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Retraction

Retracted: Comparative Study on Characteristics of Urban Road Network in Station Catchment Area between China and Other Countries for Station-City Integration

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Journal of Advanced Transportation has retracted the article titled "Comparative Study on Characteristics of Urban Road Network in Station Catchment Area between China and Other Countries for Station-City Integration" [1] due to concerns that the peer review process has been compromised.

Following an investigation conducted by the Hindawi Research Integrity team [2], significant concerns were identified with the peer reviewers assigned to this article; the investigation has concluded that the peer review process was compromised. We therefore can no longer trust the peer review process, and the article is being retracted with the agreement of the Chief Editor.

References

[1] Y.-Z. Dai and C.-Y. Zhang, "Comparative Study on Characteristics of Urban Road Network in Station Catchment Area between China and Other Countries for Station-City Integration," *Journal of Advanced Transportation*, vol. 2022, Article ID 1910404, 12 pages, 2022.

[2] L. Ferguson, "Advancing Research Integrity Collaboratively and with Vigour," 2022, https://www.hindawi.com/post/advancing-research-integrity-collaboratively-and-vigour/.

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Research Article

Comparative Study on Characteristics of Urban Road Network in Station Catchment Area between China and Other Countries for Station-City Integration

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The urban road network is one of the most important factors affecting urban traffic operation in station catchment areas, as well as the main factor in station-city integration. China's high-speed railway has developed rapidly, and station catchment areas encompassed by station-city integration have emerged as city planning and urban design aims. However, the differences in urban road network characteristics in the station catchment area between China and other countries have not been adequately researched yet. Considering 20 station catchment areas encompassed by the station-city integration as examples, this study analyzes the intersection quantity and network density in station catchment areas to compare the characteristics of urban road networks in China with those in Europe, North America, and Japan. Combined with the square block model calculation, we found the following. (1) The network density in non-China cases is concentrated in 16–22 km/km^2. The Honkong West Kowloon Station and Shapingba Station approach this range, while the Shanghai Hongqiao Station and Hangzhou East Station feature considerably lower values than this range. (2) The intersection quantity in non-China cases is concentrated in 225 pcs/km^2. Except for that of the Honkong West Kowloon Station, the values for the Shapingba Station, Shanghai Hongqiao Station, and Hangzhou West Station are lower than this range. (3) Developing small-scale blocks by gridding has an optimal effect on station catchment areas within the side-length range of 47.1–97.5 m. (4) The current situation of the entire urban road network and the specifications for the design codes of the road network exhibit a certain correlation with the road network characteristics of the station catchment areas.

1. Introduction

With the cities in Europe, North America, and East Asia paying increasing attention to the sustainability of railway construction and urban development, the implementation of station-city integration has emerged as a common share of city planning and urban design aims. Along with the ideals of station-city integration, the urban network characteristics of these areas, particularly, station catchment areas, are being reshaped. Over the past decade, China's high-speed railway has developed rapidly. The total mileage of high-speed railways has reached 35000 km, and 1500 railway stations have been built by the end of 2019.

Road networks have been found to remain central in the spatial organization of urban areas over time across significant political, economic, environmental, demolition, and reconstruction changes that are considered important for station-city integration [1, 2]. In conjunction with the respective features within a city, such as land usage or traffic, road networks may determine the important functional, social, and perceptual properties of urban settlements, such as the efficiency of transportation and space utilization, social residential segregation, and way-finding [3]. Optimizing the road network for station-city integration will enable planners understand and optimize the status quo of intensive land use between railway stations and surrounding regions to save further travel time, space consumption, and urban energy. Simultaneously, it can enhance the vitality of station catchment areas and establish a suitable connection with the environment. Although traffic accessibility and pedestrian movement in station catchment areas are related to the matching of land use form and transport systems [4, 5], the road network characteristics of station catchment areas have not been adequately researched yet.

Investigating the characteristics of road networks is an important research direction based on inspection of the distribution of the different features across the road network and correlation with the geometric and other properties of road segments [6]. In a study specifically addressing road network measures, four groups of connectivity measures for road networks were classified as typological distinctions, data differences, particular locations, and space syntax [7]. Intersection quantity and network density are reliable indicators of road network characteristics [8], and the typical unit is often a square mile. "Intersection quantity" is typically measured by the number of intersections per unit area. "Network density" is equal to the ratio of the total length of all roads in a calculated area to the total area [9]. A better understanding of the intersection quantity and network density in cities would facilitate engineering solutions and improve management and planning [10]. Most empirical studies are based primarily on the analysis of a single case for urban planning or urban design, but they are inadequate. Existing research has focused considerably on the properties of road networks, and there has been only limited investigation of the differences between China and other countries.

This study addresses the following question. How are the characteristics of road networks suitable for station catchment areas? Do the road network characteristics of station catchment areas vary consistently across different countries and regions? In this study, we extend this research by analyzing the intersection quantity and network density in station catchment areas to compare the characteristics of road networks in China with those in Europe, North America, and Japan. These countries have implemented station-city integration that is expected in China as well. Investment in construction and operation can have a profound impact on social and economic activities [11]. The study framework involves four steps: study area and case selection, network density sampling, intersection quantity sampling, and quantitative analysis with the block model.

2. Methodology

To determine the intersection quantity and network density, we derived them using the BaiduMap database that contains data on the road networks with attribute information. BaiduMap API is a Python-based research tool that easily downloads BaiduMap data for any place name, address, or polygon in the world and, thereafter, constructs it into a spatially embedded graph-theoretic object for analysis and visualization.

2.1. Study Area and Case Selection. A station catchment area is a geographic space around a station that offers physical proximity to people to access transit services. The size of the station areas typically varies according to the transit service and mobility options of transit users. Nevertheless, many guidelines suggest ideal distances of 400 m (1/4 mi) to 800 m (1/2 mi) from a station [12]. Of the residents queried in one study, 93.7% accepted a maximum walking distance between 732 and 762 m, equivalent to a 10-min walk with an average walking speed of 1.22–1.27 m/s [13]. A large proportion of people (75%) are willing to walk up to 800 m for rail services [14]. The results from these studies provide us credence to consider 800 m as the radius in the definition of station catchment areas for this study (Figure 1).

To compare the characteristics of road networks in China with those in Europe, North America, and Japan, we employed 20 station catchment areas as our empirical case study, including 16 non-China cases and 4 cases of China (Table 1). These were selected based on the following three factors:

(i) Urban environment setting of station-city integration
(ii) Access to comprehensive and high-quality data of the present road network
(iii) Accounting for different countries and regions

The existence of railways has been deeply integrated into the lives of the residents in the city corresponding to these cases. In particular, East Asian metropolitan areas have developed railway networks and improved the transportation facilities [15].

2.2. Network Density Sampling. Network density is defined as the number of roads per unit area. In conventional traffic engineering definitions, network density is usually measured as meters of road (length) per square meter of ground area (surface). The unit of the outcome is the meter of network per square meter of unit area (km/km^2) given by the following expression:

$$D = \frac{L_{ca}}{S_{ca}}, \quad (1)$$

where S_{ca} is the station catchment area and L_{ca} is the total length of the road network.

Network density is the limit of the developmental relationship between road length and land use that is an important factor affecting traffic accessibility and pedestrian movement in station catchment areas. Theoretically, in a certain district, when the density of the road network increases, the traffic capacity should increase owing to increase in road supply, thus allowing more motor vehicles to pass. However, when the road network becomes denser, the intersections become disadvantageous for motor vehicles; in other words, traffic capacity declines [16].

The network density of station catchment areas obtained from the BaiduMap database for the 20 cases is shown in Table 2 and Figure 2.

The Toronto Union Station, Hongkong West Kowloon Station, and Futako-Tamagawa Station are built near a river

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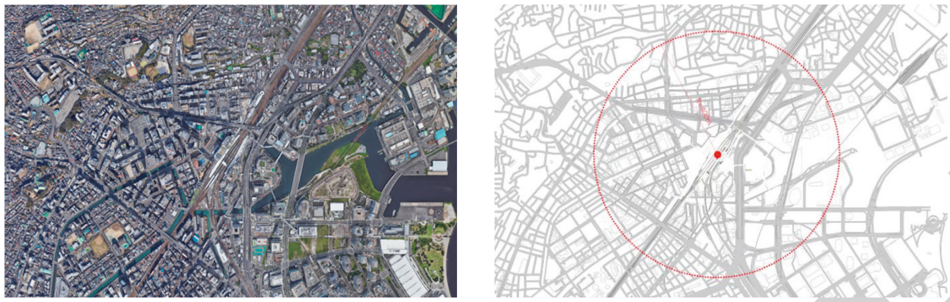

Figure 1: Overview of the study area: schematic of Yokohama station.

Table 1: Twenty station catchment areas for the current empirical case study.

Name of railway station	Location	Name of railway station	Network density
Osaka-Umeda station	Japan	Hangzhou west station	China
Shanghai Hongqiao station	China	Yokohama station	Japan
Kyoto station	Japan	Oslo central station	Norway
Nagoya station	Japan	Utrecht central station	Netherlands
Montparnasse station	France	Birmingham new road station	English
King's Cross-St. Pancras	English	Hakata station	Japan
Tokyo station	Japan	Sendai station	Japan
Lille-Europe station	France	Shibuya station	Japan
Toronto union station	Canada	Shapingba station	China
Hongkong West Kowloon station	China	Futako-Tamagawa station	Japan

Table 2: Data of road network density obtained from the BaiduMap database.

Name of railway station	Network density	Name of railway station	Network density
Osaka-Umeda station	20.63040233	Hangzhou west station	6.526844745
Shanghai Hongqiao station	6.184661618	Yokohama station	20.82194279
Kyoto station	20.88112854	Oslo central station	17.5319117
Nagoya station	21.57675201	Utrecht central station	16.05773904
Montparnasse station	17.01963173	Birmingham new road station	20.15846562
King's Cross-St. Pancras	20.97190941	Hakata station	20.44544188
Tokyo station	19.41418722	Sendai station	16.73414755
Lille-Europe station	17.64800423	Shibuya station	23.01330742
Toronto union station	12.07588131	Shapingba station	14.85960074
Hongkong West Kowloon station	14.01359274	Futako-Tamagawa station	17.71394517

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or sea, resulting in lack of consistency of study area with other cases; thus, the network density needs to be corrected. The correction factor is the ratio of total area with a radius of 800 m to the land use. The correction factor of the Toronto Union Station is 1.2000, the Hongkong West Kowloon Station is 1.2082, and the Futako-Tamagawa Station is 1.2645. The corrected road network density is 14.49105757 km/km^2 at the Toronto Union Station, 16.93122275 km/km^2 at the Hongkong West Kowloon Station, and 22.39928367 km/km^2 at the Futako-Tamagawa Station. The corrected data of road network density are shown in Figure 3.

2.3. Intersection Quantity Sampling. An intersection is the node of the road networks. In addition to network density, intersection quantity is also an indicator of traffic accessibility and pedestrian movement. There is an inverse relationship between intersection density and intersection spacing. An increase in one factor leads to a decrease in another factor. "Intersection quantity" is typically measured by the number of intersections per unit area (pcs/km^2), given by the following expression:

$$Q = \frac{N_{ca}}{S_{ca}}, \tag{2}$$

where S_{ca} is the station catchment area and N_{ca} is the number of intersections of the road network.

All types of vehicles and pedestrians on the road should be able to gather, turn, and pass through the intersection; thus, potential traffic congestion is expected. The higher the intersection density, the lower the traffic flow at the intersection that reduces the congestion at the intersection. As shown in Figure 4, from A to B at the same block size, the road network structure composed of widely spaced large roads can afford turning at seven intersections, and the road network structure composed of dense small-scale roads can afford turning at 23 intersections. However, when an

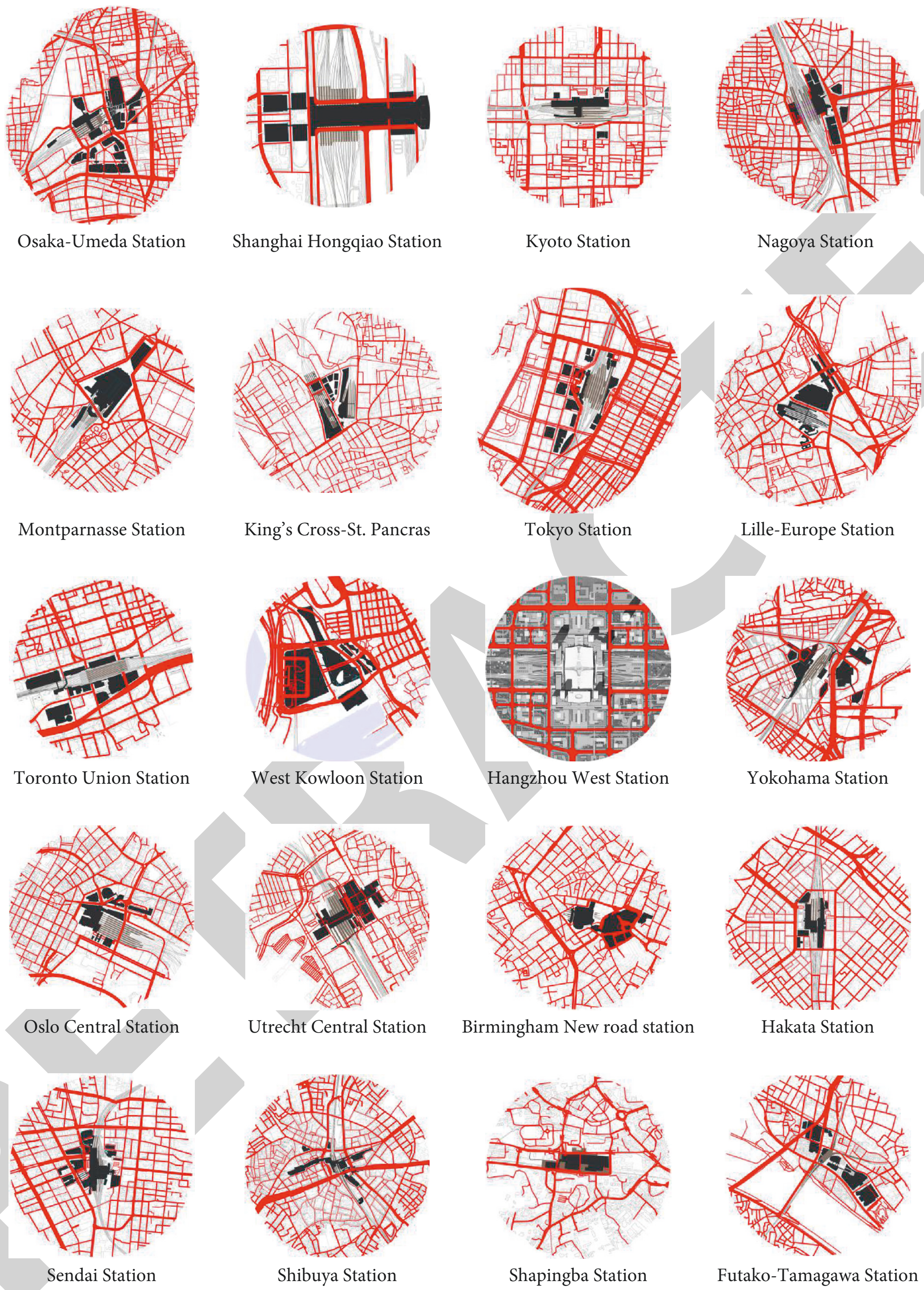

FIGURE 2: Network density sampling.

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intersection becomes denser, it is disadvantageous for motor vehicles. In principle, under a specific demand pattern, there should be an intersection value of road networks that maximizes the traffic capacity.

The data of intersection quantity of road networks obtained from the BaiduMap database for the 20 station areas are shown in Table 3 and Figure 5. The correction cases and correction factors are the same as those described in Section 2.2. The corrected intersection quantity is 82.3627 pcs/km^2 at the Toronto Union Station, 146.6219 pcs/km^2 at the Hongkong West Kowloon Station, and 200.6225 pcs/km^2 at the Futako-Tamagawa Station. The corrected data for the intersection quantity of the road networks are shown in Figure 6.

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Figure 3: Corrected data of road network density comparison.

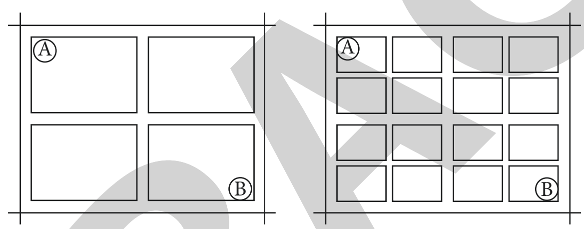

Figure 4: The road network structure.

Table 3: Data of intersection quantity of road networks obtained from the BaiduMap database.

Name of railway station	Intersection quantity	Name of railway station	Intersection quantity
Osaka-Umeda station	204.7319109	Hangzhou west station	21.88380468
Shanghai Hongqiao station	10.94190234	Yokohama station	186.0123398
Kyoto station	211.3776588	Oslo central station	134.2869833
Nagoya station	223.9872745	Utrecht central station	232.7641043
Montparnasse station	129.3133913	Birmingham new road station	204.4146301
King's Cross-St. Pancras	209.7905659	Hakata station	171.588923
Tokyo station	171.785249	Sendai station	117.8741297
Lille-Europe station	176.9768193	Shibuya station	260.1188602
Toronto union station	68.63556922	Shapingba station	102.4559946
Hongkong West Kowloon station	121.3556441	Futako-Tamagawa station	158.6575839

3. Quantitative Analysis and Results

3.1. Model Formulation. The road network structure composed of dense small-scale roads is well known for its convenience for nonmotorists; dense small-scale roads offer more direct road choices for pedestrians and cyclists; small-scale roads and intersections enable smooth crossing by pedestrians and cyclists. Nevertheless, while aspiring to these benefits, the specific design parameters of dense small roads for station catchment areas must be addressed. In cities, dense small-scale roads may lead to a rapid increase in road area ratio. A high road area ratio implies that land for nontraffic functions is reduced which is a significant challenge in the development of urban construction. The road area ratio is calculated as follows:

$$R = \frac{A_{ca}}{S_{ca}}, \quad (3)$$

where R is the road area ratio, S_{ca} is the station catchment area, and A_{ca} is the road area.

The block is the smallest urban unit surrounded by roads. Blocks with different functions are the basis for the formation of a diversified urban space. Blocks based on different scales are closely related to the intersection quantity and network density. A square block model was developed in this study to analyze the corresponding road network

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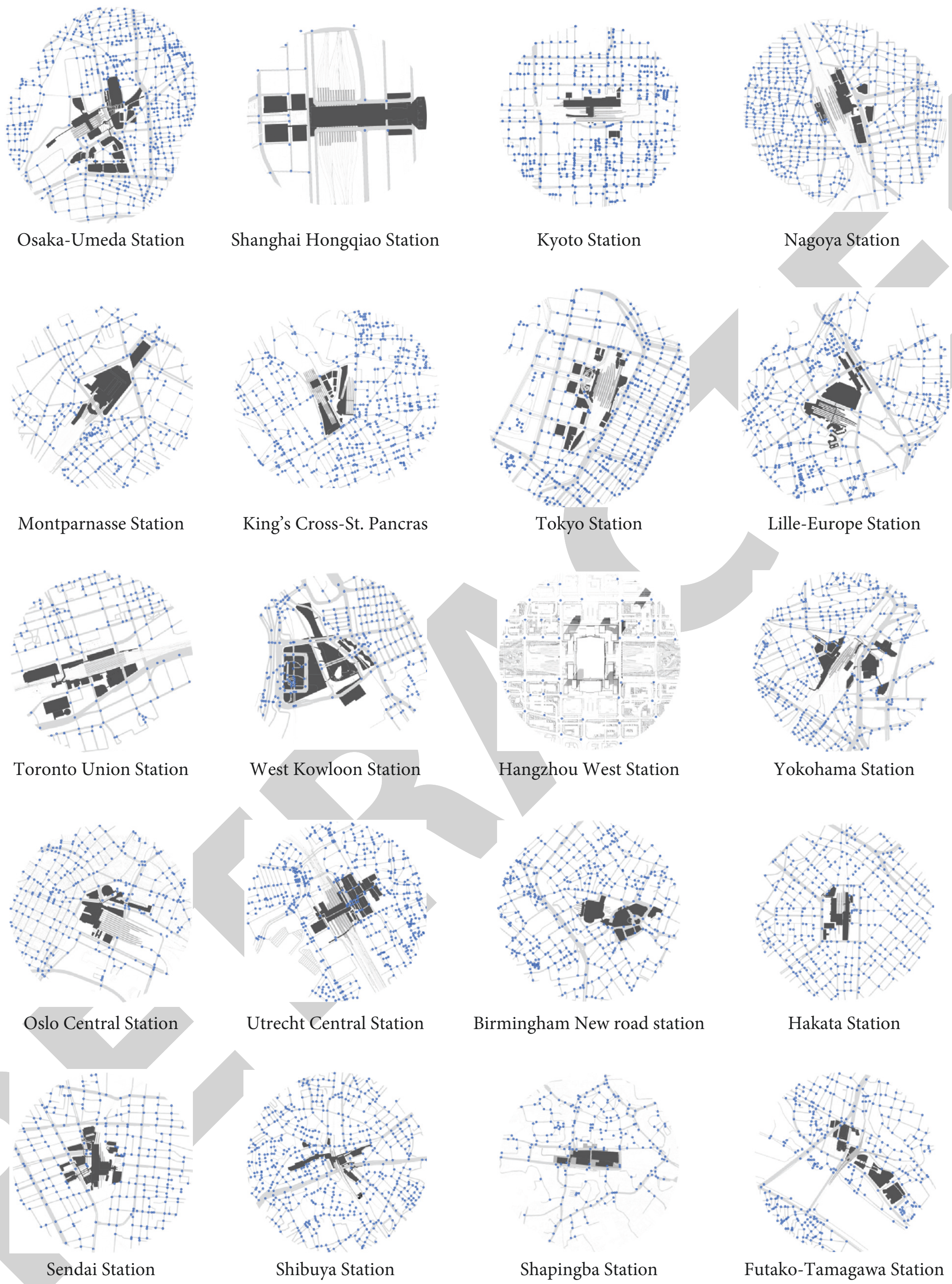

Figure 5: Intersection quantity sampling.

density and road intersection quantity under different block-scale planning in the station catchment area. This model is represented as follows:

$$B = \int (D, Q, R), \quad (4)$$

where B is the road network characteristics of the square block model, D is the network density, Q is the intersection quantity, and R is the road-area ratio. The square block model was set as a standard grid road network arranged at equal intervals with a side length of 1 km and a coverage area of 1 km 2. The square block model implies that the number of horizontal and vertical roads in the road network is the same, the number of lanes of each road is the same and arranged at equal intervals, and the road sections are two-way traffic comprising 60 m arterial road, 40 m secondary trunk road, and 20 m branch roads with red-line width.

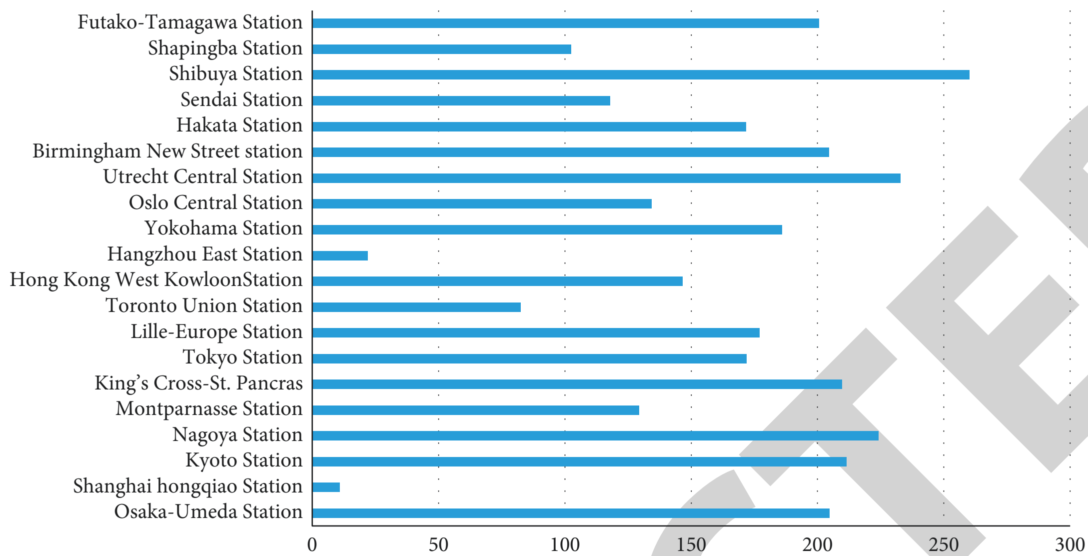

Figure 6: Corrected data of intersection quantity of road networks.

Different road network characteristics can yield different values, including the network density, intersection quantity, and road area ratio. To be consistent with the data obtained in the sample cases shown in Figure 7, the square block model continuously sets 15 numerical intervals and their corresponding structure types, as shown in Table 4 and Figure 8.

3.2. Comparative Analysis of Network Density. Figure 3 shows that the road network density in all cases is in the range of 5–25 km/km^2 that can be divided into five sections based on the distribution characteristics of the data. There are two cases corresponding to the 5–10 km/km^2 range, two cases corresponding to the 10–15 km/km^2 range, seven cases corresponding to the 15–20 km/km^2 range, and nine cases corresponding to the 20–25 km/km^2 range.

The standard deviation (STDEV) is a measure of how widely the values are dispersed from the average value (mean) that is used to calculate the dispersion of the interval value of the sample case. The formula used is as follows:

$$a = \sqrt{\frac{\sum_{i=1}^{n} (X_i - X)^2}{n-1}}, \quad (5)$$

where $\boldsymbol{X}$ is the average of all sample cases.

For the non-China cases, the interval value dispersion of 16 cases is 2.8466, reflecting that the difference in road network density in the above cases is small under station-city integration, with an average value of 18.7746 km/km^2. According to the network density clustering shown in Table 5, the road network density of non-China cases is mainly concentrated in A08–A11, and the road area ratio corresponds to 35.4–48.6%.

For the case of China, the Honkong West Kowloon Station (16.93 km/km^2) is in the range of 15–20 km/km^2. The Shapingba Station (14.86 km/km^2) and Toronto Union Station (14.49 km/km^2) are in the range of 10–15 km/km^2 that is not ideal. The road network density for the Shanghai Hongqiao Station (6.18 km/km^2) and Hangzhou West Station (6.53 km/km^2) is much lower than that in other cases that objectively reflects the insufficiency of traffic accessibility and pedestrian movement. Furthermore, all the four cases of China feature values below the average value of 18.7746 km/km^2.

3.3. Comparative Analysis of Intersection Quantity. Figure 5 shows that the intersection quantity for all cases is in the range of 0–300 pcs/km^2 and is divided into six sections. There are two cases corresponding to the intersection quantity of 0–50 pcs/km^2, one case corresponding to 50–100 pcs/km^2, five cases corresponding to 100–150 pcs/km^2, four cases corresponding to 150–200 pcs/km^2, seven cases corresponding to 200–250 pcs/km^2, and one case corresponding to 250–300 pcs/km^2.

For the non-China case, the interval value dispersion of the 16 cases was 35.8647, according to equation (5), and the average value of road intersection quantity was 181.4766 pcs/km^2. However, average value of road intersection quantity the Toronto Union Station was only 82.36 pcs/km^2. According to the intersection quantity clustering shown in Table 6, the intersection quantity of the non-China cases is mainly concentrated in A10–A14, and the road area ratio is 44.2–61.8%.

In the cases of China, the Shanghai Hongqiao Station (10.94 pcs/km^2) and Hangzhou West Station (21.88 pcs/km^2) are in the range of 0–50 pcs/km^2. The Hongkong West Kowloon Station (146.62 pcs/km^2) and Shapingba Station (102.45 pcs/km^2) are in the range of 100–150 pcs/km^2. All the four China cases feature values below the average value of 181.4766 pcs/km^2.

4. Discussion

Here, a comparative study has been conducted on the road network characteristics of station catchment areas encompassed by station-city integration between China and other

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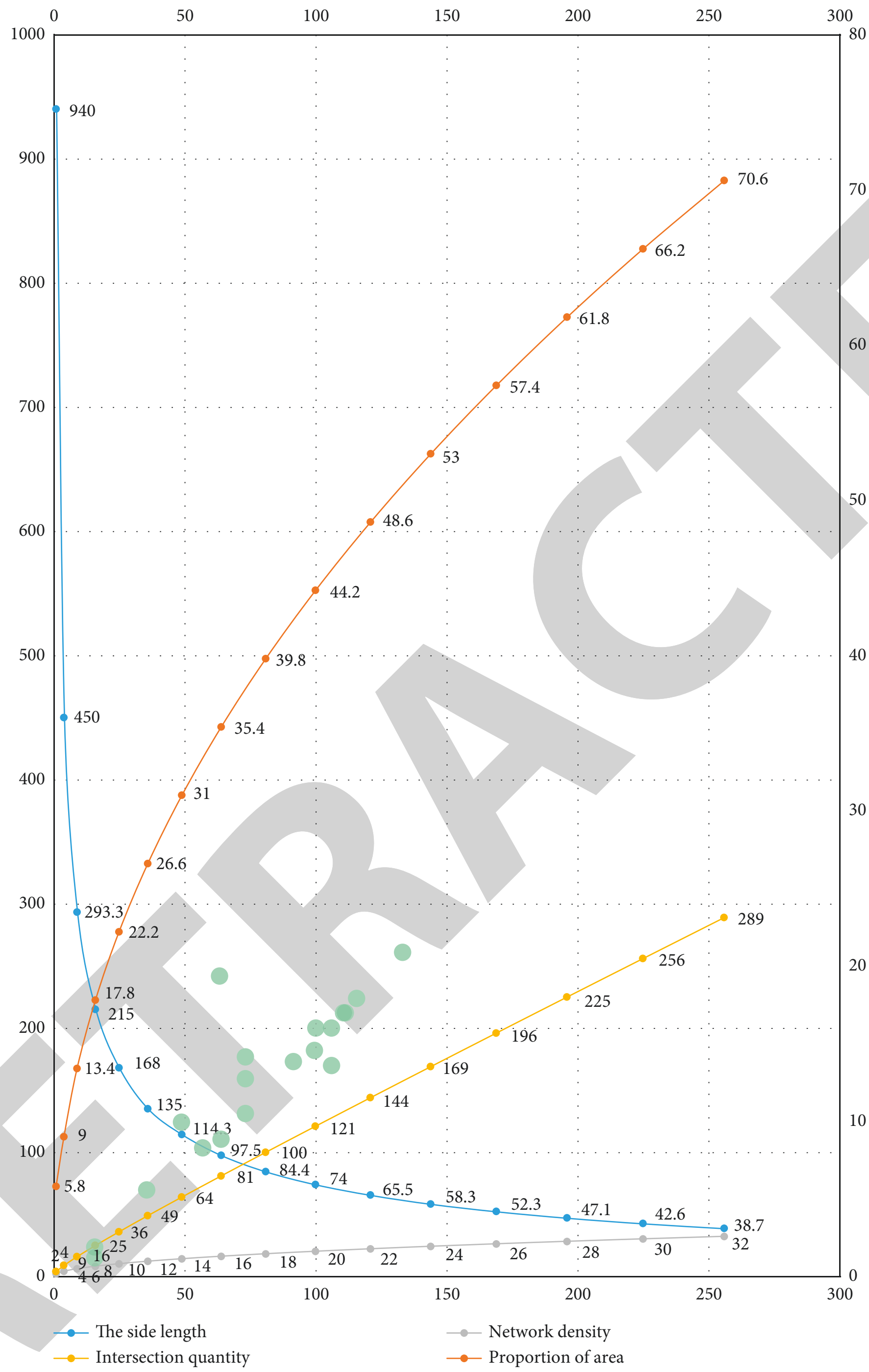

Figure 7: Simulation data of the square block model.

countries to support design practices. Based on the results of data analysis and comparison, we consider the following aspects worthy of further discussion.

4.1. Importance of Setting Planning Standards and Design Codes. As per the survey results, first, the average road network density of non-China cases was 18.7746 km/km^2, mainly concentrated in A08–A11 (16–22 km/km^2). The Shanghai Hongqiao Station and Hangzhou West Station were in A03–A04 (6–8 km/km^2), and the Hongkong West Kowloon Station and Shapingba Station were in A07–A8 (14–16 km/km^2). Second, the average road intersection quantity of non-China sample cases was 181.4766 pcs/km^2, mainly concentrated in A10–A14 (121–225 pcs/km^2). The Shanghai Hongqiao Station and Hangzhou West Station were located in A2–A4 (9–25 pcs/km^2), and the Hongkong West Kowloon Station and Shapingba Station were in

Table 4: Fifteen numerical intervals set by the square block model.

Name	Divided block	The side length (m)	Proportion of area	Network density (km/km^2)	Intersection quantity (pcs/km^2)
A01	1	940.0	5.8	2	4
A02	4	450.0	9	4	9
A03	9	293.3	13.4	6	16
A04	16	215.0	17.8	8	25
A05	25	168.0	22.2	10	36
A06	36	135.0	26.6	12	49
A07	49	114.3	31	14	64
A08	64	97.5	35.4	16	81
A09	81	84.4	39.8	18	100
A10	100	74.0	44.2	20	121
A11	121	65.5	48.6	22	144
A12	144	58.3	53	24	169
A13	169	52.3	57.4	26	196
A14	196	47.1	61.8	28	225
A15	225	42.6	66.2	30	256

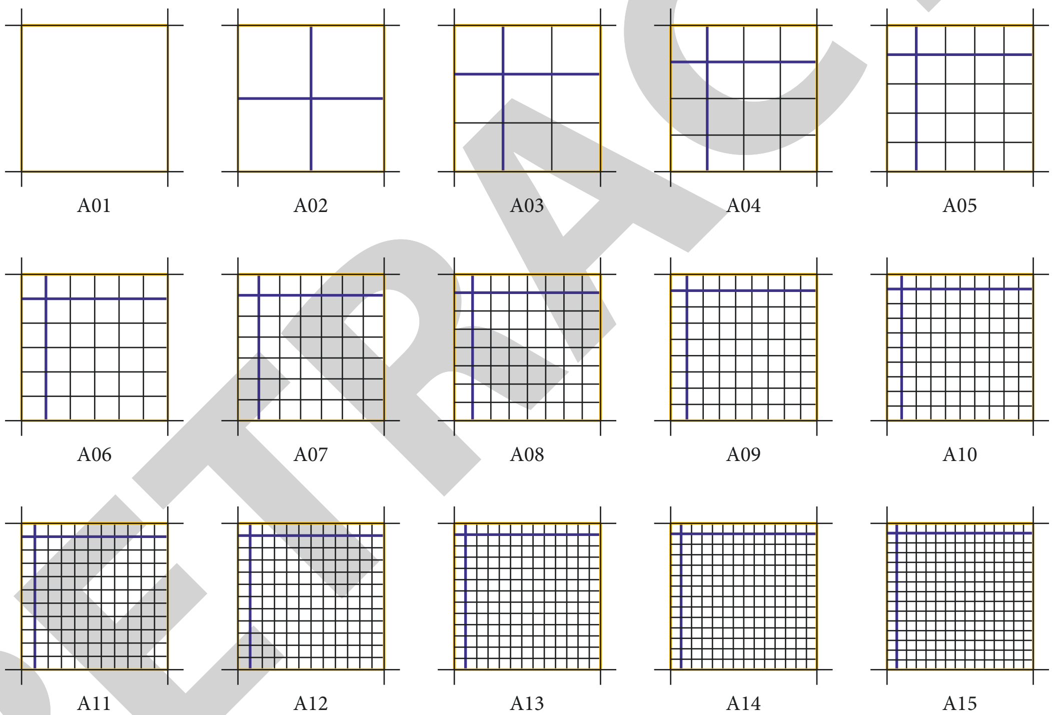

Figure 8: Fifteen types of road network structure continuously set by the square block model.

Table 5: Network density clustering.

Name of railway station	Network density	Name of railway station	Network density
(1) Osaka-Umeda station	A10-A11	(11) Hangzhou west station	A03-A04
(2) Shanghai Hongqiao station	A03-A04	(12) Yokohama station	A10-A11
(3) Kyoto station	A10-A11	(13) Oslo central station	A08-A09
(4) Nagoya station	A10-A11	(14) Utrecht central station	A08-A09
(5) Montparnasse station	A08-A09	(15) Birmingham new road station	A10-A11
(6) King's Cross-St. Pancras	A10-A11	(16) Hakata station	A10-A11
(7) Tokyo station	A09-A10	(17) Sendai station	A08-A09
(8) Lille-Europe station	A08-A09	(18) Shibuya station	A11-A12
(9) Toronto union station	A06-A07	(19) Shapingba station	A07-A08
(10) Hongkong West Kowloon station	A07-A08	(20) Futako-Tamagawa station	A08-A09

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Table 6: The intersection quantity clustering.

Name of railway station	Intersection quantity	Name of railway station	Intersection quantity
(1) Osaka-Umeda station	A13-A14	(11) Hangzhou west station	A03-A04
(2) Shanghai Hongqiao station	A02-A03	(12) Yokohama station	A12-A13
(3) Kyoto station	A13-A14	(13) Oslo central station	A10-A11
(4) Nagoya station	A13-A14	(14) Utrecht central station	A14-A15
(5) Montparnasse station	A10-A11	(15) Birmingham new road station	A13-A14
(6) King's Cross-St. Pancras	A13-A14	(16) Hakata station	A12-A13
(7) Tokyo station	A12-A13	(17) Sendai station	A09-A10
(8) Lille-Europe station	A12-A13	(18) Shibuya station	A15-A16
(9) Toronto union station	A07-A08	(19) Shapingba station	A09-A10
(10) Hongkong West Kowloon station	A10-A11	(20) Futako-Tamagawa station	A11-A12

Table 7: Entire urban road network density with the corresponding station catchment areas.

Name of railway station	Urban road network density	Name of railway station	Urban road network density
Osaka-Umeda station	23.99	Hangzhou West station	6.98
Shanghai Hongqiao station	7.15	Yokohama station	23.22
Kyoto station	21.19	Oslo central station	18.6
Nagoya station	25.08	Utrecht central station	16.3
Montparnasse station	15.4	Birmingham new road station	17.9
King's Cross-St. Pancras	18.1	Hakata station	22.4
Tokyo station	19.92	Sendai station	5.10
Lille-Europe station	17.78	Shibuya station	19.92
Toronto union station	23.74	Shapingba station	6.49
Hongkong West Kowloon station	22.9	Futako-Tamagawa station	19.92

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A9–A11 (100–144 pcs/km^2). Third, the average road area ratio of the non-China cases was greater than that of the cases of China.

However, it is surprising to note that the road network characteristics of the cases of China meet the current specifications.

(i) 《Code for transport planning on urban road GB 50220-95》stipulates that the road density should be 5.3–7.1 km/km^2 in large cities, 5.2–6.6 km/km^2 in medium-sized cities, and 6–14 km/km^2 in small cities.

(ii) 《Standard for urban comprehensive transport system planning GB/T 51328-2018》proposes requirements for road network density for different types of functional areas from the perspectives of block scale and road network density. The standard requires the road network density of residential functional areas to be 7–15 km/km^2 and that of business functional areas to be 10–20 km/km^2.

(iii) 《Code for Classification of Urban Land Use and Planning Standards of Development Land GB 50137-2011》stipulates that the proportion of road area should be 10–25%.

As the implementation of station-city integration has started only recently in China, there are no absolute specifications for the planning standards and design codes of the road network in station catchment areas in China. It is necessary to comprehensively understand the characteristics of road networks in station catchment areas for station-city integration and to advance the setting of planning standards and design codes conducive to rapid development in the later stages.

4.2. Entire Urban Road Network Correlation. It should be noted that there are significant differences in the characteristics of road networks across different cities. The road network of station catchment areas is a part of the entire urban road network; therefore, it is also affected by the entire urban road network.

Table 7 presents the overall urban road network density for the corresponding station catchment areas. Figure 9 shows the correspondence of two groups of data: the entire urban road network density and the corresponding road network of the station catchment areas. It can be observed that the two groups of data are the same. The correspondence analysis illustrates the implicit feature that the sample case does not deliberately enhance the road network density of station catchment areas; it is merely an extension of the characteristics of the entire urban road network density. Thus, the judgement of road network density of road network in station catchment areas involves the entire urban road network. This also indirectly shows that station-city integration is based on a higher level of urban development.

4.3. Development of Small-Scale Blocks. The square block model shows that the road area ratio is closely related to the road network density and road intersection quantity. Figure 8 shows that small-scale blocks may lead to a rapid increase in the road-area ratio by more than 50%. The development of station catchment areas is not entirely

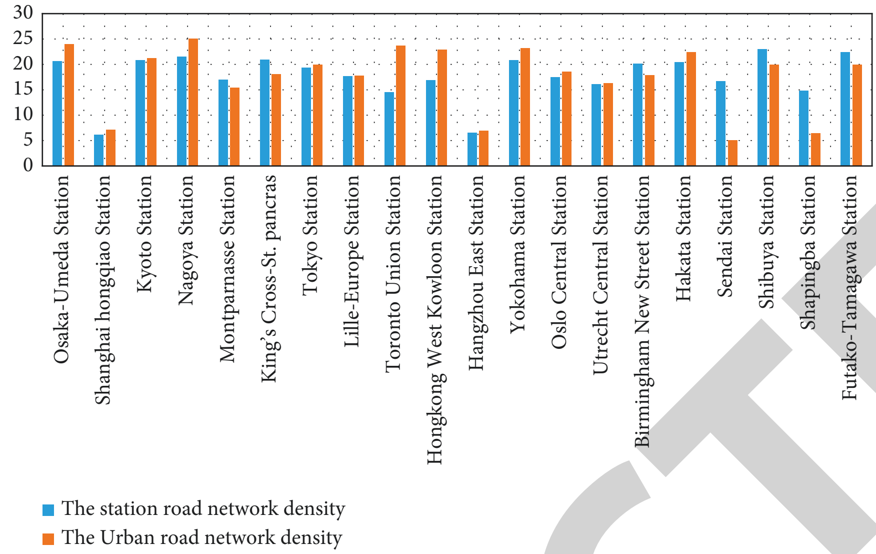

Figure 9: Correspondence of two groups of data.

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spontaneous, but entails conscious spatial guidance to adapt to station-city integration; the development of small-scale blocks is the primary starting point. Increased number of road intersections is generally associated with increased walking and biking [17].

Based on the results of the comparative analysis, non-China cases were concentrated in A08–A14, and the corresponding road area ratio was 35.4–61.8%. Based on the above interval, the side length of the block was 47.1–97.5 m. In contrast, the Shanghai Hongqiao Station and Hangzhou West Station were "large blocks," with a side length of 215.0–293.3 m. The larger the blocks are, the smaller and narrower is the road space available for external public transport. Traffic flow can only be concentrated on a limited number of roads that are prone to congestion and affects public interests.

Although the connectivity of the station catchment areas was improved in the small-scale blocks, it would incorporate more road intersections and T-shaped roads to the block, increasing the complexity of traffic flow and increasing the travel time. Therefore, developing small-scale blocks by gridding had an optimal effect on station catchment areas within a side-length range of 47.1–97.5 m.

4.4. Limits and Prospects. Overall, the conclusions of this study convey the differences in road network characteristics in station catchment areas between China and other countries from three aspects: road network density, road intersection quantity, and road area ratio. Nonetheless, the study has the following limitations: First, owing to the limited number of samples, the applicability of the conclusions drawn by the study to other regions is still to be explored. Second, the study did not analyze the appropriate grade proportion of road networks in the station catchment areas. Third, in the sample case, the rationality of the road network in the station catchment areas depends partly on synthetic judgement.

Despite these deficiencies, this study still makes a significant contribution. Through an investigation of a series of cases, the characteristics of road networks in station catchment areas were compared by rational quantitative means. To compensate for these shortcomings, future research needs to be combined with new technical means and methods for expansion. (1) Computer science, particularly, the application of simulation tools, would provide a fast evaluation method for the performance of road network. (2) The synergetic method can clarify the correlation between transportation exchange centers and road networks in station catchment areas.

5. Conclusion

The road network is one of the most important factors affecting urban traffic operation in station catchment areas as well as the main factor of station-city integration. Based on 20 sample cases, this study compares the performance of road networks in China with those in Europe, North America, and Japan and draws the following conclusions:

(1) Through a comparative analysis of road network density, it is found that the road network density of the station catchment areas is concentrated in 16–22 km/km^2. The Honkong West Kowloon Station and Shapingba Station approach this range, while the Shanghai Hongqiao Station and Hangzhou West Station exhibit values considerably lower than this range.

(2) Through a comparative analysis of road intersection quantity, it is found that the road intersection quantity of station catchment areas is concentrated in 121–225 pcs/km^2. Except for the Honkong West Kowloon Station, the Shapingba Station, Shanghai Hongqiao Station, and Hangzhou West Station exhibit lower values than this range.

(3) According to the calculation results of the square block model, the road area ratio is 44.2–61.8%, and the side length of block is 47.1–97.5 m. Small-scale blocks in station catchment areas could be developed based on the aforementioned range.

(4) It is found that the current situation of the entire urban road network and specific specifications for the design codes of the road network are correlated with the road network characteristics of the station catchment areas.

Data Availability

The data are obtained based on the authors' building model and meet the specified requirements.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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