east, the Pearl River Road in the west, facing the railway station in Xinwu District, Wuxi, Haichuang Fourth Road in the south, and Xinhua Road in the north. As shown in Figure 1. Wuxi Xinwu Station will have the intersection of Wuxi Metro Line 3 and Line 4 in the future, making it a large-scale transportation hub.

Figure 1 Base region map.

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The total land area of the Baolong 2BC plot project is 58948.60m2. The base is divided into two zones, north and south, with Haichuang Second Road as the boundary. The total construction area of the BC plot is 159414.80m2, and the total plot ratio of the BC plot is 1.3. The base has 1346 motor vehicle parking spaces (9 above ground taxi parking spaces and 1337 underground parking spaces) and 3339 non motor vehicle parking spaces (1850 above ground and 1489 underground parking spaces). The construction of the base includes supporting facilities such as shopping centers, commercial streets, and public health facilities.

According to the "Regulations on the Construction of Motor Vehicle Parking Facilities for New Wu District Construction Projects" implemented in December 2019, New Wu District can be divided into two types of parking policy zones based on land development and traffic conditions. The first type of zone is the balanced supply zone, which has a high degree of construction and a small increase in the amount of land available for development. The current traffic congestion is prominent, and traffic policies are inclined towards public transportation, with some existing standards appropriately raised, Emphasize the construction of social parking lots to balance historical gaps; The second category area, namely the moderately developed area, is the main increment space carrier for the future Xinwu District, and aims to improve the existing parking and construction standards.

The matching standard for the building plan before the improvement of the local area is 0.8 parking spaces/100m2, which only meets the indicator of no less than 0.6 parking spaces/100m2 specified in the Jiangsu Province Urban Planning and Management Technical Regulations 2011 (Provincial Standard). The provincial standard was issued in 2011, which is not suitable for the increasing number of motor vehicles currently in use. Considering that the base is adjacent to a rail transit hub with a high passenger volume, the proportion of public transportation is relatively high, and the parking space allocation index can be appropriately reduced. Therefore, this study comprehensively considers the current situation of the base and the parking operation status of nearby large commercial complexes, studies the reasonable allocation indicators of the base, and summarizes the general rules, providing experience and suggestions for the parking allocation of large commercial complexes in Wuxi City.

3. Research and Analysis of Parking Conditions in Nearby Large Commercial Complexes

3.1 Related Specifications

Referring to the "Suzhou City Building Parking Lot Index": In addition to residential, medical, educational, and transportation facilities, if the underground space of a new project is seamlessly connected to the entrance and exit of a rail station, its motor vehicle parking quota can be reduced to 80% of the parking quota. If there is an entrance and exit of a rail station on the land where the construction project is located, its motor vehicle parking quota can be reduced to 85% of the parking quota; If more than 50% of the land area of the construction project is located within a straight distance of 300m from the nearest entrance and exit of the rail station, the parking quota for motor vehicles can be reduced to 90% of the quota; Referring to the "Standards and Guidelines for Setting up Parking Facilities for Buildings and Traffic Impact Assessment in Kunshan City": For large-scale comprehensive public buildings, commercial buildings with a total construction area of more than 50000 square meters can be calculated based on 90% of the cumulative demand for parking spaces, while fully considering the possibility of shared parking spaces; According to the Wuxi Special Plan for Parking Facilities 2016-2035, the allocation index of public buildings within 300m of the rail station can be appropriately lowered to 80-90% of the original allocation index.

Analogous to the parking space allocation standards in Suzhou and Kunshan, as well as the special plan for parking facilities in Wuxi, it can be seen that if the underground space of the building is connected to the rail station, considering the passenger flow distribution capacity of the rail transit, the proportion and demand of

motor vehicle travel in this building have decreased, and the allocation index can be reduced to 80%. However, whether to reduce parking spaces in the local area according to relevant standards requires first demonstrating whether the reduced parking spaces can meet actual needs, rather than blindly following regulatory standards. Therefore, taking into account the experience of other cities, the upper level planning of this city, and the special planning results of Xinwu District, this study predicts the actual situation of the local block during the operation period and analyzes the actual berth demand of the plot, in order to obtain reasonable allocation indicators.

3.2 Horizontal Comparison of Adjacent Projects

Considering that the base is located in Xinwu District, Wuxi City, and considering that the customer travel patterns and internal employee commuting OD distribution of large commercial complexes in Xinwu District are relatively similar, this study investigates the actual parking conditions during the operation period of other large commercial complexes in Xinwu District, Wuxi City, and compares them horizontally with the building size, store types, and quantity of the local area, Analyze the internal parking needs of employees and customers during the operation period of Baolong 2BC plot.

Wanda Plaza in Xinwu District is located in Taike Park, Xinwu District. The north side of the base is Zhenze Road, the west side is Jinghui West Road, and the east side is Square East Road, as shown in Figure 2. Opened on July 30, 2020, the plot has 4 floors above ground and 1 floor underground, with a total construction area of 140800m2 and 847 motor vehicle parking spaces. It can be seen that the construction ratio of Wanda parking spaces in Xinwu District is 0.85 berths/m2. Although the construction index meets the provincial standard of 0.6 berths/m2, it does not meet the current indicators in Xinwu District.

Further investigation was conducted on the distribution of internal shops in Xinwu Wanda Plaza, which can be divided into large area shops and small and medium-sized retail shops. Xinwu Wanda has a total of one underground floor and four above ground floors, with a total of 221 small shops and 5 large shops.

After the opening of Xinwu Wanda, the surrounding traffic was relatively congested, with underground garages and ground parking spaces full. The nearby parking lots were also occupied, and there were still a large number of cars illegally stopping on strictly controlled roads such as Zhenze Road and Jinghui West Road; Not only that, non motorized vehicles also have no space to park, and they park randomly in the green area of the square, causing chaos in the surrounding traffic.

In order to understand the peak parking demand during the opening of a large-scale commercial complex in Qingxin Wu District, a one week (August 7-16) parking survey was conducted on Wanda Parking in Xinwu. (Table 1)

From the data in Table 1, it can be seen that on weekdays and weekends, the 169 berths on the ground of Xinwu Wanda Plaza have been in a saturated state since 10am. The 714 underground parking spaces, except for 10:00-11:00 in the morning and 3:00-16:00 in the afternoon, are all saturated. After saturation, the underground garage will be closed and entry is prohibited, resulting in vehicles having no space to park and illegally stopping on surrounding roads. Xinwu Wanda has set up 700 non motorized vehicle parking spaces, which have been in a saturated state since 10am.

On weekends, the administrative approval center on the north side of the plot, “Meihua” (with a total of 280 parking spaces), is available for social vehicles to park. However, on weekdays and weekends, there are varying degrees of motor vehicles (road boards, a small number of motor lanes, greenery) and non motor vehicles (green belts, road boards, non motor lanes) violating regulations on peripheral roads (number of violations on Zhenze Road>Jinghui West Road>Qingyan Road, all of which are strictly managed roads).

In the saturated situation of “plum blossom”, during the peak period of weekends, there are at most about 361 motor vehicles and 1140 non motor vehicles that violate parking regulations; Approximately 114 motor vehicles and 1015 non motor vehicles were parked illegally on weekdays.

Table 1 Wanda plaza parking survey form.

August 7th (Friday)						**August 8th (Saturday)**				
	Peripheral parking violation		**Peripheral parking violation**			**Peripheral parking violation**		**Peripheral parking violation**		
	Motor vehicles	**Non motor vehicles**	**Basement**	**Ground**	**flow**	**Motor vehicles**	**Non motor vehicles**	**Basement**	**Ground**	**flow**
8:00						0	35	E	E	
10:00-11:00	0	345	RE	S		1	430	S	S	
12:00-13:00			S	S	320	93	510	S	S	380
15:00-16:00	3	430	RE	S		103	560	S	S	
17:30-18:30	60		S	S		169	880	S	S	116
After19:00	70	820	S	S		289	1110	S	S	
August 9th (Sunday)						**August 10th (Monday)**				
	Peripheral parking violation		**Peripheral parking violation**			**Peripheral parking violation**		**Peripheral parking violation**		
	Motor vehicles	**Non motor vehicles**	**Basement**	**Ground**	**flow**	**Motor vehicles**	**Non motor vehicles**	**Basement**	**Ground**	**flow**
8:00	0	35	E	E		0	86	E	E	
10:00-11:00	1	430	S	S	**380**	25	560	S	S	
12:00-13:00	93	510	S	S		242	720	S	S	240
15:00-16:00	103	560	S	S		25	740	S	S	
17:30-18:30	169	880	S	S	**116**	303	960	S	S	116
After19:00	289	1100	S	S		361	1140	S	S	
August 11-13th (Tuesday-Thursday)						**August 14th (Friday)**				
	Peripheral parking violation		**Peripheral parking violation**			**Peripheral parking violation**		**Peripheral parking violation**		
	Motor vehicles	**Non motor vehicles**	**Basement**	**Ground**	**flow**	**Motor vehicles**	**Non motor vehicles**	**Basement**	**Ground**	**flow**
8:00	0	83	E	E		0	104	E	E	
10:00-11:00	0	220	RE	S	80	0	279	MP	S	
12:00-13:00	2	350	S	S		2	298	S	S	128
15:00-16:00	3	375	RE	S	85	1	348	MP	S	
17:30-18:30	7	690	S	S		7	620	S	S	107
After19:00	78	945	S	S		90	1015	S	S	
August 15th (Saturday)						**August 16th (Sunday)**				
	Peripheral parking violation		**Peripheral parking violation**			**Peripheral parking violation**		**Peripheral parking violation**		
	Motor vehicles	**Non motor vehicles**	**Basement**	**Ground**	**flow**	**Motor vehicles**	**Non motor vehicles**	**Basement**	**Ground**	**flow**
8:00	1	137	E	E		0	159	E	E	
10:00-11:00	4	360	RE	S	170	0	333	LP	S	
12:00-13:00	60	475	S	S		82	506	S	S	180
15:00-16:00	19	480	RE	S	103	76	680	LP	S	
17:30-18:30	87	828	S	S		152	950	S	S	98
After19:00	98	1106	S	S		194	1070	S	S	

"S" represents Saturation, "E" represents Empty, ,"RE" represents Relatively Empty, "MP" represents More Parking, "LP" represents Less Parking.

The maximum passenger flow during peak hours on weekends is 380pcu/h, and during peak hours on weekdays it is 322pcu/h.

According to the calculation of the number of violations and passenger flow during peak hours, the current demand for motor vehicle parking in Xinwu Wanda is about 1367 parking spaces during peak hours, and the demand for non motor vehicle parking spaces is about 1880 parking spaces. Far higher than the number of berths

in the base.

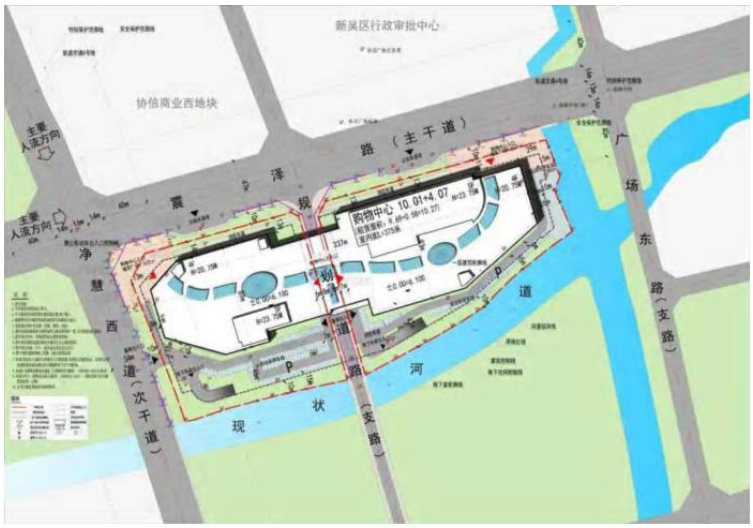

Figure 2 Map of Wanda plaza area.

The current Wanda Commercial Shopping Center has a total of 221 shops, which are internal shops. Therefore, a survey was conducted on the parking needs of Wanda's internal employees.

From Table 1, it can be seen that the demand for fixed parking spaces for employees is 365, so the commercial parking spaces available for customers in Xinwu Wanda are only 518, which is lower than the actual parking demand, resulting in more serious parking conflicts around Xinwu Wanda.

In addition to the serious parking conflicts analyzed above, the current management of the underground parking lot in Wanda plot is relatively chaotic. Vehicles occupy the passage for parking, and the passage can only meet one-way traffic, with extremely low traffic capacity and easy to cause safety accidents; The surrounding roads are all strictly managed, and the lack of parking resources coupled with strict management forces vehicles to stop illegally on road boards and other places has led to a relatively chaotic traffic order in the Wanda plot.

Based on this survey, it can be analyzed that the transportation modes of the Xinwu Wanda plot are shown in Table 2.

Table 2 Wanda plaza travel mode prediction table.

Method	Walk	Non motor vehicles	Regular public transportation	Subway	Private car	Taxi	Total
Proportion	8%	32%	7%	0%	38%	15%	100%

4. Case Analysis and Improvement Suggestions

4.1 Prediction of The Proportion of Transportation and Travel in the Station Front Area

Before the completion and put into use of the 2BC plot in the long term, Metro Line 3 had already started operation and passenger flow had been relatively stable. Therefore, an analysis was conducted based on the travel modes of commercial districts around other urban rail stations in China.

Analogous to the changes in surrounding travel modes before and after the introduction of domestic rail stations, the specific details are as follows:

Chengdu Metro Line 1: 49.8% for subway, 28.5% for regular buses, 10.9% for private cars, 6.4% for non motorized vehicles, 1.9% for unit cars, and 2.6% for walking. Shanghai Metro Line 16: Subway 25.4%, regular public transportation 35.6%, private cars 4.6%, taxis 2.5%, non motorized vehicles 30%, and others 1.9%.

According to the 2013, 2017, and 2019 resident travel surveys in Wuxi, the structure of resident travel

modes in Wuxi is shown in Table 3.

Table 3 Travel modes of residents in wuxi city.

Year	Walk	Non motor vehicles	Public transportation +subway	Taxi	Motorcycle	Shuttle bus	Private car	Other
06	19.2	40.7	14.33	1.6	5.5	8.1	8.9	1.6
13	22.2	37.4	18.1	0.9	--	5.5	13.4	1.8
17	22.2	31	10+1.2	0.3	1.5	3.4	29.6	0.8
19	26	29.7	13.3	2.1	1.0	2.4	23.4	2.1

(Unit: %)

Based on the survey data of residents' travel in Wuxi City and the survey results of similar scale commercial complexes in Wuxi City (Xinwu Wanda, Wanxiang City), as well as the survey results of the proportion of residents' travel after the use of other urban rail stations, the transportation proportion around the intercity station is obtained:

The transportation around the plot is convenient, and the comprehensive transportation mode is relatively mature. The proportion of travel in all directions at the urban railway station is shown in Figure 3.

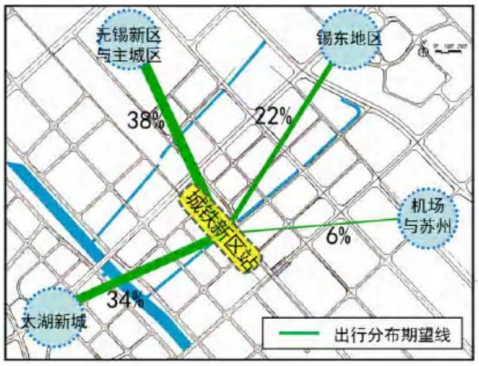

Figure 3 Proportional diagram of travel in all directions at the urban railway station.

Subway lines 3 and 4 have been completed and opened to traffic, while lines 5 and 6 are under construction. The subway has initially formed a network, and the number of surrounding bus routes has increased, gradually increasing the share of public transportation.

Private cars remain the main mode of transportation.

Based on comprehensive analysis, the structure of passenger flow absorption and generation modes for intercity stations during peak hours in the long term is predicted as shown in Table 4.

Table 4 Prediction of travel modes around the airport.

Method	Walk	Non motor vehicles	Regular public transportation	Subway	Private car	Taxi	Total
Proportion	9%	25%	6%	10%	35%	15%	100%

4.2 Analysis of Internal Employee Parking Space Requirements

We have conducted parking research on the Wanda plot in the early stage, and from the data, it can be seen that the Wanda plot is very similar to the Baolong 2BC plot in terms of area and current surrounding traffic conditions. Analogous to the parking demand survey data of employees in Xinwu Wanda, Calculating the parking needs of employees in Baolong plot (Baolong's shops have not been sold yet, and the current statistics only show the number of architectural design shops. Considering that the outer street is mostly for catering and retail, the probability of one household having multiple shops is relatively small, while the inner street is mostly

for boutique commerce, the probability of one household having multiple shops is relatively high, and they are calculated at 0.85 and 0.8 respectively. Considering that Baolong's outer street shops are small and dense, mostly for catering and retail small stores, and the staff in the shops are not internal employees, the parking space needs to be rented monthly, and the parking demand is not high. The inner street is for internal employees.), There is a high demand for parking spaces. Obtain parking demand for each shop of Baolong. (Table 5)

Table 5 Parking demand of employees in Baolong's each shop.

	Small and medium-sized retail stores		Large scale merchants (electrical appliance stores, cinemas, etc.)		Total
	Inner Street Shop	Outer Street Shop	Number	Area	
	245	208	4	5496m^2	470
Demand	270	208	37		515

From Table 5, it can be seen that the motor vehicle parking demand for employees within the Baolong 2BC plot is about 515 parking spaces. Based on the predicted travel mode division ratio of the local block, it can be concluded that the non motor vehicle travel volume of employees within the Baolong 2BC plot is 914.

4.3 Customer Parking Space Demand Analysis

Due to the limited number of bus stops and no subway lines in the surrounding area of Xinwu Wanda, the proportion of private car travel is currently high. However, when the Baolong plot was completed and put into use, the subway line 3 had already been put into operation, and the passenger source was relatively stable.

Considering the high turnover rate of commercial parking spaces for customers, with an average of 2-3 vehicles per hour, the passenger flow was calculated and analyzed during the daytime (9:00-18:00) and nighttime (6:00-22:00), as well as during corresponding peak hours (11:00-12:00 during the day and 7-8:00 at night). Table 6 shows the predicted operational parking demand for the 2BC plot.

Table 6 2BC Block operation parking demand forecast table.

		Predicting operational parking demand (day, night)				Predicting operational parking demand (peak hours)			
		Motor vehicles		Motor vehicles		Motor vehicles		Motor vehicles	
	date	day	night	day	night	day	night	day	night
Traffic volume	weekday	1909	818	2475	1061	573	245	742	318
	weekend	3025	1296	4242	1818	1210	5109	1697	727

4.4 Initial Plan Berth Supply and Demand Analysis

4.4.1 Construction Timeline

According to the timeline bar chart of Baolong plot construction, it can be seen that when the 2B&2 plots were completed and delivered, the surrounding plots had already been put into use, and parking resources could be allocated in time and space.

4.4.2 Developed Public Transportation in the Surrounding Area

At present, Metro Line 3 has been put into operation. After the completion of the 2B&2C plots, Metro Line 4 has also been put into operation, which can share a large amount of passenger flow and further reduce the proportion of private car travel.

4.4.3 Reserved Underground Passage, Shared Parking Spaces with Staggered Peaks

The 2B&2C plot serves as a large commercial complex adjacent to the new district station, with an underground garage reserved for connecting to the station. Considering that 400 social parking spaces will be reserved during the construction of the 1B plot (school), all day social parking spaces on weekdays and weekends will be available for the use of the 2BC plot. The floor plan of the underground connecting passage of Baolong

2BC plot is shown in Figure 4.

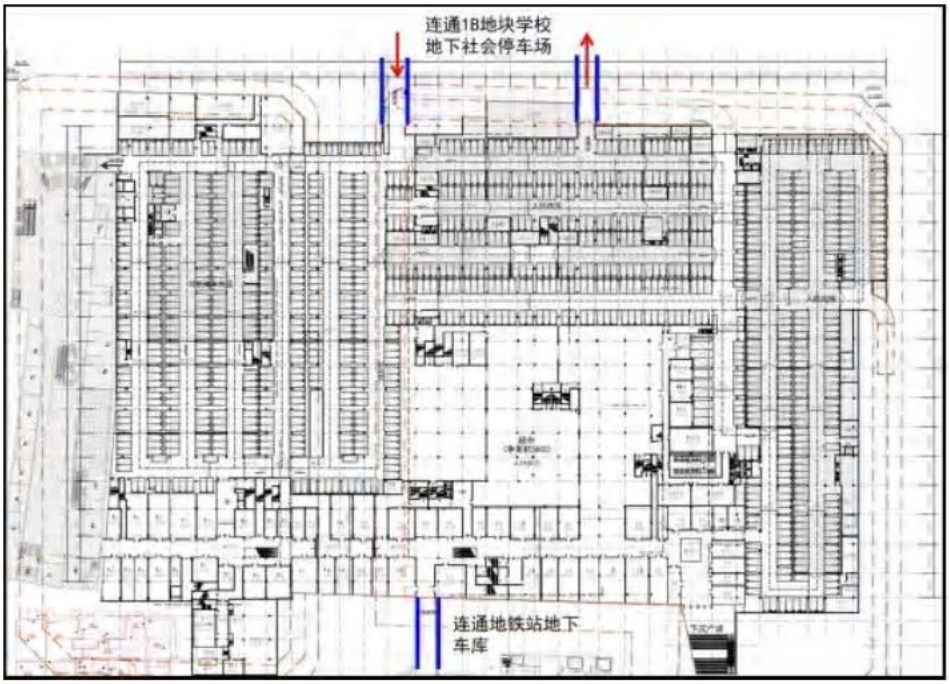

Figure 4 Plan of the connecting passage between the basement of Baolong 2BC plot

Therefore, based on the above three factors, the actual number of operating vehicles and demand for the 2BC plot are shown in Table 7.

Table 7 2BC Actual berth supply and demand list

		2BC **Predicting operational parking demand (day, night)**				2BC **Predicting operational parking demand (peak hours)**			
		Motor vehicles		**Motor vehicles**		**Motor vehicles**		**Motor vehicles**	
	date	**day**	**night**	**day**	**night**	**day**	**night**	**day**	**night**
Employee parking	**Every day**	**515**	**515**	**927**	**927**	**515**	**515**	**927**	**927**
Traffic volume	**weekday**	1909	818	2475	1061	573	245	742	318
	weekend	3025	1296	4242	1818	1210	5109	1697	727
Weekday parking demand						1088	760	1669	1245
Supply of berths on weekdays						896	1296	3331	3331
Weekend parking demand						1725	1034	2624	1654
Supply of berths on weekend						1296	1296	3331	3331

From Table 7, it can be seen from the berth supply and demand balance table that according to the initial plan's allocation index of 0.8 berths/100m2, if the demand exceeds the supply, parking difficulties will still occur during peak periods. Moreover, the allocation index of 0.8 berths/100m2 does not meet the current allocation index requirements in Xinwu District. Therefore, based on the predicted berth situation and the building area of the case, the case needs to be allocated according to the allocation index of 1.2 berths/100m2, Only then can the predicted actual parking demand be met, and this situation can be fed back to the architectural design unit for modification.

4.5 Analysis of Case Improvements

The revised 2BC plot plan includes a total of 1342 parking spaces (including 8 loading and unloading

spaces and 1334 car parking spaces), with two underground floors. The first underground floor has 996 parking spaces, and the second underground floor has 346 parking spaces. The supporting construction index is 1.2 parking spaces per 100m^2.

According to the modified berth setting plan, recalculate the actual number of berths during the operation period of the 2BC plot, as shown in Table 8.

Table 8 Adjusted supply and demand balance of berths on block 2BC

		2BC **Predicting operational parking demand (day, night)**				2BC **Predicting operational parking demand (peak hours)**			
		Motor vehicles		**Motor vehicles**		**Motor vehicles**		**Motor vehicles**	
	date	**day**	**night**	**day**	**night**	**day**	**night**	**day**	**night**
Employee parking	**Every day**	**515**	**515**	**927**	**927**	**515**	**515**	**927**	**927**
Traffic volume	**weekday**	1909	818	2475	1061	573	245	742	318
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As shown in Table 8, the adjusted base equipped parking spaces can meet the parking needs of customers and internal employees on weekdays and weekends. There are about 9 extra parking spaces during peak hours on weekends. Considering the randomness of passenger flow arrival, the adjusted base equipped parking spaces can meet the parking needs of customers and employees.

5. Conclusion

(1) The business format of large-scale commercial complexes is relatively complex, and it is not possible to calculate berths based on the general allocation indicators. The actual berth demand needs to be divided into two types: fixed berth demand for employees and mobile berth demand for customers.

(2) The demand for internal employee parking spaces in large commercial complexes needs to be determined comprehensively based on the size of internal parking spaces and operating methods.

(3) Whether the construction indicators of large commercial complexes near transportation hubs can be reduced requires calculating the actual parking demand of the plot before determining, and cannot be determined solely by applying the construction indicators.

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