Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 3, No. 3, 2022

Analysis of Traffic Carrying Capacity of Rail Transit TOD: A Case Study of Chongqing Bishan TOD Project

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Abstract: The TOD model has risen in many cities in China because of its advantages of functional compounding and high degree of intensification. As a fast and large-capacity mode of public transportation, rail transit has gradually become the strongest mode of transportation to achieve TOD function. The traffic carrying capacity analysis of the rail transit TOD project is an important analysis tool for testing the coordination degree of land use and urban transportation, taking the Chongqing Bishan TOD project as an example for case analysis, the traffic carrying capacity of the research project is found, and the analysis of the calculation results Shows that the comprehensive score of the traffic carrying capacity of the Bishan TOD project is 0.7581 points, which is in the stage of relative coordination. The traffic carrying capacity analysis method proposed in this paper has certain practicality, which can reflect the problems of land use and transportation system, point out the direction for improving the traffic carrying capacity of the research area, and provide a certain reference and basis for the formulation of urban planning.

Keywords: TOD, Traffic carrying capacity, Rail transit, Land use.

1. Introduction

TOD model was first proposed by Peter Calthorpe, an American New Urbanism scholar, to solve the problems of traffic congestion and low utilization of land resources brought by social development. For rail transit TOD, on the one hand, too much land development intensity around rail stations will overload rail transit and road traffic facilities, causing congestion at rail stations and road traffic congestion; on the other hand, too low development On the other hand, too low development intensity will reduce the value of the land around the rail station, resulting in the waste of land resources and transportation capacity. Zhang Lei[1] analyzed the TOD integrated development model to improve the quality of rail transit construction by optimizing the land use around rail transit. Chen Yao[2] studied the TOD development model with Chengdu rail transit as an example. Li Xue[3] Summarizes the difficulties and planning difficulties encountered in the TOD development of Shapingba high-speed railway hub in Chongqing. Zhao Dawei[4] Analyzes and summarizes the planning techniques and strategies of Jinhua Rail Tower Station as an example to provide reference for similar stations. Song Ziruo[5] Through studying the law of rail transit TOD development in recent years, focusing on the analysis of Shenzhen and Chengdu cities, summarizing the relevant experience and putting forward relevant suggestions and technical routes.

This study analyzes the TOD project in the Six Flags area of Bishan District, Chongqing, and analyzes the traffic carrying capacity level of the area through the study of the construction degree of land and traffic facilities around the rail Bishan station, and the results of the study will point out the direction for further improving the traffic carrying capacity of the study area; finally, this study has far-reaching significance for the integration of land use and urban traffic in the area and the promotion of rationalization of urban spatial structure. Finally, this study has far-reaching significance for the integration of land use and urban traffic in the area and the rationalization of urban spatial structure.

2. Introduction to the TOD project in the Six Flags area of Bishan District, Chongqing

Since Bishan Station of Chongqing Railway Line 1 and Bishan High-speed Railway North Station are located at the north and south ends of Six Flags Area, the traffic connection between the two stations needs to run through the whole Six Flags Area, so the traffic carrying capacity analysis of Six Flags Area should consider the whole area of the area, with a total area of 564.08 hectares.

The residential communities within the study area are: Xiangjiang Jiayuan Community (covering an area of 71,828 square meters), Tianzheng Bicheng Central Community (covering an area of 60,826 square meters), Jiwang Community (covering an area of 128,453 square meters), Xinhong Jinxiu New Town (covering an area of 30,599 square meters), China Railway Construction Xiangman Creek, North City Xingyuan (covering an area of 22,410 square meters), Bishan Huashi Street Community, Jinrongju, North City Sunshine (covering an area of 6,460 square meters), and Gantang Garden District (covering an area of 60,615 square meters), Xiangmanxishi (covering an area of 141,597 square meters), Hongyu Family House (covering an area of 5,442 square meters), etc. The residential community is concentrated near the orbital Bishan Station.

The bus lines within the study area are: Bishan 101, 106, 107, 108, 109, 112, 203, 204, 205, 333, etc. The bus stops are distributed around Six Flags Avenue and Jingshan Road, which can meet the travel needs of most residents.

The schools within the study area are: Chengzhong Kindergarten, Aino Kindergarten, Chengbei Primary School, Chongqing Traffic Cadre School (Bishan Campus), Bishan District Special Education School, etc.

The companies within the study area are: Chongqing Highway Engineering (Group) Company Limited, Lianfeng Casting and Forging, Chongqing Hongyu Friction Products Company Limited (Jiwang District West), Chongqing Hainel Rubber and Plastic Products Company Limited, Chongqing

Jinxin Filter Manufacturing Company Limited, Chongqing Qijin Foodstuffs Company Limited, Chongqing Xin Yisong Auto Parts Company Limited (Bishan Branch), Chongqing Hefang Machinery Company Limited. Most of the residents can realize the office in the study area.

2.1. Research project traffic carrying capacity measurement

2.1.1. Calculation of land use indicators

The plot ratio is equal to the ratio of the total area of buildings in the area to the total area of land in the area . According to the information published on T.Y. Lin's Rail Transit and Urban Development e-site, the floor area ratio of some buildings around the rail Bishan Station is shown in Figure 1. The floor area within the area is calculated to be 2.0.

Figure 1. Partial floor area ratio of buildings around Bishan Railway Station

The population density is equal to the ratio of population in the area to the total land area of the area. According to "Bishan District Urban Master Plan (2004-2020)", the total population of Six Flags area is 11,765, and the population density in the area is 2086 people/square kilometer.

According to the analysis of the planned land in Six Flags Area, it is known that the area of residential land in the area is 191.08 hectares, the area of commercial and financial land is 30.36 hectares, the area of urban construction land excluding these two types of land is 285.65 hectares, and the area of non-construction land and non-urban land in the area is 57.98 hectares. According to Equation 3.3, the land mix can be calculated as 0.4810.

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The employment ratio in the district is equal to the ratio of employment jobs to the employed population. According to the statistical data of Chongqing Statistical Yearbook, it is known that the average number of resident population per household in Bishan District is 3, and the average number of employees per resident population is 1.68, so we can find out the employed population is 6588.

According to the gross regional product of Bishan District in 2018, it is known that the ratio of primary, secondary and tertiary industries in the district is 5%, 62% and 33% respectively, which can be derived that the number of jobs in Six Flags area is 3098, and the employment ratio in the district is 0.4702.

The total area of planned road land in the study area is 121.49 hectares and the area of construction land is 549.98 hectares, and the road area ratio can be calculated as 0.2209 according to Equation 3.5.

Urban road level is divided into four categories, through the review of network information, combined with electronic maps, resulting in six flags area urban road information statistics table as shown in Table 1. There are 7 urban roads in Six Flags Area, including 3 north-south roads, namely Daishan Avenue, Xinpu Road and Jiguan Shi Road; 4 east-west roads, namely Six Flags Avenue, Jingshan Road, Yangliuba Road and Longxuoshan Road. It is calculated that the total length of urban roads in Six Flags area is 15.4km.

Table 1. Six Flags Area Urban Road Information Statistics

Road name	Road classification	Road width/m	Number of lanes	Length of roads in the district/km
Daisen Avenue	Main roads	32	Two-way 8 lanes	4
Six Flags Avenue	Main roads	32	Two-way 8 lanes	2.2
Jingshan Road	Secondary roads	24	Two-way 6 lanes	2.2
Cockscomb Road	Secondary roads	22	Two-way 6 lanes	1.5
Longshore Hill Road	Secondary roads	15	4 lanes in both directions	0.6
Xinpu Road	Branch Road	12	2 lanes in both directions	3.6
Yangliuba Road	Branch Road	12	2 lanes in both directions	1.3

In 2018, the number of motor vehicles in Bishan District reached 110,000, and the number of motor vehicles in the recent planning of Six Flags Area is 2417, which can be derived from the density of motor vehicles per kilometer of 157.

Six flags area will adopt "public transportation-oriented complex traffic travel mode", and has good public transportation travel conditions, coupled with the comprehensive transportation plan of Bishan District, which aims to develop "efficient, convenient and comfortable experience traffic travel". "The green transportation travel sharing rate in Six Flags Area is high. Combined with the prediction of the traffic composition in the Detailed Planning of TOD Urban Design and Transportation System of Six Flags Area, the proportion of various travel modes in Six Flags Area is shown in Fig. 2, which can be calculated that the travel sharing rate of green transportation in the area is 0.78.

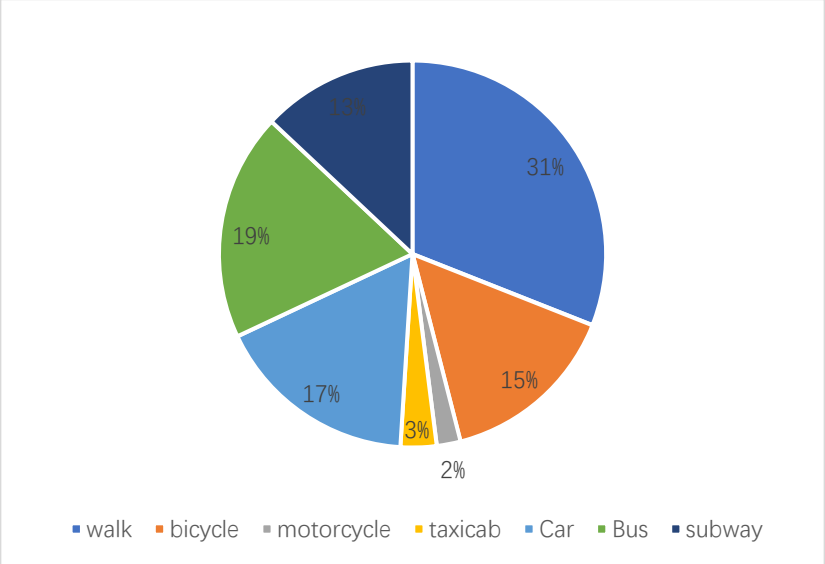

Figure 2. Proportion of various modes of travel in the zone

The rail transit station in the Six Flags area is Bishan Station of Chongqing Rail Transit Line 1. The 800-m radius coverage of rail transit in the study area is shown in Figure 4. From this, it can be calculated that the area covered by 800 meters of rail transit is 182 hectares, and the coverage rate is 0.3309.

With reference to many domestic design standards and the research of existing scholars, the range of values of each index in Bishan District of Chongqing City is obtained by comprehensive analysis. After calculation, the results of each index were calculated as shown in Table 2.

Table 2. Summary of calculation results of each index

Indicators	Lower limit of value	Upper limit of value	Calculation results	Score
Volume ratio	1	2.5	2	0.8000
Population density	-	2500	2086	0.8344
Land Mix	-	0.45	0.481	1.0689
Employment ratio in the district	0.2	0.6	0.4702	0.7837
Road area ratio	0.15	0.3	0.2209	0.7363
Density of motor vehicle ownership	-	270	157	0.4185
Green transportation trip sharing rate in the district	0.3	0.8	0.78	0.9750
Rail Transit 800m Coverage	0.2	0.75	0.3309	0.4412

3. Evaluation of Traffic Carrying Capacity of Research Projects

The maximum characteristic roots and consistency tests for the urban land use judgment matrix are as follows.

$$MW = \begin{pmatrix} 1 & 2 & 3 & 3 \\ 1/2 & 1 & 2 & 5 \\ 1/3 & 1/2 & 1 & 3 \\ 1/3 & 1/5 & 1/3 & 1 \end{pmatrix} \begin{pmatrix} 0.4307 \\ 0.3127 \\ 0.1758 \\ 0.0807 \end{pmatrix} = \begin{pmatrix} 4.2390 \\ 4.1044 \\ 4.0831 \\ 4.2789 \end{pmatrix}$$

The maximum characteristic root is.

$$\lambda_{max} =$$

$$\frac{1}{3}\left(\frac{4.2390}{0.4307} + \frac{4.1044}{0.3127} + \frac{4.0831}{0.1758} + \frac{4.2789}{0.0807}\right) = 4.1763$$

Rule.

$$CI = \frac{4.1763 - 4}{4 - 1} = 0.0588$$

and.

$$CR = \frac{0.0588}{0.96} = 0.0612 < 0.1$$

Therefore, the consistency of the judgment matrix is considered good and the result is acceptable; similarly, the CR value of the judgment matrix of urban traffic can be found to be 0.0724, and its result is still reasonable.

In this study, it is considered that the contribution of urban land use and urban transportation system to traffic carrying capacity is the same degree, so the weight of both urban land use and urban transportation system is 0.5. According to the scores of each index in Table 2 and the priority vectors of each index, the traffic carrying capacity of the study project can be calculated, and the calculation results are shown in Table 3.

Table 3. Traffic carrying capacity score of the study project

Target layer	Guideline layer	Indicator layer	Weights	Weighted Score	Total
Traffic Carrying Capacity Level of TOD Project in Six Flags Area, Bishan District, Chongqing	Urban land use system (0.5)	Volume ratio	0.2154	0.1723	0.7581
		Population density	0.1563	0.1304	
		Land Mix	0.0879	0.0940	
		Employment ratio in the district	0.0404	0.0317	
	Urban transportation system (0.5)	Road area ratio	0.0529	0.0390	
		Density of motor vehicle ownership	0.0218	0.0091	
		Green transportation trip sharing rate in the district	0.1762	0.1718	
		Rail Transit 800 Coverage	0.2491	0.1099	

4. Analysis of Research Project Evaluation

According to the calculation results, with reference to the classification of traffic carrying capacity level in Table 4, it can be seen that the traffic carrying capacity level of TOD project in Six Flags area in Bishan District of Chongqing is high, indicating that the coordination degree of land use and traffic facilities construction in the area belongs to a relatively coordinated stage.

Table 4. Traffic carrying capacity level grading table

Traffic carrying capacity score	Urban land use and urban transportation coordination level
0.8~1.0	Highly coordinated
0.6~0.8	More coordinated
0.5~0.6	Slight coordination
0.4~0.5	Not very harmonious
0.2~0.4	Incongruity
0.0~0.2	Extremely incongruous

Analysis of the weighting and scores of the indicators in the area led to the following conclusions.

The two indicators of volume ratio and population density in the land use system and the two indicators of green transportation trip sharing rate and 800-meter coverage rate of rail transportation in the urban transportation system have larger weights, all of which exceed 0.15; all indicators are positive except for motor vehicle ownership density. Within a certain range of values, the lower the density of motor vehicle ownership is, the more favorable the evaluation results are, and the higher the values of volume ratio, population density, land mix, employment ratio in the district, road area ratio, green transportation trip sharing rate in the district and 800-meter coverage rate of rail transportation are, the more favorable the evaluation results are.

The population density in the area is relatively high, the analysis of the reasons that: the area is in the planning and development stage, the geographical location advantage is obvious, the area has a world-class theme park - Six Flags Paradise, rail transit line 1 Bishan station, only a mountain away from the University City, Six Flags tunnel has already started construction, after completion will strengthen the traffic between the University City Linkage, but the price of the university city is significantly higher than that of the Six Flags area. Therefore, the population density index of the Six Flags area, which is livable, has convenient transportation and good development momentum, scores higher.

The high score of employment ratio in the area indicates that the urban design based on rail transit TOD mode is effective, and one of the characteristics of TOD mode is that it is functionally complex, convenient and efficient, which can realize the clothing, food, housing, transportation, employment and entertainment in the area to a large extent, reduce transit traffic and improve the travel efficiency of residents in the area.

The weighted score of urban land use indexes in the area is 0.4284, and the weighted score of urban transportation system indexes is 0.3298. Therefore, it can be considered that the land use situation in the area is better than the construction of transportation facilities. Because the urban design of the area adopts the TOD model of rail transit, the comprehensive planning and integrated construction of the station square of the rail Bishan station have significantly enhanced the urban land use effect and also driven the construction of the surrounding traffic. However, there is still room for further improvement of the construction of transportation facilities in the area.

5. Conclusion

Using the established index system, the traffic carrying capacity of the TOD project in the Six Flags area of Bishan District, Chongqing was evaluated based on the hierarchical analysis method. The land composition, population and number of jobs, urban road mileage and traffic trip composition in the study area were analyzed, and the weight factors of each index were derived using the judgment matrix to analyze the score of the study project, showing the whole process of traffic carrying capacity analysis and evaluation, and the calculation results concluded that the traffic carrying capacity of the study project was at a relatively coordinated stage.

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