THE RESEARCH AND EVALUATION OF ROAD ENVIRONMENT IN THE BLOCK OF CITY BASED ON 3-D STREETSCAPE DATA

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ABSTRACT:

This paper focus on the problem of the street environment of block unit, based on making clear the acquisition mode and characteristics of 3D streetscape data，the paper designs the assessment model of regional block unit based on 3D streetscape data. The 3D streetscape data with the aid of oblique photogrammetry surveying and mobile equipment，will greatly improve the efficiency and accuracy of urban regional assessment, and expand the assessment scope. Based on the latest urban regional assessment model, with the street environment assessment model of the current situation, this paper analyzes the street form and street environment assessment of current situation in the typical area of Beijing. Through the street environment assessment of block unit, we found that in the megacity street environment assessment model of block unit based on 3D streetscape data has greatly help to improve the assessment efficiency and accuracy. At the same time, motor vehicle lane, green shade deficiency, bad railings and street lost situation is still very serious in Beijing, the street environment improvement of the block unit is still a heavy task. The research results will provide data support for urban fine management and urban design, and provide a solid foundation for the improvement of city image.

1. INTRODUCTION

The city is a huge system, which involves all aspects of society, economy, life and so on. At the present stage, Chinese urban diseases are more prominent in the population congestion, traffic congestion, environmental pollution, housing difficulties, etc. Megacities like Beijing, urban diseases is manifested in the following four aspects: The disorderly rapid increase in the population make the congestion condition, traffic jam has become the normal traffic in Beijing; The poor quality of city environment caused widespread discontent; Housing and infrastructure supply is far from the needs of the residents. To cure the "urban disease" is a complex and lengthy process, need multi sectoral and multi domain to play coordinated governance. Among them, the street environment problems of block unit are directly related to people's living experience and travel experience. At present, the street environment problems of block unit in the megacity, including motor vehicle parking occupied roads, green shade deficiency, bad railings, street lost situation and so on. The effective street environment assessment of the present situation is an effective way to solve the quantitative problems of the street environment, make clear the sick degree of the city, in order to facilitate the transformation and upgrading of the street environment, to achieve piercing to the heart of the matter, as the medicine took effect the symptoms lessened. Therefore, in order to solve the street environment problems of block unit, we must do a good job in the street environment assessment. In the aspect of street environment assessment, the domestic scholars have a lot of research, which is mainly concentrated in the commercial areas, residential areas, open plazas, parks and so on. Pan Haixiao et al (2011) proposed that encouraging diverse activities in the street is an important method to improve the attractiveness of the streets; Zhuo Jian (2014) introduced the concept of European city mobility and the construction of humane transportation; Zhao Xiumin (2006) sorted out the main behavior patterns of Japanese small city residents in the waterfront environment, took the needs of specific populations

in particular areas into account; Ye Zhen et al (2015) introduced the complete streets policies; Zhang Shanfeng et al (2011) introduced the design level and steps of green street landscape; She Meixuan et al (2015) introduced the micro green design practice in Macao. Jane Jacobs (1961) pointed out that more narrow the sidewalk is, the roadway will have more harassment when children play. These studies are mainly based on the theoretical level, but there is still no assessment model research of block unit found on the 3D streetscape data. This paper, based on the 3D streetscape data, achieved the new street environment assessment of block unit in Beijing.

2. STREET ENVIRONMENT PROBLEMS OF THE BLOCK UNIT IN THE MEGACITY

The megacity's fine management has high level, but the urban streets of block unit are still facing many environment problems, including motor vehicle lane, the green shade deficiency, bad railings and street lost situation.

(1) Motor vehicle parking occupied roads
The motor vehicle parking occupied roads problem in the city has been the main problem of pedestrian and bicycle travel, it is also a major contradictory source of city motor vehicle and non-motor vehicle. In Beijing, occupied parking area is even more than the old city of Beijing (the total area within the second ring road). Taking Beijing central city as an example, according to the statistics of Baidu streetscape map in 2013, there are at least 38% bicycle lanes and 51% sidewalks was occupied motor vehicle parking (red, because the streetscape collection non-peak hours, the actual motor vehicle parking occupied roads will be more serious), at least 78% bicycle lanes' effective width is less than 2 meters (grey), 37% sidewalks' effective width is less than 1.5 meters (grey), the world-class sidewalks and bicycle lanes network are separated by parking. In Beijing, China World Trade Center CBD, 1700 cars were illegal parking on sidewalks, 800 cars were illegal parking on the bicycle lanes on working days, some sidewalks even designated car parking

charges by hand. According to the investigation results on bicycle lanes by Nature Friends Organization in 2010, the results show that: motor vehicle occupied parking 77% bicycle lanes along the southern section of Beijing metro line 2 and metro line 4, according to a survey by Beijing City Planning Institute, 88% riders oppose set motor vehicle parking spaces on the bicycle lanes in Beijing, 85% riders oppose designated motor vehicle roads on the bicycle lanes [1-3].

(2) Green shield deficiency
Serious air pollution makes people pay more attention to the ecological function of road green space. There is willingness investigate, the question is: if you want to improve the bicycle traffic environment, which problem do you want to solve? The result is physical isolation requirements between vehicle and non-vehicle and ensures the roads right are at the top of the list, and then there's increasing greening shade. The intensity of the public's demand for shade exceeds our expectations. There are two main points for avenue dissatisfaction: first, no large trees on vehicle and non-vehicle isolation belt. Beijing has more three plates roads, although we have planted trees along the new roads in recently twenty years, but there are only shrubs and flowers on vehicle and non-vehicle isolation belt, while ignoring the large trees planting. Second, there is no big trees in intersections. In the past twenty years, the intersections expand motor vehicles, the trees of the green belt is eradicated empty. And it is precisely at the intersection of red lights, pedestrians, cyclists in need of shade most [4-6].

(3) Bad railings
Pedestrian guardrail landscaping and security issues are often controversial. The guardrail is divided into crash barrier and isolation barrier. The crash barrier is used for expressway with the control of the national standard, and the isolation barrier is mainly used in roadways and sidewalks, does not have the anti-collision performance. For this type of guardrail, although our country has the state of the material requirements, but there are not uniform standards for the specific design and specifications [7-9]. Isolation barrier production has no control requirements in different provinces, the security can't be guaranteed. In a guardrail survey in Beijing, 87% of the pedestrian support install sidewalk guardrail; Objections to install sidewalk guardrail is the sidewalk is too narrow , it is not beautiful, it interfere with the emergency evacuation, bicycle parking is not convenient, it is not easy to cross the street; In the sidewalk sections which installed guardrail, there are still many people walking in the bicycle lanes because crowded sidewalks, comfortable, convenient to across the street, efficiency and other reasons; 54% of the people think that the sidewalk guardrail is not beautiful.

(4) Street lost situation
Looking from the network form, the road density and accessibility are high in Beijing large residential areas, a large range of villages and large parks, and form self-contained network. In fact part roads play a role similar to branch "distribution road" in developed city. Because the absence of planning and design basis, these streets with the function of traffic microcirculation and slow potential has become blind area in urban construction, were severely eroded by car parking[10]. According to the statistics in 2014 in Beijing central city, the total length of alley streets, residential roads, park roads is more than ten thousand kilometers, is more than two times to the municipal road mileage. Chinese city has a large number of residential roads, historical streets, village roads, open plazas and parks, because of the one-sided

emphasis on the car efficiency and closed management, these streets with the function of blocks traffic microcirculation and slow activity has become blind area in urban construction, were severely eroded by car parking

3. ACCESS AND EVALUATION OF APPLICATION MODE OF 3D STREETSCAPE DATA

Due to its high positioning accuracy, strong visualization, texture measurement and other characteristics, the 3D streetscape data is widely used in various fields for city fine management. Based on a clear 3D streetscape data acquisition principle, the application model of the 3D streetscape data will be discussed in the street evaluation of city block unit in detail.

3.1 Acquisition ways of 3D streetscape data

The ways to obtain 3D streetscape data on the whole can be divided into three kinds: vehicle borne laser scanning technology, technology based on the oblique photogrammetry, air and ground integration hybrid modeling technology. The technical results are shown in Figure 1.

(a) vehicle based laser scanning technology

(b) Oblique photogrammetry technologye

(c) Hybrid modeling results of the air and ground integration
Figure 1. Different techniques to obtain 3D streetscape data

(1) Vehicle borne laser scanning technology
Vehicle borne laser scanning technology is the way to put the laser scanner on the mobile platform. The vehicle borne laser scanning surveying system includes three basic parts: mobile platform, POS system (position and attitude surveying system) or navigation sensor, surveying system. The mobile platform is generally used for carrying the mobile surveying system such as automobiles, ships and so on. Vehicle borne laser scanning instrument can work within a short distance, it has fast acquisition speed, high precision, high density, due to its fast running characteristic along the street, so it can get the

geometric information and texture information of both sides of the streets quickly, it has become one of the main means of rapid acquisition of urban spatial information. In this way, you can quickly get the streetscape data, it is an effective way for obtaining urban spatial information. At present, vehicle borne laser scanning has been used in obtaining 3D streetscape data in the main street of Beijing.

(2) Oblique photogrammetry technology
The 3D streetscape data based on oblique photogrammetry technology is obtained from a bird's-eye view, mainly used to obtain the urban roads and the texture of building top and sides. First, we get the laser point cloud building top and sides by using airborne LiDAR, and get the laser point cloud data to describe the overall framework of buildings, for the production of building body frame model; we use oblique and vertical cameras to collecte landmark images, realize texture through the semi-automatic matching process, finally we complete the construction of fine model.

(3) Hybrid modeling technology of the air and ground integration
The hybrid modeling technology of the air and ground integration belongs to the data processing technology of 3D streetscape model, the overlooking texture obtained from oblique photogrammetry technology and the parallel visual texture from vehicle borne laser scanning technology were integrated and combined, through high precision docking, and ultimately form the automatic 3D modeling method. This technology is still in the experimental stage because of the high requirements of the vehicle borne laser scanning technology.

3.2 The characteristics and applying patterns of 3D streetscape data

After obtaining a clear acquisition ways of 3D streetscape data, characteristics and applying patterns of 3D streetscape data are more obvious.

3.2.1 The characteristics of 3D streetscape data: The characteristics of 3D streetscape data mainly for the following aspects:

(1) Data has high positioning accuracy. Due to the use of vehicle borne laser scanning technology, navigation sensor and POS system determines the positioning accuracy of 3D streetscape data, it can reach centimeter or decimeter level. For urban management, it is a high positioning accuracy data[11-12].

(2) Data has strong texture visualization. 3D streetscape data has all elements and full texture, contains massive information society. The texture of the data is intuitive, and the multi period data can reflect the change of the current situation of the city. It is of great significance for the assessment of the city, especially the district unit.

(3) Data is measurable.3D streetscape data contains high resolution close-range image of all the buildings along the streets even the small objects (such as: traffic signs, road marking, fire hydrants, telephone booths and so on). Just statistics according to the objects number, the information amount is at least 20 times more than the traditional map. The image can complete the geometric measurement of the target (such as length, width, height, area, volume, etc.) and extract its attribute information.

(4) Data has rapid update speed. In the high speed vehicle, it obtained spatial data and attribute data of roads and sides fast, and stored in the onboard computer, edited and processed by special software to form all kinds of useful GIS data results, which included road map, facilities or POI data (points of interest). The process of 3D streetscape data has less manual intervention, data acquisition and production efficiency are high. Therefore, the data can be quickly updated.

3.2.2 Urban regional assessment model based on 3D streetscape data: In the absence of 3D streetscape data, urban regional assessment model often used to obtain the present situation of urban district by the way of basic geographic data + artificial property acquisition by the field operation, spent a lot of manpower and material resources. After the introduction of 3D streetscape data, it replaces the manual verification of field operation, saves the manpower and material resources. At the same time, the basic geographic data can be updated and checked by the rapid update of the 3D streetscape data.
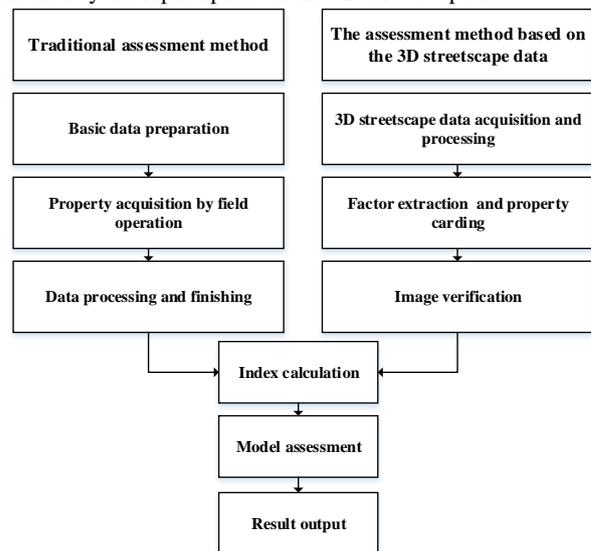

Figure 2. Urban regional assessment model based on 3D streetscape data

4. STREET ENVIRONMENT SITUATION ASSESSMENT MODEL OF BLOCK UNIT

The street environment assessment model is to solve the assessment problem at the level of block unit, including the current assessment model of street form and street environment.

4.1 The assessment model of street form

The assessment object of the current street form situation assessment model is the different type street in the city, including the urban road, park road, historical street, village road, etc. The assessment indexes include the street density, the intersection density, the link-node ratio of the street section, block length, the connected node ratio, the connected node ratio and the grid pattern. We get the changes of different type of streets in different periods through recording the changes of indexes. The assessment model of the current situation of street form is shown in Figure 3, and the calculation methods of each index are shown in Table 1.
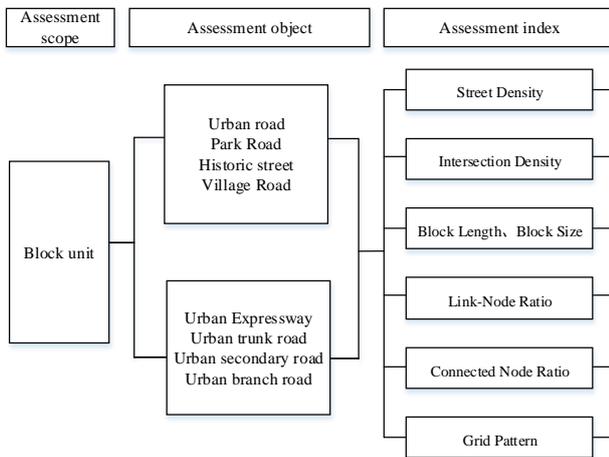
Figure 2. The current assessment model of the street form

Assessment index	Computing method	Significance
Street Density （km/km2）	L/S L：Total length of all streets in the area； S：Total area.	The higher density of the streets, the higher the slow accessibility.
Intersection Density	n/s n: Number of intersections in the region S：Total area	To evaluate the walking suitability.
Block Length, Block Size	The length of the road between the center of the adjacent intersection	The block length is the length of the street intersection center, which is an important factor to measure the walking suitability. The most suitable for walking is less than 90m, 120 ~ 150m is suitable, 180 ~ 240m is not suitable.
Link-Node Ratio	Nodes number per unit area / Node number； （Node: Intersection and the end point of the Cul-de-sac）	The Link-Node Ratio (LNR) is the ratio of the sections number and the nodes number in the unit area, which includes the intersection and the end point of the end Cul-de-sac. The LNR of the grid road is the highest, about 2.5. The LNR can reflect the amount of path choice, which is more conducive to evaluate vehicle accessibility quality.
Connected Node Ratio	Intersection number/Node number	The higher the CNR, the less the hanging node, the maximum value is 1 that means there is no cul-de-sac. That CNR should not be less than 0.5, it is suitable for slow when CNR is more than 0.7.
Grid Pattern	The coverage rate of the grid	Defined as the coverage rate of the grid land in 1/4
	land in 1/4 square mile area of land, can be predicted by the intersection number of four directions	square mile area of land, can be predicted by the intersection number of four directions. Some scholars use the nominal variables to define it, the pure grid form is 1, non-grid form completely is 0.

Table 1. The computing method and significance of the assessment index of the street form

Taking the street density index as an example, the usability of the assessment index is explained in detail. The higher density of the streets, the higher the slow accessibility, but should pay special attention, the expressway and the trunk road to slow the accessibility effect is not always positive. The domestic cities is mainly reflected in crossing time delays, taking Shanghai as an example, whether it is time to bypass Expressway, or the red light waiting time on trunk road is often more than 3 minutes; While in foreign countries especially the cities of North America, it usually embodied as slow channel interrupt, because the expressway auxiliary road and trunk road do not set pedestrian trails and bicycle lanes, based on this, the concept of slow Impedance Arc was put forward in Portland. It is not difficult to see, after removing Impedance Arc, slow network density plummeted and from north to south directions was completely cut off. In domestic cities, a large number of residential zones, company internal roads and alley have not been included into the municipal road category, so the saying "Chinese urban road network is less than the western developed city" is not exact for the slow network. Taking Tongji University block as an example, according to the municipal road statistics, road density is only 4.9km/km2, if school roads are included, the road network density is actually 26km/km2. After removing Impedance Arc, slow road network form is as shown in Figure 4.
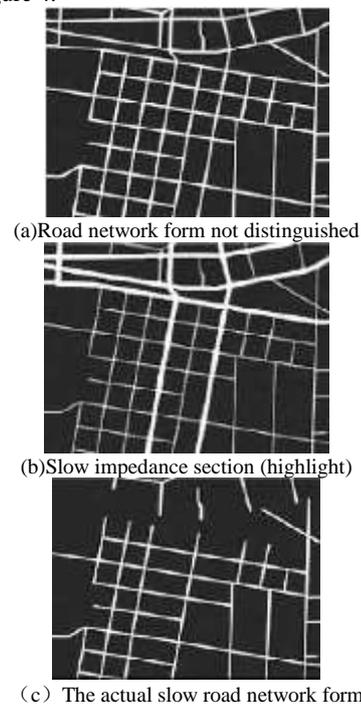

(a)Road network form not distinguished

(b)Slow impedance section (highlight)

（c）The actual slow road network form
Figure 4. Road network form after removing Impedance Arc

4.2 Street environment assessment model

The street environment assessment model divides the roads into the urban roads and the non-urban roads, the non-urban roads includes the residential area roads, the alley and so on, different assessment index systems are used for urban and non-urban roads. This paper focuses on the evaluation of City Road, including sidewalk width, bicycle lane width, motor vehicle parking and several other indicators, street environment evaluation index system model as shown in Table 2.

Assessment class	Index	Significance
Sidewalk width	Sidewalk section width	Sidewalk section width is an important index reflecting the urban pedestrian traffic right space distribution.
	Effective sidewalk width	Effective sidewalk width is the direct reflection of urban road design and daily management.
Bicycle road width	Bicycle road section width	Bicycle road section width is an important index reflecting the urban bicycle traffic right spatial distribution.
	Effective bicycle width	Effective bicycle width is the direct reflection of urban road design and daily management.
Motor vehicle parking occupied roads	Sidewalks occupied by motor vehicle parking	According to the position and severity of motor vehicle parking, it is divided into four categories indicators: sidewalk parking, sidewalks parking seriously, bicycle lanes parking and bicycle lanes parking seriously, among them: if there are parking on sidewalks or bicycle lanes, it is classified as motor vehicle parking occupied roads; if there are more than 5 motor vehicles parking on sidewalks or bicycle lanes, and hindering walking and bicycle travel, it is classified as serious motor vehicle parking occupied roads.
	Bicycle lanes occupied by motor vehicle parking	
Isolated form between vehicle and Non-Motor Vehicle	Physical isolation	Including: green belt isolation, facilities isolation and fence isolation.
	Line isolation / No isolation	Isolation facilities construction between vehicle and non-motor vehicle is primary measures to alleviate contradictions, guarantee the bicycle traffic space.
Sidewalk greening shielding rate	Sidewalk greening shielding rate	The sidewalk greening rate is the vertical projection area that sidewalk trees covered sidewalk space, the sidewalk greening shielding rate level is divided into five stages: the first stage is the avenue of the high covering rate (more than 91%), the second level is the urban streets of the better covering rate (61%-90%), the third level is
		the urban streets of the acceptable covering rate (41%-60%) the urban streets, the fourth level is the urban streets of the poor covering rate (21%-40%), the fifth level is the urban streets basically of no green covering (Lower than 20%).

Table 2. Assessment model index system of street environment (Urban Road)

5. APPLICATION CASE

5.1 Application case of street type assessment

Taking the Nanlishi road in Beijing as an example, street type is analysed in this paper. The results are shown in Figure 5 and Table 3.
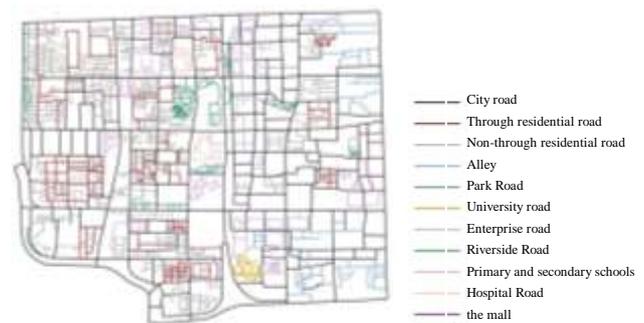

Figure 5. Street type Analysis of Nanlishi road

From the street density index, the slow accessibility is higher in this road of the block.

Road classification	Road density	ID	Road classification	Road density
City road	9.3	6	University road	0.02
Through residential road	2.3	7	Enterprise road	2.5
Non-through residential road	5.2	8	Riverside Road	0.04
alley	0.1	9	Hospital Road	0.4
Park Road	1.1	10	the mall	0.1

Table 3. Street type assessment of typical area

5.2 Application case of street Network Environment assessment

Nine indicators in a certain area of Beijing are evaluated in this paper, including the width of sidewalks, the width of bike lanes, the condition of motorized parking, the non-isolated form of the machine and the shelter, greening rate of sidewalks and so on. Among them, taking the sidewalk section width and the effective width of the sidewalk as an example, the assessment process is detailed.

(1) Data processing
Based on the 3D street data and the tilt photogrammetry data, the sidewalk width and the effective travel width of the sidewalk are obtained through the industry measurement. First,

the preliminary width is obtained based on the oblique photogrammetric data, and then the shadow is verified by the 3D street scene image data, and the misjudgment of the width caused by the tree shelter is removed. Compared with the traditional field verification methods, the methods save a lot of manpower and resources.

(2) Index calculation
The width of the pavement and the effective width of the pavement were statistically evaluated to obtain the calculated results, as shown in Figure 6- Figure 7. According to the width of the pavement cross-section evaluation results, if the width of the reference pavement cross-section of not less than 1.5m minimum construction standards, all district assessment results in the Center City except Daxing District are as much as 50%. Among them, the highest is for the Shijingshan District, followed by Haidian and the lowest is for the Daxing District. if the width of the reference pavement cross-section of not less than 3.0m, all district assessment results in the Center City are lower than 41%. Among them, the highest is for the Fengtai District, followed by Xicheng and the lowest is for the Daxing District. According to the effective width of the sidewalk evaluation results, if the reference to the effective width of the sidewalk is not less than 1.5m minimum construction standards, all district assessment results in the Center City except Daxing District are as much as 40%. Among them, the highest is for the Shijingshan District, followed by Haidian and the lowest is for the Daxing District. If the reference to the effective width of the sidewalk is not less than 3.0m minimum construction standards, all district assessment results in the Center City are as lower as 30%. Among them, the highest is for the Dongcheng District, followed by Shijingshan and the lowest is for the Daxing District.
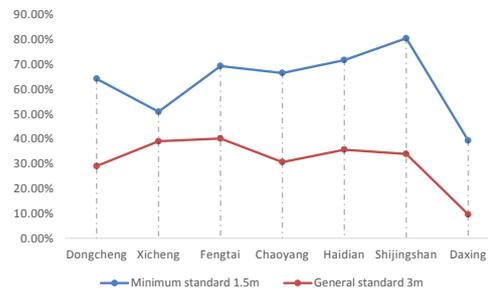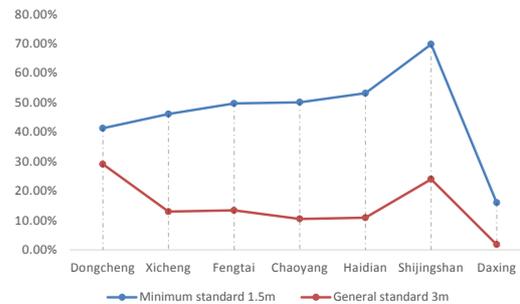

(a) Minimum standard 1.5m

(b) General standard 3m
Figure 6. Assessment of the effective width of the sidewalk network

(a) Sidewalk section width evaluation

(b) Sidewalk effective width assessment
Figure 7. Sidewalk width evaluation results of the partition

From the result analysis, for the pavement section width index, with reference to the sidewalk section width of not less than 1.5m minimum construction standards, the compliance rate of pavement section width in the Center City is 66.7%. Among them, the old city (second ring) and the peripheral zone are not very different. With reference to the sidewalk section width of not less than 3.0m conventional standards, the compliance rate of pavement section width in the Center City is 18.5%, in which the old city slightly higher than the peripheral area. For the effective width of the sidewalk indicators, if the pavement effective width is not less than 1.5m minimum construction standards, all district assessment results in the Center City are lower than 48%. If the pavement effective width is not less than 3.0m conventional standards, all district assessment results in the Center City are lower than 5.3%.

The evaluation map of the indicators and the partitioned result graphs, including the width of bike lanes, the condition of motorized parking, the non-isolated form of the machine and the shelter, greening rate of sidewalks and so on, are shown in Figure 8- Figure9. From the analysis of the results, the present situation of the road environment of the whole blocks in Beijing still needs to be improved.

(a) Evaluation of width of bike lanes

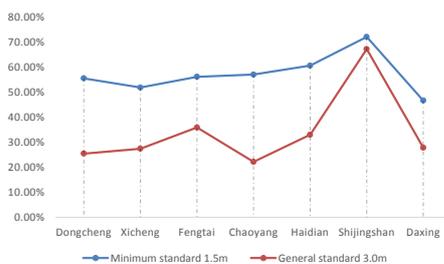(b) Evaluation of the condition of motorized parking

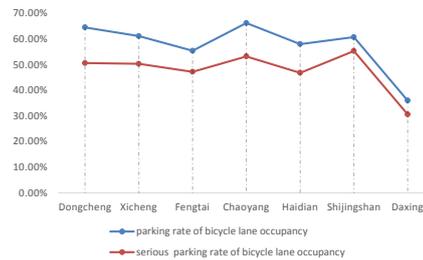(c) non-isolated form of the machine and the shelter

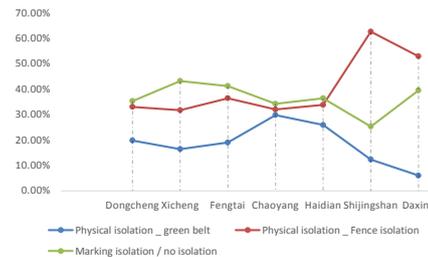(d) Evaluation of greening rate of sidewalks

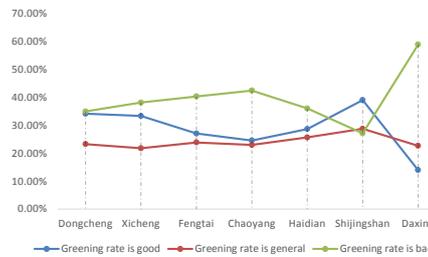Figure 8. Assessment map of Road environmental indicators

(a) Evaluation of width of bike lanes

(b) Evaluation of the condition of motorized parking

(c) Non-isolated form of the machine and the shelter

(d) Evaluation of greening rate of sidewalks

Figure 9. Partitioned assessment map of Road environmental

6. CONCLUSION

This paper starts with the street environment problem of the block unit in the megacity, after confirming acquisition principle and characteristics of the 3D streetscape data, designs the new urban assessment model of the block unit based on the 3D streetscape data. The 3D streetscape data with the aid of oblique photogrammetry and mobile equipment, it not only improves the efficiency and accuracy of urban area assessment，but also effectively expands the assessment scope，realizes the synchronization and real time of regional assessment. Based on the new data, this paper makes use of the street environment assessment model of the current situation to realize the street environment assessment in the typical area of Beijing. Through the street environment assessment of the block unit, the street environment assessment model of block unit based on 3D streetscape data in the megacity has revolutionary change for improving the efficiency and accuracy of assessment. At the same time, the assessment model of urban areas can also be used for the assessment of other special projects in urban areas, it has a broad space for development.

REFERENCES

Bi Linglan., ZHONG Yi., 2012. Study on pan-social values of historic district preservation and development: a case study on Chengdu. *City Planning Review*, 7, pp. 44-59.

Cui Shuping., 2010. The inspiration form Hangzhou slow speed modes planning. *Urban and Rural Planning*, 12, pp. 30-31

Fu Shuai., HU Wantai., ZHANG Zhengtao., 2014. Thoughts of dimension design of city street space based on urbanism. *Urban Planning International*, 2, pp. 111-117.

Jin Jian., GUO Zizheng., 2006. Research on the traffic calming measures in urban residential area. *Journal of Transportation Engineering and Information*, 3, pp. 42-45.

Jørgensen F., A høyer., P Sandersen., X He., and N Foged., 2015. Combining 3D geological modelling techniques to address variations in geology, data type and density-An example from Southern Denmark, *Computers & Geosciences*, 81, pp. 53-63.

Murgitroyd E., Madurska M., Gonzalez J., and Watson A., 2015. 3D digital anatomy modelling e Practical or pretty, *Surgeon Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland*, 3(13), pp. 177-180.

PAN Haixiao., Shen Qing., and Xue Song., 2010. Intermodal transfer between bicycles and rail transit in shanghai, China. *Journal of Transportation Research Record*, 2114, pp. 181-188.

Pan Haixiao., Tang Yang., Mai Xianming., and Mu Yuijiang., 2010. MU Yuijiang. Comparing public bike development mode. *Urban Transport*, 08(6), pp.40-43.

Qian Jian., Zheng Zhifeng., and Feng Yufeng., 2010. Survey and thinking on Hangzhou public bike facility in Hangzhou. *Planner*, 26(1), pp. 71-76.

Zhao Zhongshu., and HU Min., 2012. Some thoughts on the preservation of historic conservation area. *Modern Urban Research*, 10, pp. 8-12.

Zhou Jian., 2013. Rethinking of slow transportation: its roles and development in Chinese cities. *Ideal Space*, 59, pp. 12-15.