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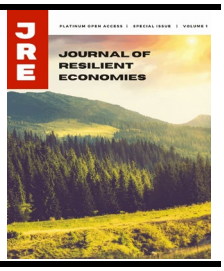

Research Note: Optimising Urban Furniture in External Space of Subway Stations in China- A Case Study of Wushan Station in Guangzhou

Weixuan Chen[1], Ali Cheshmehzangi[2], Eugenio Mangi[3], Timothy Heath[4]

Abstract

With the Transit-Oriented Development (TOD) model developing in urban construction in China, the contradiction between limited space resources outside subway stations and the enormous demands of stakeholders has become more prominent. The present research on urban furniture mainly focused on the underground space system and the development of surrounding industries. Still, there was a lack of in-depth discussion on the external space of subway stations. This research aims to explore the spatio-temporal differences of activities in the external space of the subway station and put forward the corresponding optimising strategies of urban furniture. The external space of Wushan station in Metro Line 3 in Guangzhou was selected as the research area to investigate and analyse human activities and their demands through the PSPL Survey. It was found that there were significant peaks of human flow on weekdays and weekends separately. On weekdays, the peak was mainly concentrated in the morning and evening. At the same time, that was slightly behind, concentrated primarily on the weekend meal times and apparent differences in the routes of human flow, resulting in different stakeholders having demanded seats. Therefore, this paper proposed foldable and modular design strategies. It could provide a reference for optimising public facilities in the same type of space and a research basis for urban space renewal and rail traffic optimisation.

Keywords: Subway Station; External Space; Optimisation of Urban Furniture; Spatio-temporal Difference of Activities; PSPL Survey; China

[1] Department of Architecture and Built Environment, University of Nottingham, Nottingham, United Kingdom, ORCiD: 0000-0003-4121-9589
[2] Corresponding author: Department of Architecture and Built Environment, University of Nottingham Ningbo China, Ningbo, China, email: ali.cheshmehzangi@nottingham.edu.cn, ORCiD: 0000-0003-2657-4865
[3] Department of Architecture and Built Environment, University of Nottingham Ningbo China, Ningbo, China, ORCiD: 0000-0003-0438-5828
[4] Department of Architecture and Built Environment, University of Nottingham, Nottingham, United Kingdom, ORCiD: 0000-0002-5833-2097

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1. Introduction

Rail transit is the backbone of the urban transportation system, and subway stations are important nodes connecting urban rail transit and public space. The original living street space in the city and subway stations developed in or over the track construction form a unique station external space. The development of subway stations has driven the development of commerce and service industries in the surrounding areas, creating a population agglomeration effect. Most surrounding environments include residential areas, commercial areas, and public management service areas such as universities. However, a contradiction cannot be ignored between the limited space resources in the external space of subway stations.

This research took the external space of the entrances and exits of Wushan Metro Station A and B1 of Guangzhou Line 3 as an example of the characteristics of the rich distribution of business types and active public activities in typical subway stations in the central urban area. Through the PSPL survey method, the spatio-temporal distribution of human activities was analysed. It accordingly proposed optimisation strategies for urban furniture in such space, providing design references for the renewal of the external space of subway stations.

2. Literature Review

The relevant research on the external space of subway stations began from Transit-Oriented Development (TOD) model developed by Calthorpe (1993). TOD is a compact, mixed-use, pedestrian and bicycle-friendly planning strategy (Salat & Ollivier, 2017). Cervero et al. (2002) proposed that the TOD development model needs to create a more compact and diverse walking environment. Whether the original street space environment of the city can meet the needs of people, the flow of resources brought by the newly implanted subway stations for the space environment supporting has become a trend to create a vibrant urban space (Song & Xia, 2018).

Existing research has been carried out on the surrounding space of subway stations. Many scholars paid attention to the relationship between human behaviour and the built environment, such as the distribution mechanism of pedestrians outside subway stations (Townsend & Zacharias, 2010; Zacharias, 2015; Zacharias & Zhao, 2018), Chinese TOD development models (Jin et al., 2011), the underground space planning method of the subway station (Wang, 2018), the business situation outside the subway station (Chen et al., 2013) and the use of public art in the subway space (Wen, 2020). Additionally, related research also was carried out on the external space and human behaviour of subway stations, such as the appropriate walking scale of rail transit stations (Liu, 2019), the influencing factors of environmental walkability (Chen et al., 2015), and the environmental suitability evaluation system of subway stations (Duan et al., 2018). As such, the underground space system and the development of surrounding industries have been fully studied. However, as Wu et al. (2021) stated, subway stations have a significant role in promoting the vitality of their external space, which is always neglected.

Furthermore, existing studies explored the optimisation and design of urban furniture. For example, Zhan (2021) proposed that the design path of environmental facilities can be considered and practised from the directions of regional adaptability, modular combination, structural change, ecological sustainability, and intelligent interaction but lacks exploration for specific urban spaces. Armato and Follesa (2021) and Jiang and Yu (2020) put forward the optimisation design strategies of urban furniture for the space between living streets, sidewalks, and streets and verified the specificity of space, the characteristics of different types of space, and the existence of facility optimisation strategies. Therefore, it is necessary to carry out optimisation strategies for urban furniture, specifically for the external space of subway stations, to effectively improve the quality of such space.

3. Methods

This research mainly adopts a qualitative case approach, allowing the development of an in-depth understanding of the case (Yin, 2015). A typical site, Wushan station, was selected as the case, and the materials used in the analysis included fieldwork data. The fieldwork was conducted in April 2021 after an ethics clearance. During the fieldwork, we frequently visited there to observe how the place was used by pedestrians.

3.1 Case study

The research area is located at the junction of Yuehan Road and Wushan Road in Tianhe District, Guangzhou, connecting the Wushan Station entrance of Metro Line 3, the main entrance of South China Agricultural University, and the side entrance of South China University of Technology (Figure 1). There are two entrances and exits in the area, Wushan Metro Station A and B1, with a small square surrounded by restaurants, retail shops, and newsstands (Figures 2 & 3). These entrances provide convenience to the lives of teachers, students, and residents around and bring a huge flow of people.

The study area is typical and representative of the external space of subway stations in China. There are many residential areas, commercial areas, and public management service areas such as colleges and universities around the area. There are plazas with hard paving and green facilities at the entrances and exits. The users are diverse, mainly college teachers and students, local community residents, and businessmen, with a high degree of public activities.

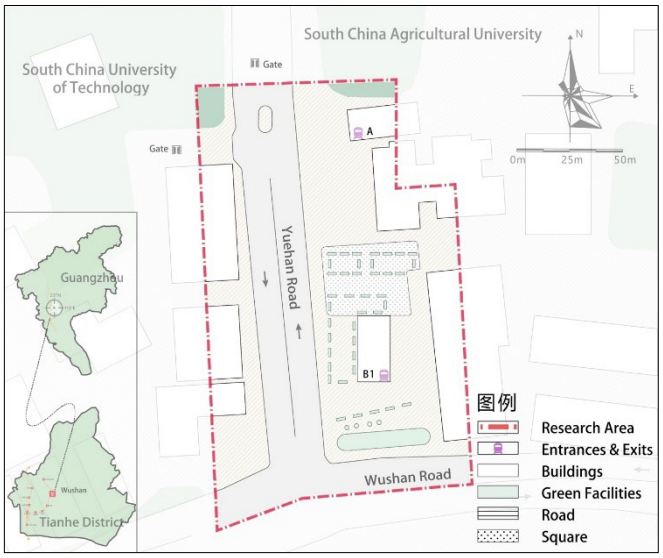

Figure 1- Research area (source: authors' edition based on the Google Maps)

Figure 2- The small square (source: authors' own)

Figure 3- Figure 3 Shops (source: authors' own)

4. Data Collection and Analysis

In this project, we elaborated on the Public Space - Public Life (PSPL) theory to construct a methodological framework that embeds the spatial and temporal distribution of space users. This method was formed by Jan Gehl from 1966 to 1971, divided into three parts: Public Space Analysis-Public Life Investigation-Summary and Recommendation (Gehl, 2013). We have developed a survey instrument based on the principles of PSPL to evaluate the quality of urban public space and the public living conditions of citizens.

Based on the complexity and functional differences of the site, this study divided the research site into two statistical areas (Figure 4). Area 1 is Exit B1 of Wushan Subway Station, the intersection of Yuehan Road and Wushan Road, and KFC's west side. Area 2 is Exit A of Wushan Subway Station, the east section of Yuehan Road, and commercial streets, including Wushan Zhengfeng Supermarket and its surrounding public spaces. This study was conducted on weekdays from 14th to 17th April 2021 and weekends from 18th to 19th and from 25th to 26th April 2021, for a total of 8 days, from 8:00 to 22:00, every 5 minutes per hour. By counting the number of people who were active in the two areas in different periods and taking the average of the same period on different days, the number of people per unit within the hour was calculated.

Furthermore, more than 650 person-times within 5 minutes were observed as the baseline for the peak flow of people to reflect the time difference in crowd behaviour. We conducted unstructured interviews that did not have a set pattern, and questions were not arranged in advance and were relative to situations of the space, which could introduce more detail and nuance to the micro-level space (Zhang & Wildemuth, 2009).

Ten types of main users including four residents, two university students, one university teacher, one street office and two shop staff were interviewed, and their behavioural characteristics and demands were summarised. Moreover, the notation method was to observe the spatial distribution and activity routes of different types of users in the space and record the crowd behaviour paths, aiming to obtain more accurate information to reflect the spatial differences of crowd behaviour in the outer space of the subway station.

Figure 4- Statistics areas (source: authors' edition based on the Google Maps)

5. Results and Discussion

5.1 Temporal Distribution Characteristics

As Figure 5 shown, there were obvious characteristics of the time distribution of pedestrians on weekdays and weekends when there was a peak of the number of pedestrians around 18:00. Furthermore, there were different characteristics of that. For example, the peak periods of pedestrians mainly occurred at 8:00 and from 17:00 to 19:00 on weekdays, while they occurred from 9:00 to 10:00, from 12:00 to 13:00 and from 18:00 to 21:00 on weekends. This phenomenon was mainly because many people had meals there.

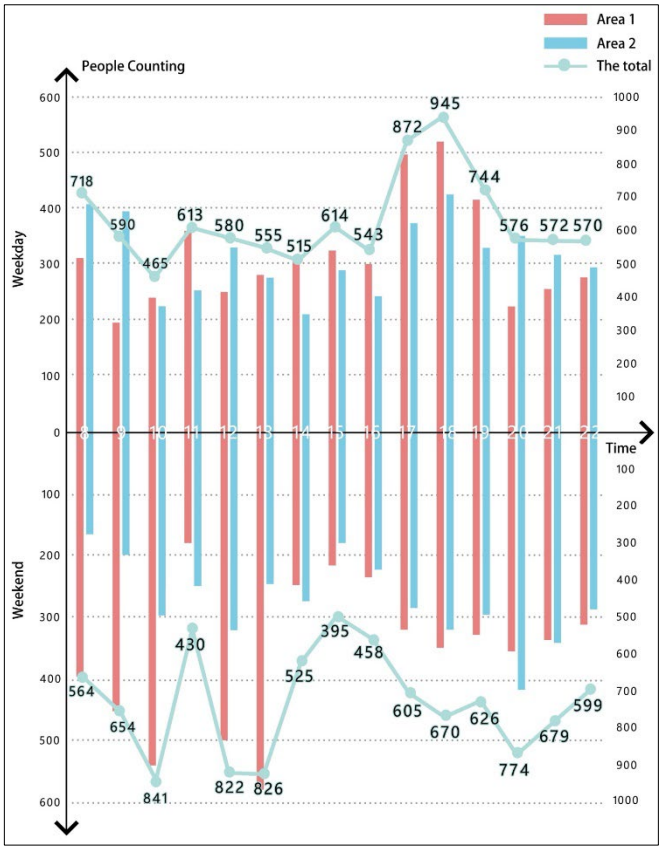

Figure 5- Time distribution of people (source: authors' edition)

Except for a peak of nearly 600 people at around 13:00, the total pedestrian flow fluctuated between 150 and 500 people within 5 minutes in Area 1 on weekends. The overall flow of people did not fluctuate much in Area 1 on weekends. On weekends, the peak hours mainly occurred from 9:00 to 10:00 and from 12:00 to 13:00. On weekdays, the rush hour mainly occurred from 16:00 to 20:00, mostly because off-duty workers went shopping, had dinner, went home, and students returned to universities. People's use of Area 2 was mainly concentrated in the evening. Except around 13:00 and 18:00, there was no apparent fluctuation in the flow of people at Exit A on weekends.

The flow of people fluctuated between 200-450 people in 5 minutes, with different peak times on weekends and weekdays. The peak hours on weekends mainly appeared between 10:00-14:00 and 17:00-20:00, and even the highest peak in a day was at 20:00. On weekdays, the peak hours mainly occurred from 8:00-9:00 and 17:00-20:00. By comparing weekdays and weekends, it was found that during off-peak hours, the fluctuations in the flow of people on weekdays and weekends were the same, and only during peak hours, there were more people on weekdays than at weekends.

To sum up, Figure 6 shows the peak time of human activity in the venue during different hours. The flow of people fluctuated greatly in terms of time distribution, and the flow of people had prominent aggregation characteristics. The peak flow of people on working days was in the morning and evening. Compared with the peak flow of people on working days, that on weekends and weekends were slightly behind, mainly concentrated in the period of three meals and meals, which was related to the effect of commercial agglomeration around subway stations. Nevertheless, the present space layout was difficult to meet a considerable load of people during the peak periods.

Figure 6- Distribution of people traffic during peak hours (source: authors' edition)

5.2 Spatial Distribution Characteristics

The main flow routes of the peak and off-peak periods in the venue were delineated (Figures 7 & 8). Due to the psychological tendency to choose the spatial scale (Gehl, 2013), the pedestrians would unconsciously go around the flower bed during off-peak hours and move in a wider space. Still, they would deliberately walk into the garden with green facilities during peak hours.

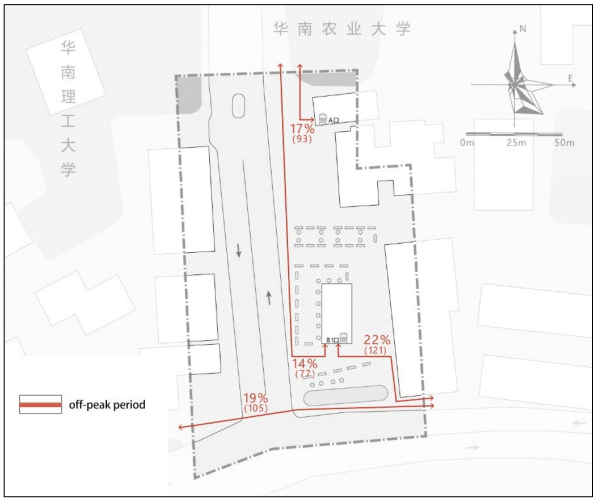

Figure 7- Streamline during the off-peak period (source: authors' edition based on Google Maps)

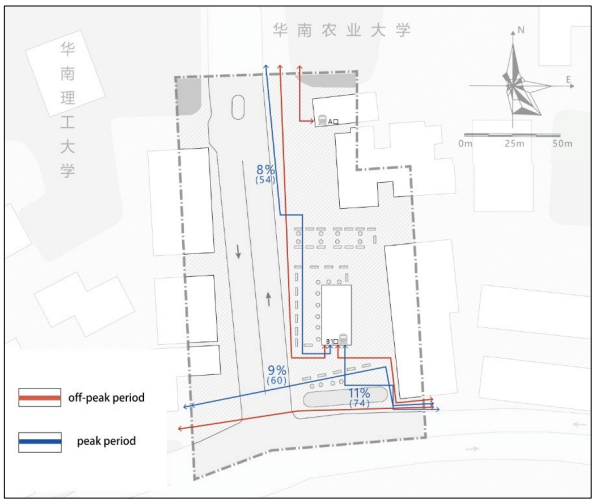

Figure 8- Peak flow line (source: authors' edition based on Google Maps)

In addition, the main gathering points of people flow were at the entrances and exits of subways A and B1, and many green facilities occupied the square space where people could gather. As a result, the flow of people could not pass and use this space. In addition to many commuters, some people stop and talk in the external space of subway entrances and exits. Because there were no rest facilities such as seats in the venue, they could only stand or squat on stone piers or flower bases (Figures 9 & 10), resulting in congestion at subway entrances and exits.

Figure 9- People who stop and communicate (source: authors' own)

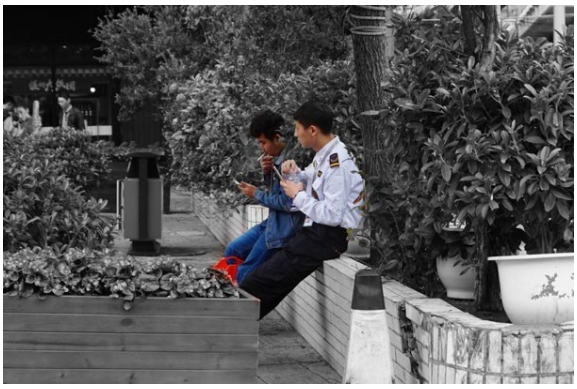

Figure 10- Crowds squatting on the flower base (source: authors' own)

Therefore, in terms of spatial distribution, there were obvious differences between the pedestrian flow routes during the peak and off-peak periods, mainly because too many green facilities cut the space. The square, originally responsible for gathering and dispersing people, was also occupied by unnecessary greening facilities. The gathering function of traffic made the functional zoning in the site chaotic, and the space was not used reasonably.

According to the above investigation and analysis of the spatiotemporal differences, this type of space had several salient features: (1) The flow of people had significant peak periods, and the working days were mainly concentrated in the morning and evening peaks, while weekends were mainly concentrated in three meals; (2) There are obvious differences in the flow routes of people during peak periods and off-peak periods. It was necessary to set up corresponding facilities to meet the demands of different types of people. Therefore, this paper proposed the following facilities optimisation strategies to provide a reference for the renovation and redevelopment of the same type of space.

6. Optimisation Strategies

Based on the research on the spatio-temporal differences of human activities in the surrounding space of subway stations, this paper proposed urban furniture optimisation strategies of foldable design and modular design.

6.1 Foldable Design

Due to the limited space at the entrances and exits of the subway, it is necessary to carry the traffic diversion function of the flow of people. However, setting fixed seats at the entrance and exit reduces the space for pedestrians to pass through and cause congestion during the peak flow of people. The needed seats are essential when the space function is switched during off-peak hours. Hence, this paper proposes a design strategy for foldable facilities. Folding facilities originated from the concept of folding furniture and have been widely used in interior design and product design (Cao, 2011). However, its application to urban public space lacks in-depth research references.

Due to the diverse structures of foldable facilities, their appearance and shape can be reasonably adjusted according to the space (Zhang & Jin, 2020). Taking the folding seat as an example, the design is combined with the original green facilities such as flower boxes and flower bases. Seats can meet the needs of pedestrians for short-term waiting, stopping, and resting during off-peak periods such as morning and afternoon. It can then be folded onto the greening facilities not to affect the needs of a large number of pedestrians for accessibility (Figure 11). The folding seats of the green facility provide a new solution that can meet pedestrians' basic needs for short-term resting activities and does not occupy ample space. They can be folded to the original facility when not in use.

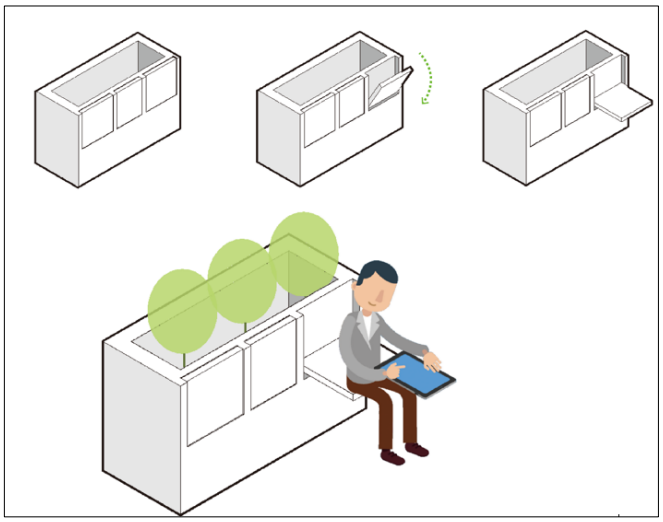

Figure 11- Figure The folding seat (source: authors' edition)

6.2 Modular Design

Residents require external space to provide facilities that can stay for a long time and accommodate a large volume. Modular design is one of the effective design paths. The facility does not have a fixed form and is flexible and changeable according to needs. Through the free combination, splicing, and stacking of single modules, various types of rest spaces, such as benches and grandstand seats, can be spelt out (Zhan, 2021). This type of space connects the subway station to the entrances and exits of colleges and universities, shopping plazas, and other places with dense crowds and plays a vital role in crowd dispersal. The design also needs to meet the needs of college teachers, students, and residents for spontaneous activities such as rest during off-peak periods.

Cube-shaped modules replace decorative facilities such as flower boxes. Through the free combination of modular facilities used by different groups of people, different combinations can be put together according to the differences in their needs in different periods. Blocks, such as single modules, can be used for resting, waiting and other activities for a single person, and the surrounding or row volume can provide multi-person conversations; during peak traffic times, the single modules can be stacked to make full use of the vertical space (see Figure 12). The modular design can meet the different needs of different groups of people in different periods, improve the interaction between people and space and rationalise the flow of people through space guidance.

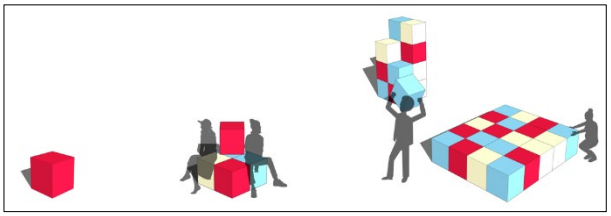

Figure 12- Modular design of the square (source: authors' edition)

7. Conclusions

With the TOD model's increasingly prominent urban catalyst effect, the development of rail transit stations in many cities in my country has entered a stage of thermalisation. While paying attention to the development of surrounding industries and land value by subway stations, it is also necessary to pay attention to improving the living environment space. This study selected the external space of Guangzhou Metro Line 3 Wushan Metro Station as the research area, which has the characteristics of business distribution and public activities of typical subway stations in the city's central area.

PSPL survey method was adopted to analyse the spatial and temporal differences in crowd activities in this space. The study found that in this type of space, the flow of people has significant peak periods. They were mainly concentrated in the morning and evening rush hours on weekdays, while they were slightly behind, mainly in the time of three meals on weekends. Based on the spatio-temporal differences of human activities, according to public space analysis and public life investigation, this paper summarised and recommended optimisation strategies for the facilities in the external space of subway stations, providing references for optimising environmental facilities in the same type of space.

Furthermore, this paper only proposed urban furniture's design ideas and strategies and did not involve specific technological construction. The technical aspects of the proposed strategy need to be further explored in future research.

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