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Road Landscape Morphology of Valley City Blocks under the Concept of “Open Block”—Taking Lanzhou City as an Example

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Abstract: The unique valley geographical environment and the congestion-prone road landscape make valley city traffic jammed easily. In this paper, under the background of “open blocks”, two open patterns, which correspond to two different road landscapes (“ideal grid opening” and “open under realistic conditions”), are proposed. Taking Lanzhou city as an example, six basic statistical characteristics are used to compare and analyze the changes of road network topology in blocks to find out which open pattern is more suitable for valley cities. The results show that the pattern “open under realistic conditions” has a significant effect on the improvement of network performance and capacity. Specifically, breaking the “large blocks” and developing the small-scale blocks help to alleviate the traffic pressure. Besides, the opening of blocks located along river valley has a more positive effect on improving road network performance than the blocks sited in the inner area of cities.

Keywords: “open block”; road landscape morphology; valley city; complex network

1. Introduction

In Lynch’s urban image theory, road and blocks are two main elements that people perceive the overall image of the city [1]. Urban roads as the veins of the city, and blocks as the places of people’s activities, both them are the main elements that make up the overall cityscape. For a long time, China’s urban residential communities are mainly closed blocks. For example, closed small neighborhoods account for 83% of the total residential quarters in Shanghai, and in Guangdong Province they cover more than 70% of urban and rural areas and more than 80% of the population [2]. The closed block mainly refers to the neighborhood where the internal road system is closed to the outside world. In the city, the closed block is a complete land with no urban roads. It can be seen as dividing the urban land into blocks, which can easily cause the city to form a sparse and wide road network and destroy the connection between urban road networks. Furthermore, reducing the density of the branch networks and the accessibility between the roads can easily lead to traffic congestion [3]. In the closed blocks, the internal road system of the block presents an introverted tree structure, only one or two main roads are connected to the outside urban road network. These closed neighborhoods cut off the “capillary vessels” of the urban road network, so that the traffic flow is concentrated on a few main roads of the city, which leads to regional paralysis of the traffic system once traffic jams occur in the main roads [4].

In order to solve this problem, the concept of “open block” has been attached great importance. Open block mode is a planning pattern developed from the new urbanization, specifically relates

to the house construction along the roadside without fencing or access control, and advocates for walking friendly, mixed use as well as resource-sharing [5]. In essence, open block is an increase in the supply of transportation resources [3]. Under the background of open blocks, open or semi-open closed roads inside the neighborhood will not only cancel the separation of the closed block from the outside world, but also publicize the internal roads and allow vehicles around the block to freely travel through the block, and then provide pedestrians with more travel route options. It can divert the saturated traffic flow of the main road, thus forming a road network system with the coordination of expressway, main and secondary roads and branch roads, thus alleviating the urban traffic congestion to a certain extent [6]. In China, the open block is still in the early stage of development at present. The theoretical researches mainly re-understand the open block from the aspects of adaptive strategy [7,8], advanced experience and reference [9,10], and study the open block pattern, which is suitable for Chinese cities from the aspects of residential branch system improvement [11], network reliability [12], traffic accessibility [13], etc., but the use of open concept from the block level to solve the overall urban traffic congestion problem is rarely studied.

In actual traffic, the congestion of a certain road section will gradually spread to adjacent sections and nodes in the urban transportation network. Therefore, a thorough study of the formation mechanism of traffic flow at congestion bottlenecks and the evolution law of the specific complex weighted network of urban traffic network can essentially explain the mechanism of urban traffic congestion, and then find the fundamental cause of local traffic paralysis. Therefore, it is of great scientific significance to analyze the impact of different topological characteristics on congestion propagation on the basis of systematic analysis of the traffic network topological characteristics and the evolution characteristics of the urban traffic network itself, and then to put forward effective road planning and control strategies to alleviate and prevent traffic congestion [14].

Complex network theory focuses on the macro-phenomena of the system caused by the micro-interaction between individuals. It can link the micro-and macro-properties and predict the overall behavior of complex systems, including small-world, scale-free and so on. Therefore, it becomes a powerful tool for studying traffic networks. A large number of studies have shown that the urban traffic network has the structural characteristics of complex network and traffic congestion is closely related to the topological structure of traffic network, which suggests that we can study traffic problems from the perspective of changing the network topological structure [15]. Hence, traffic congestion and its dynamical relation to network structures have become a hot topic of investigation [16,17]. Besides, Wu et al. used the SIR (Susceptible/Infected/Removed) model to study traffic congestion propagation on complex networks and find that the behavior of the traffic system is tightly related to the average rate of infection, the average recovery rate and the topological properties of traffic network [18,19]. Later, they further found that for the same value of congestion factor, there may be different efficiency, which shows that only congestion or efficiency alone cannot evaluate the performance of networks effectively [20]. By analyzing the public transport networks of 22 cities in Poland, Sienkiewicz et al. found that all the networks exhibit small world behavior, and the degree distribution of the networks also conforms to the power law distribution (or exponential distribution) [21]. Latora et al. found that the original network statistical parameters (average path length and clustering coefficient) are not applicable to the analysis of Boston's metro network. Furthermore, two new parameters, local efficiency and global efficiency, are introduced. On this basis, it is found that the Boston metro network has the characteristics of small world [22].

The above studies are all for general urban road traffic networks, and for the valley cities studied in this paper, they have their own particular characteristics due to their unique topographical conditions. A valley is a trough-shaped zone caused by river geological effects on the surface. The general types of river valleys are: valleys, canyons, wide valleys and complex river valleys [23]. A valley city refers to a city whose development is directly restricted by the strong terrain of the river valley. The city itself is forced to develop along the terrain and the river. Due to the limitation of mountains and the division of rivers, the urban space is narrow and the integrity is poor, and the urban development is

laid out along with the special terrain. Compared with plain cities, valley cities are difficult to form urban ring road because of the large undulation of terrain, and the road is often arranged along the mountain or river bank to reduce the slope. In addition, since the main axis of urban development generally extends along the main channel of the river, the urban road network presents a narrow and long strip-shaped dense spatial structure, which results in the organization of valley city traffic is quite different from other cities, and a large number of traffic is concentrated in the urban main roads and bridges on both sides of the river valley [24].

As one of the major urban types in western China, the valley city is formed and developed in the valley. Due to the special shape of the valley, the urban road network presents the characteristics of unbalanced distribution and is easily congested [25]. How to effectively reduce the traffic congestion in river valley cities has an essential impact on shaping the landscape pattern of urban roads. As a typical valley city in the western region, Lanzhou's traffic landscape construction and development has attracted more and more attention. Scholars have studied the urban road traffic in Lanzhou City from the aspects of the causes of traffic congestion [25], cross-river traffic [26], transit traffic [27], residents' travel pattern choice [28], traffic gradation system [29], characteristics and planning of public transport network [30,31], respectively.

Road network, as the basis of road traffic research in valley cities, is also one of the research contents of urban road landscape morphology. Road landscape morphology uses morphological perspectives in the study of urban road landscapes by combining landscape morphology [32], landscape planning and construction, architecture and urban design and other related disciplines. It not only has the meaning category of road landscape, but also contains the thought of morphology and landscape morphology, including physical pattern, virtual pattern and image pattern. Among them, from the macro view point of the virtual pattern constitutes the road network of the urban space vein, the road itself is the spatial sequence and order influenced by the road alignment and architectural layout [33]. At present, the research on the virtual pattern of urban road landscape mainly focuses on the impact of road network construction on urban ecological landscape, such as the impact of road network expansion on the connectivity of ecological landscape [34–36], the impact on ecological risk of urban landscape [37], the impact on the urban ecological landscape pattern [38], the impact on the ecological diversity of agricultural landscapes [39] and so on.

This paper studies the landscape pattern of valley urban block roads from the following two aspects: (1) pay attention to traffic microcirculation of road network in block. In urban roads, if the main and secondary roads outside the block are regarded as arteries and veins, then the road network in the block is equivalent to capillaries. Only arteries and veins cannot support the normal blood circulation of the human body. Capillaries must be spread everywhere to make the blood flow more smoothly, which means that the internal road circulation in each area of urban road construction planning is also essential. Traffic congestion is a common problem in urban road landscapes. Most of the researches or strategies to solve this problem are based on the improvement of urban primary and secondary road network outside the blocks, while neglecting the internal road network of the blocks. (2) Starting from the level of urban road network, how to use the urban terrain characters to alleviate traffic congestion by constructing urban road landscape patterns with river valley characteristics is the key to the current research. However, the existing traffic landscape researches do not combine the regional characteristics of valley cities. Therefore, in this paper, we take the regional characteristics of valley cities into consideration and explore traffic development patterns from different block opening patterns to provide theoretical basis and scientific strategies for alleviating urban traffic congestion in valley cities.

The rest of this paper is organized as follows. Section 2 discusses the research method and takes Lanzhou City as an example, selecting 10 case blocks as the research object. Then, Section 3 presents two open patterns, namely “ideal grid opening” and “open under realistic conditions”, and gives the road network topological structures of the case blocks. Further, Section 4 analyzes the complex network characteristics of case blocks under the two open patterns, and finds that the “open under

realistic conditions” is more effective, then, summarizes the research results. On these bases, Section 5 proposes an idea for the construction of road landscapes in valley cities in the future.

2. Complex Network Theory and Case Blocks

2.1. Complex Network Theory

In 1998, Watts and Strogatz of Cornell University, and in 1999, Barabasi and Albert of Notre Dame University put forward the WS (Watts-Strogatz) model [40] and BA (Barabasi-Albert) model [41], respectively, which revealed the small world effect and scale free property of complex network, and laid a solid foundation for the research of complex network theory. The study of complex network theory pays attention to the macroscopic phenomena of the system caused by the micro-interaction between individuals. It can link the microscopic and macroscopic properties and predict the overall behavior of complex systems, including self-organizing characteristics, emergence, etc., thus becoming a powerful tool for the study of traffic network. From the perspective of graph theory to analyze urban traffic, the urban roads can be regarded as edges, the intersections can be regarded as nodes, and the travel cost or flow rate of different paths can be regarded as the weights of edges, so the traffic system can be completely abstracted as a complex network. The application of complex network theory in an urban traffic system mainly includes evolution mechanism of traffic complex network, traffic network dynamics, traffic congestion control, etc. [42–47]. In the aspect of urban traffic network, it mainly studies the influence of network topology on network capacity and network traffic flow, so as to find an effective approach for urban traffic congestion alleviation [15]. In the study of the statistical characteristics of complex network structures, many concepts have been proposed, including: average degree, clustering coefficient, average path length, density, diameter and global efficiency. Therefore, in this paper, we also use these six statistical parameters commonly used in complex network theory to study the changes of road traffic network topology in valley cities under different “open block” patterns, and then put forward suggestions for the urban road landscape mode in valley cities.

- (1) Average degree. Degree represents the number of edges directly connected to a node in the network. Average degree is the arithmetic average of the degrees of all nodes. Average degree is more scientific to represent the connection characteristics of the network [48]

$$\bar{k} = \frac{1}{N} \sum_{i=1}^n k_i, \quad (1)$$

where, k_i is the degree of node i , and N is the number of network nodes, $\bar{k}$ is the average degree. If a node in the network has the largest degree, it is considered that the node is in the center of the network, that is, the node has the largest “power”. The degree of a node emphasizes the number of nodes directly connected to it, but ignores the connection with the indirect connection point, so the degree usually represents the local characteristics of the network. The average of all node degrees is called average degree, which can represent the density of the network structure as a whole. The smaller the $\bar{k}$ is, the better the traffic network accessibility.

- (2) Average shortest path length. The average shortest path length is the arithmetic mean of the shortest path length between all nodes in the network. It is often used to measure the network tightness. In the empirical research, many real networks have small average shortest path lengths and small world effects. The calculation formula is as follow [48].

$$L = \frac{1}{N(N-1)} \sum_{i \neq j} d_{ij}, \quad (2)$$

where, d_{ij} is the shortest path length between two nodes, and the smaller the L is, the better convenience of the network is, and the average travel distance length is not too long. In the empirical study of complex networks, it is found that the average shortest path of many complex networks is much smaller than that imagined, which also reflects the characteristics of small world of complex networks.

- (3) Clustering coefficient. The ratio of the number of edges actually connected between the neighbor nodes to the maximum number of possibly connected edges, indicating the possibility that the neighbors of the nodes in the network are also neighbors to each other. It is often used to measure the degree of network grouping [48]. The clustering coefficient of node i is:

$$C_i = \frac{2l_i}{k_i(k_i - 1)}, \quad (3)$$

where, l_i is the actual number of boundaries between node i and its adjacent nodes. The larger the C_i is, which indicates that the tighter the connection between node i and its adjacent nodes, the better the traffic network accessibility.

- (4) Density. Density is used to measure the connection strength between nodes in a network. A network with a density close to 0 is called a sparse network [43].

$$C_c(i) = \left[\sum_{j=1}^N d_{ij} \right]^{-1}. \quad (4)$$

The larger the C_c is, the closer the relationship between nodes in the network, the better the network accessibility.

- (5) Diameter. The maximum distance between any two nodes is the diameter of the network, which is the longest shortest path between any two nodes in the network, describing the connectivity efficiency and size of the whole network [44].

$$D = \frac{1}{N(N-1)} \sum_{i \neq j} D_{ij}, \quad (5)$$

where, D_{ij} is the maximum distance between node i and node j . The smaller the D is, the higher the accessibility of the road network and the greater the network carrying capacity.

- (6) Global efficiency. The global efficiency E is the average of the reciprocal sum of the distance between all nodes in the network and other nodes different from that node, which indicates the average degree of traffic convenience and the global transmission capability of the network [45].

$$E = \frac{1}{N(N-1)} \sum_{i \neq j} \frac{1}{d_{ij}}. \quad (6)$$

Besides, when the network is attacked, the connectivity of the network is reduced and the global efficiency of the network is reduced. Therefore, the global efficiency is also used to measure the reliability and robustness of network.

2.2. Status of Lanzhou Road Network

Lanzhou is the capital of Gansu Province. It is located in northwestern China and central Gansu Province. It is a comprehensive transportation hub for railways, highways and aviation in the northwest of China, with a total area of 13,100 km². By 2018, the built-up area is 321.75 km². The population is 3,753,600 and the urbanization rate is 81.03%. The Yellow River passes through the city and divides the city into two parts. The two sides can only be connected by seven bridges. With the limitation of

the mountains and rivers, the transportation is mainly concentrated on the main road, there is not enough land space to expand the urban road and share the traffic pressure when the urban main road is saturated. The regions of the two sides have formed a relatively independent road traffic network because of their unique terrain. Therefore, taking Lanzhou City as an example, this paper studies the characteristics of street landscape form and seeks strategies to improve the road network structure of valley cities in order to construct the road landscape form with valley characteristics, refine the texture of Valley cities, and provide theoretical basis for alleviating traffic congestion in valley cities. At present, the road landscape pattern in Lanzhou has the following problems.

2.2.1. Low Road Network Density

According to the “Annual report on road network density in major Chinese cities” (2019), the overall road network average density of 36 major cities in China is 5.96 km/km². The valley city belongs to the strip-shaped city. The average road network density of the strip city obtained in the report is 4.49 km/km², while the road network density of Lanzhou City is only 4.13 km/km², which is not only lower than the average level of the strip cities, but also lower than the overall average density in the northern cities of 5.14 km/km² and the overall average density of the road network.

2.2.2. Congestion-Prone Road Landscape

Due to the limitation of the special valley terrain, the main body of Lanzhou city develops along the direction of the valley, resulting in the typical dumbbell shaped spatial structure of the urban road, and a large number of traffic flows are concentrated along the east-west main road of the central area of the city extending along the valley. In addition, the existence of a large number of closed blocks in the city, such as closed residential districts and campuses, because they do not allow outside vehicles to enter the block and share their internal roads, so that social vehicles can only be concentrated on the main and secondary roads, which increases the traffic burden of the main and secondary roads compared with the situation that the open blocks allow social vehicles to pass through the interior of the community. Moreover, with the development of urban construction, there are more and more closed blocks, which increase the number of T-shaped roads and end breaking roads and easily cause traffic jams. All of these contribute to the further increase of intersections, “big” road network, serious privatization of urban roads, and destroy the continuity of urban road landscape.

2.2.3. Case Blocks

Lanzhou City has the typical strip characteristics of valley cities. In order to fully reflect the impact of valley characteristics on urban road network, we selected 10 case blocks under the condition of spatial syntactic characteristic parameters based on the research results of road traffic network structure in Lanzhou City [49,50]. Meanwhile, in order to study the influence of the unique valley terrain on the results, we selected five blocks along the river and five blocks within the city for comparison. The length of each side of the block within 1–2 km, covering different city functions. The location of these blocks is shown in Figure 1. Among them, blocks 1–5 are located along the valley, and blocks 6–10 are located within the city.



Figure 1. Location of case blocks.

3. Open Patterns and Topological Structures of Case Blocks

3.1. Open Patterns

Before construct the case block topology network, assume that the T-shape road inside the closed block can be extended, and the fence can be opened and connected to the outside road. We defined the following two open patterns.

- (1) “Ideal grid opening”: In the existing researches, the open pattern of the block road network is mainly gridded, so this paper regarded it as one of the open patterns of the valley city open block. In this pattern, regardless of the practical implementation conditions, the road network inside the block is gridded and the complex characteristics were studied.
- (2) “Open under realistic conditions”: In reality, some blocks of roads are not allowed to open, such as government courtyards, private territories, etc. Besides, the distribution of connectivity degrees in river valley cities shows that roads with relatively long distances and good connectivity in urban road networks (main roads) are far less than those with relatively short distances and poor connectivity (branch roads). Therefore, in this pattern, considering the actual situation and feasibility, it keeps the number of current road network nodes unchanged to open the road network, mainly including: connecting the end breaking road in the block, extending the extendable road and so on.

3.2. Topological Structure of Case Blocks

Taking the road as the edge and the intersection as the point, the road network topology under the “status”, the “ideal grid opening” and the “open under realistic conditions” of the case blocks are obtained.

3.2.1. Road Network Topology under the “Status”

The road network structure topology diagrams of case blocks under the status as shown in Figure 2.

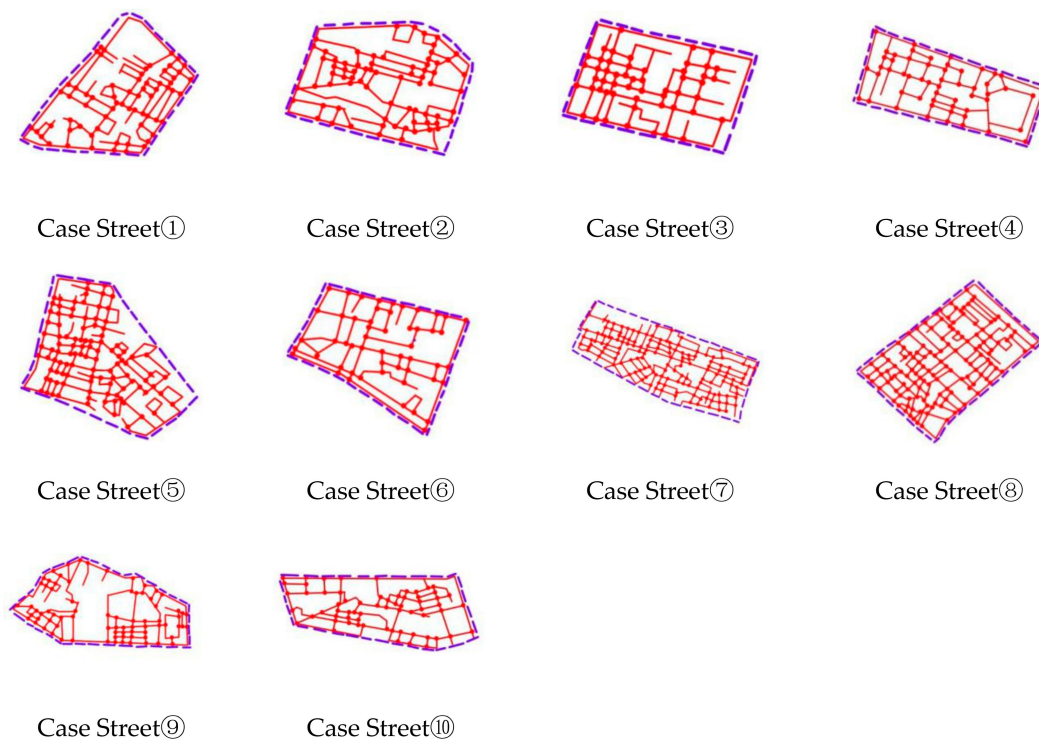


Figure 2. Status road network topology of case blocks.

3.2.2. Road Network Topology under the “Ideal Grid Opening”

The maximum block length is generally between 86 and 170 m [51]. Under this condition, the inner road networks of the selected blocks are gridded, and their topological structure diagrams are shown in Figure 3.

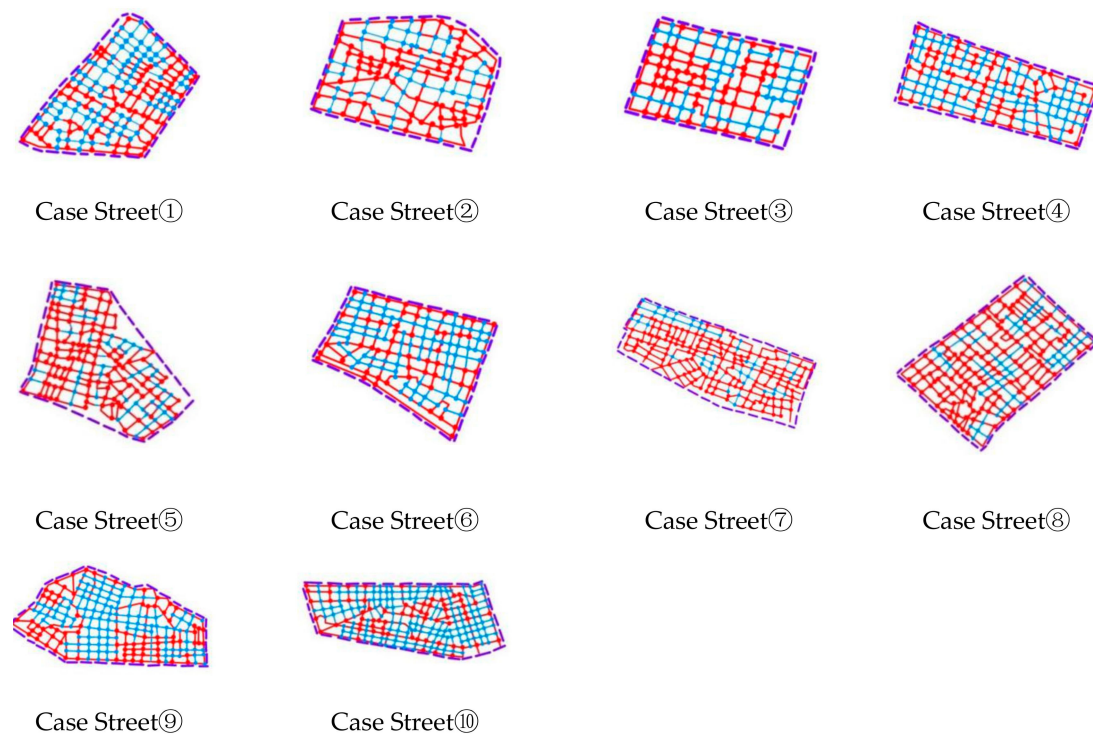


Figure 3. Road network topology under the “ideal grid opening”.

3.2.3. Road Network Topology in case of “Open under Realistic Conditions”

Under the “open under realistic conditions” pattern, connecting the end breaking road inside the block and extending the extendable road, keeping the number of current road network nodes unchanged to open the road network. The corresponding network topology structure diagrams are shown in Figure 4.

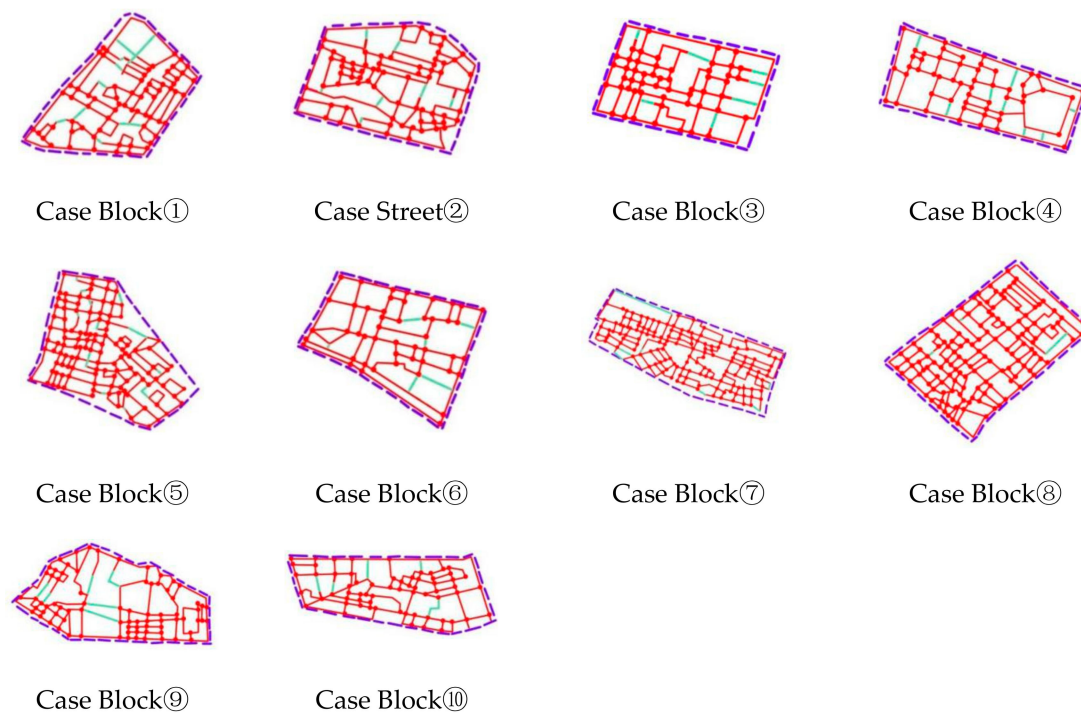


Figure 4. Road network topology under the “open under realistic conditions”.

4. Results and Analysis

Based on the current topological structure of the case blocks, the adjacency matrix was constructed, and then, the Pajek software was used to analyze the complex characteristics of the case street topology. The complex characteristics of the case blocks under different open patterns are shown in Table 1. In which, the open pattern “real conditions” was the pattern “open under realistic conditions” for short.

Based on the above experimental data, the complex characteristics of each block under different open patterns were compared. The comparison figure of each characteristic was as follows.

Table 1. Complex network characteristics of case blocks under different open patterns.

Case Blocks	Open Pattern	Number of Nodes	Number of Edges	Average Degree	Average Shortest Path Length	Clustering Coefficient	Density	Diameter	Global Efficiency
1	Status	66	134	5.697	6.030	0.044	0.044	16	0.17
	Ideal grid opening	145	292	7.228	6.877	0.076	0.026	20	0.162
	Real conditions	66	134	6.485	5.107	0.159	0.049	11	0.173
2	Status	58	118	5.724	5.087	0.055	0.05	11	0.257
	Ideal grid opening	160	322	7.013	8.267	0.047	0.022	22	0.223
	Real conditions	58	119	6.345	4.873	0.153	0.055	10	0.274
3	Status	133	268	6.376	7.256	0.072	0.037	15	0.236
	Ideal grid opening	196	394	6.929	8.551	0.013	0.018	20	0.178
	Real conditions	133	269	6.526	7.154	0.059	0.025	15	0.261
4	Status	77	156	6.234	6.696	0.034	0.041	16	0.189
	Ideal grid opening	197	396	7.168	8.179	0.033	0.018	22	0.172
	Real conditions	77	156	6.597	5.972	0.042	0.043	14	0.208
5	Status	66	134	6.121	5.251	0.13	0.047	10	0.219
	Ideal grid opening	189	361	7.083	8.616	0.099	0.016	23	0.217
	Real conditions	66	134	6.667	4.849	0.109	0.051	10	0.264
6	Status	76	154	6	5.744	0.043	0.04	12	0.189
	Ideal grid opening	155	312	6.658	7.962	0.03	0.022	18	0.165
	Real conditions	76	155	6.737	5.081	0.183	0.044	11	0.193
7	Status	60	122	5.8	5.298	0.023	0.049	11	0.222
	Ideal grid opening	159	320	7.069	7.959	0.056	0.022	22	0.172
	Real conditions	60	122	6.667	4.908	0.149	0.056	10	0.24
8	Status	111	224	5.946	7.631	0.093	0.027	20	0.265
	Ideal grid opening	164	328	6.744	8.447	0.02	0.021	22	0.175
	Real conditions	111	225	6.414	6	0.074	0.029	16	0.277
9	Status	53	108	5.585	5.235	0.048	0.054	12	0.253
	Ideal grid opening	171	344	7.029	8.251	0.011	0.021	19	0.172
	Real conditions	53	109	6.377	4.523	0.158	0.06	9	0.293
10	Status	147	296	6.313	8.609	0.016	0.022	22	0.251
	Ideal grid opening	193	388	6.933	8.572	0.01	0.018	22	0.175
	Real conditions	147	297	6.367	8.369	0.048	0.022	21	0.27

4.1. Average Degree

Figure 5 shows the average degree of the case blocks in three cases: the “status”, “ideal grid opening” and “open under realistic conditions”.

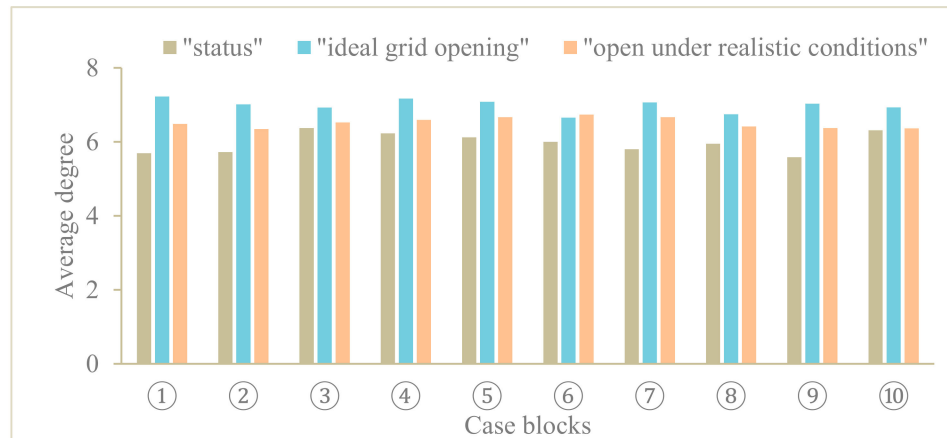


Figure 5. Average degree of case blocks.

It can be seen that the average degrees of case blocks under the “status” were between 5.6 and 6.4, they were between 6.3 and 6.7 under the “open under realistic conditions” and the pattern “ideal grid opening” had the highest average degree; the average degrees of case blocks under the “open under realistic conditions” were greater than that of “status” but less than that of “ideal grid opening”. In case of “open under realistic conditions”, the mean of the average degree of the blocks located along the river (namely, blocks 1–5) increased from 6.048 to 6.524 and for the blocks located within the city (namely, blocks 6–10), which increased from 5.929 to 6.512. After opening, the connectivity of the blocks along the river was greater than that of the blocks within the city. Therefore, “Open under realistic conditions” was effective to improve the road connectivity of blocks, but its connectivity was generally smaller than that of grid opening pattern.

4.2. Average Shortest Path Length

Figure 6 shows the average shortest path length of the case blocks in three cases: the “status”, “ideal grid opening” and “open under realistic conditions”.

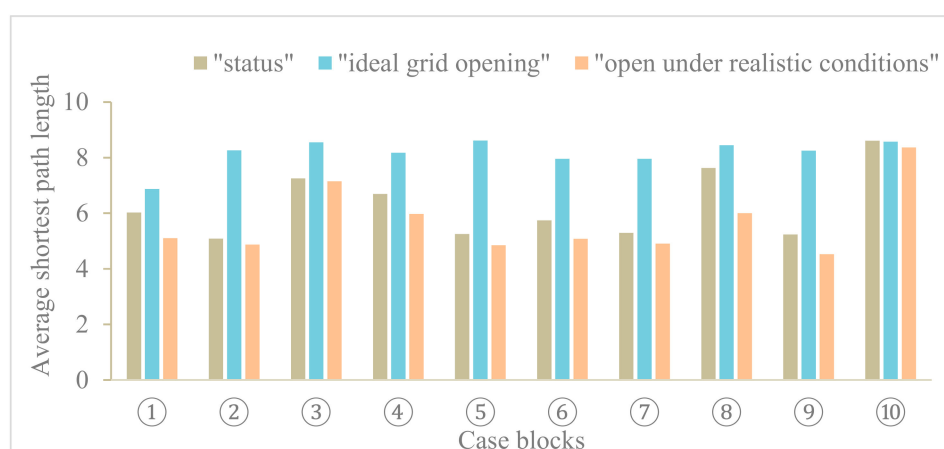


Figure 6. Average shortest path length of case blocks.

It can be seen that the average shortest path length of case blocks under the “status” were between 5.1 and 8.6, and they were between 4.5 and 8.4 under the “open under realistic conditions”, which were less than that of “status” and “ideal grid opening”. In case of “open under realistic conditions”, the mean average shortest path length of the blocks along the river decreased from the “status” of 6.064 to 5.591, and for the blocks within the city, which decreased from 6.503 to 5.776. Indicating the accessibility of block roads located within the city was greater than that of blocks located along the river. In addition, the average shortest path length of all blocks decreased after opening under realistic conditions, and it was reduced more than the “ideal grid opening”, so it had an optimization effect on improving the accessibility of the block roads.

4.3. Clustering Coefficient

Figure 7 shows the clustering coefficient of the case blocks in three cases: the “status”, “ideal grid opening” and “open under realistic conditions”.

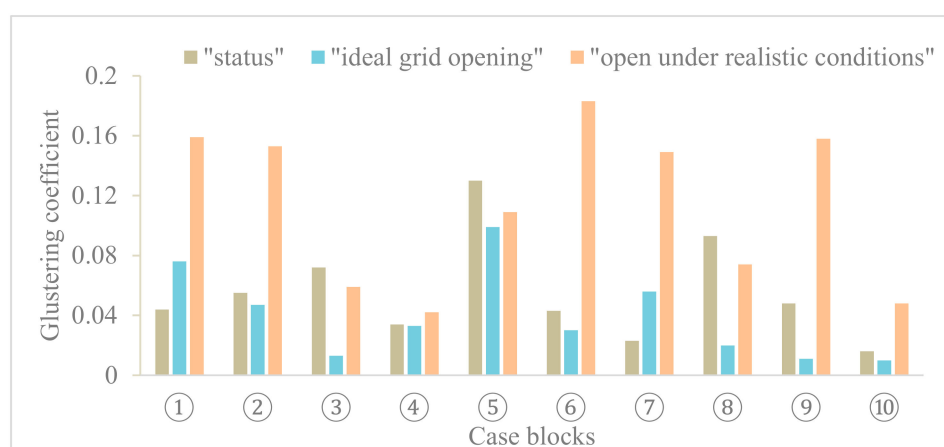


Figure 7. Clustering coefficient of case blocks.

In Figure 7, the clustering coefficients of case blocks under the “status” were mainly between 0.016 and 0.093, and most of them were greater than 0.1 under the “open under realistic conditions”, which were much larger than the “status” and “ideal grid opening”, except the case block 8. The mean clustering coefficients of the blocks located along the river increased from the “status” of 0.067 to the “open under realistic conditions” of 0.104, and for the blocks within the city, which increased from 0.042 to 0.122. Therefore, opening under realistic conditions, the accessibility of block roads located within the city was still larger than that of the blocks along the river, but the connection tightness of adjacent roads in each block was significantly improved.

4.4. Density

Figure 8 shows the density of the case blocks in three cases: the “status”, “ideal grid opening” and “open under realistic conditions”.

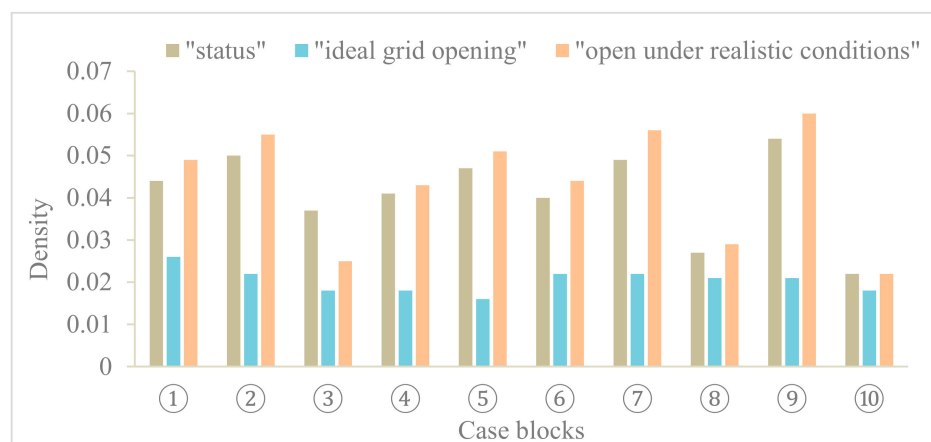


Figure 8. Density of case blocks.

It can be seen that the densities of case blocks under the "status" were between 0.022 and 0.054, and they were between 0.022 and 0.06 under the "open under realistic conditions", which were slightly larger than that of "status", much greater than that of "ideal grid opening". In case of "open under realistic conditions", the mean density of the blocks located along the river increased from the "status" of 0.038 to 0.044, and for the blocks located within the city, which increased from 0.038 to 0.042, which was less than that of blocks along the river. Hence, compared with the pattern "ideal grid opening", the accessibility of the internal roads in the blocks was significantly improved after the opening under the realistic conditions.

4.5. Diameter

Figure 9 shows the diameter of the case blocks in three cases: the "status", "ideal grid opening" and "open under realistic conditions".

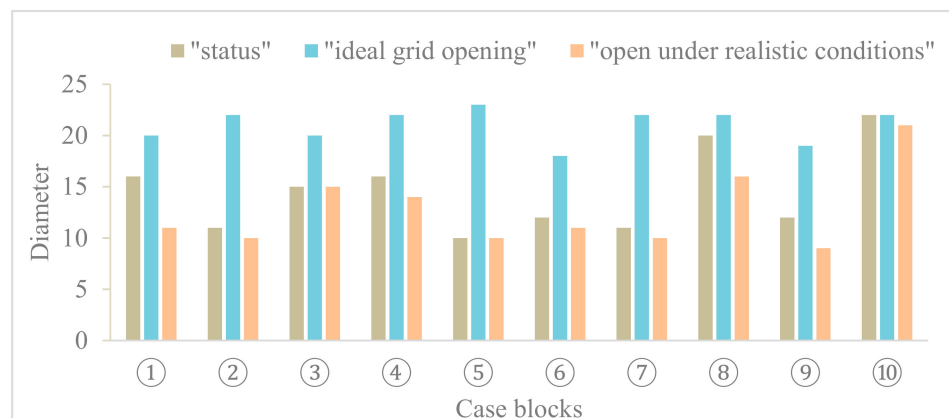


Figure 9. Diameter of case blocks.

It can be found that the diameters of blocks were mostly between 10 and 22 under the "status". In case of "opening under realistic conditions", the diameters were mainly between 9 and 21, which smaller than that of "status" and "ideal grid opening"; besides, the mean diameter of the blocks along the river decreased from the "status" of 13.8 to 12, and for the blocks within the city which decreased from 15.8 to 13.4. Though the network diameter of case blocks had little change compared with the "status", the decrease was obvious compared with the "ideal grid opening" case. In addition, the diameters of the blocks located along the river were smaller than that of the inner city blocks. Therefore, opening under realistic conditions, which had little impact on the overall connectivity of

the block roads, but it had a more significant role in improving the efficiency of the block roads located along the valley.

4.6. Global Efficiency

Figure 10 shows the global efficiency of the case blocks in three cases: the “status”, “ideal grid opening” and “open under realistic conditions”.

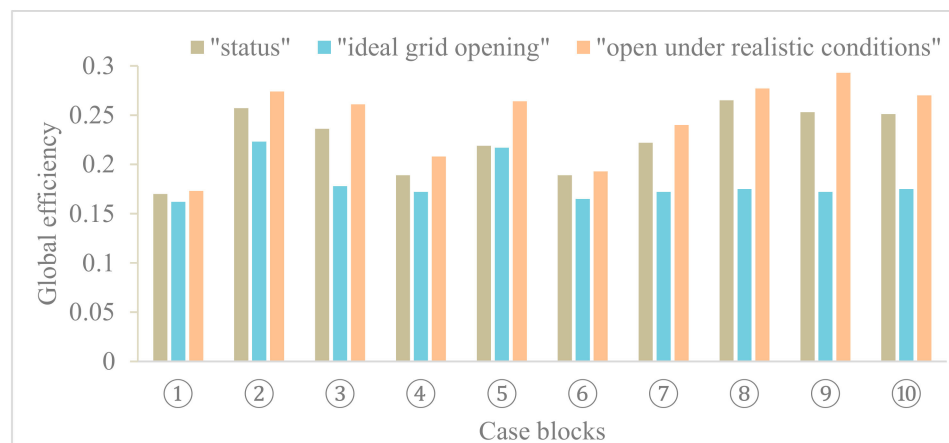


Figure 10. Global efficiency of case blocks.

It can be found that the global efficiency of case blocks were mostly between 0.17 and 0.27 under the “status”, they were between 0.16 and 0.22 under “ideal grid opening” and between 0.17 and 0.29 under the “open under realistic conditions”. The global efficiency of case blocks under “open under realistic conditions” was larger than that of “status” and “ideal grid opening”. Besides, in case of “open under realistic conditions”, the mean global efficiency of the blocks located along the river increased from 0.214 to 0.236, and for the blocks within the city it increased from 0.236 to 0.255, namely, the global efficiency of all case blocks increased significantly, while it decreased significantly under “ideal grid opening”. Therefore, the pattern “open under realistic conditions” had a significant effect on the improvement of traffic convenience and capacity.

5. Discussion

By comparing the complex network characteristics of 10 blocks under two different open patterns, it can be found that in case of “open under realistic conditions”, the average degree of the block road network was higher than that of “status”, but the increment was relatively lower than that of “ideal grid opening”; the average shortest path length of all blocks were reduced after opening, and they were reduced more than the “ideal grid opening”; the clustering coefficient, network density and global efficiency were significantly increased compared with the “status” and “ideal grid opening” pattern; the network diameter decreased slightly compared with the “status”, but it decreased significantly compared with the “ideal grid opening” pattern. Specifically:

(1) Open based on reality was the first choice. In a sense, closed blocks are a way of internalizing urban public roads. The larger the closed blocks, the less and narrower the road space available for external public transport. Traffic flow can only be concentrated on a limited number of roads, which is prone to congestion and affects public interests. Under the pattern of “open under realistic conditions”, opening and connecting roads appropriately would increase the connectivity and capacity of the block road network, and then reduce the traffic congestion and the travel time. It has an obvious optimization effect on the block road landscape and has a certain influence on improving the overall road landscape of the valley city. Therefore, developing the small-scale blocks, breaking the “large blocks”, opening its internal roads and connecting them with the outside roads on the basis of considering the practicability

of reality, not only facilitates the travel of residents in the blocks, but also helps to alleviate the traffic pressure around the blocks and share the traffic flow around the blocks.

Besides, although the connectivity of the blocks was improved under the “ideal grid opening” pattern, it would bring more road intersections and T-shaped roads to the block, making the traffic more difficult and the travel time longer. Therefore, simply increasing the density of the road network by gridding only had an optimal effect on partial blocks, but the effect on improving the accessibility and convenience was weak. In other words, for the valley cities, the pattern “open under realistic conditions” was preferable.

(2) Opening the blocks along the texture of the valley. Compared with the other blocks in the city, the blocks along the valley were restricted by the special terrain of the river valley, so that the traffic could only be developed along the valley or towards the inner part of city. The development scope and space of the districts located along the valley were smaller than those within the city. At the same time, the roads on both sides of the valley were often the main road of urban traffic, and which bore a large number of passengers. The more closed blocks distributed along the valley, the lower the density of the surrounding roads. Vehicles could only be limited to a few main roads to travel, which could easily lead to congestion. Therefore, along the texture of valley, on the basis of considering the practicability of reality, pays attention to the opening of blocks along the valley, increases the density of road network on both sides of the valley and makes it the development skeleton of the river urban road landscape, which has great significance to alleviate the urban traffic congestion in valley cities.

Therefore, we put forward an idea of the future construction of the valley urban road landscape under the concept of open blocks—“developing small-scale blocks along the texture of river valley”.

(3) Focus on traffic micro-circulation. In the future construction of valley cities, it is necessary to construct urban road landscape patterns with valley characteristics based on special terrain and focus on traffic micro-circulation. Firstly, open the “large blocks” distributed along the river direction, such as residential areas, university campuses, etc., select the main roads, which are along the valley direction, with strong traffic capacity and high connection performance in the “large blocks”, and open them to the outside areas to allow external vehicles and pedestrians to pass. Secondly, connect the end breaking roads in the block, extend the extendable roads to the roads with strong traffic capacity, release the traffic pressure of the main roads, and improve the traffic efficiency. Thirdly, support the road network inside the block to form a small traffic cycle (that is, the effective connection of the internal roads of the block, if possible, to form a ring road, which can not only ensure the internal traffic of the block is more smooth and convenient, but also help the external social vehicles to have more path options when entering and passing the block) and ensure that its internal traffic is completed through this cycle; make the block road network and the external road network form a large cycle, connect them by the road with strong capacity and high connection performance; publicize the roads in some blocks, and make the external road network connect to the roads in the block, so that the road network is more fine. In this way, the traffic micro-circulation formed by the connection between the external large cycle and the internal small cycle increases the density of the urban road network, and while constructing the road landscape with the topographical features, the traffic flow is dispersed, and the traffic pressure of the main road is reduced, thereby alleviating the traffic congestion problem.

6. Conclusions

Road network structure was one of the important factors affecting urban traffic operation, and also the main content of urban road landscape morphology. The traditional “big” road network development pattern divided the urban space into enclosed space, making the road network becomes more and more sparse and forming a vicious circle. Especially for valley cities, the space of urban road development was limited, the more serious the dilemma caused by this phenomenon. How to turn the disadvantage into an advantage, increase the density of road network and promote traffic micro-circulation within the city by means of opening block, which has great significance to the road landscape construction of valley cities. This study found that the appropriate opening and connection of the block road

under realistic conditions had obvious effects on improving the performance of the road network. Specifically, considering the unique geographical conditions, it was more suitable for valley cities to pay attention to the opening of blocks located along rivers and promote the traffic micro-circulation. Namely, breaking the “large blocks” and developing the small-scale blocks helped to alleviate the traffic congestion, because it increased the supply of urban road traffic in essence, gave social vehicles more choice of travel roads, and decomposed the pressure of the main and secondary roads. Therefore, for the future construction of the valley city road landscape under the concept of open blocks, developing small-scale blocks along the texture of river valley is a viable alternative.

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