RESEARCH ARTICLE

Study on Fine Design Method of Intersection under Slow Traffic System

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Abstract: In the process of rapid development of urban traffic, Chinese intersections have made great progress in meeting the basic needs of urban road traffic, but the intersection design method under the slow traffic system is imperfect.First of all, by analyzing the problems of walking and non-motor vehicle intersections in domestic cities, and comparing and analyzing the excellent foreign cases, the basic idea of fine intersection design is constructed.Finally, take the slow traffic intersection as an example, from the perspective of the traffic individual analysis, the fine design of the intersection under the slow traffic system.Drawing on the organizational experience of the design of foreign intersections under the slow traffic system, it proposes the fine design strategy of urban intersections in China.

Keywords: slow traffic system, intersection optimization, non-motorized lane, refinement.

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Foreword

The development of urbanization, accompanied by the traffic model with motor vehicles as the main body, leads to a series of urban problems, such as environmental pollution, traffic congestion, traffic accidents and human physical and mental health.Many countries in the world advocate sustainable urban development and encourage the development mode of “walking and bicycle” slow traffic system, which has proved to be a feasible way to solve urban problems.In China, the “walking + bicycle” slow traffic system is paying more and more attention, and the public recognition has also improved.document[1]It is found that the public attaches more attention to and favors non-mobile transportation modes, including walking and bicycle, and the construction of excellent environment, safe and convenient walking and bicycle transportation system has become an urgent demand of the general people.document[2]It is proposed that developing bicycle transportation in line with local conditions will help to optimize the transportation structure, reduce the dependence of cars, save road space and energy, and reduce pollutant emissions.At the same time, as a traditional low-cost means of transportation, lower-income people are more dependent on it, so ensuring bicycle traffic is also an important means to promote social harmony.document[3] It is believed that the walking transportation system is the symbol of the urban harmony, the reflection of the urban civilization level and the scientific degree, and the concrete embodiment of the urban two-oriented society construction and the people-oriented principle.

However, at the signal control intersection, because the motor vehicle and pedestrian-bicycle share the traffic space, the motor vehicle and pedestrian-bicycle traffic interfere seriously, and the traffic contradiction is particularly significant[4]. At present, the phenomenon of non-conflict is serious in major cities and the frequent traffic accidents occur, which makes more and more attention to the study of safety and efficiency of bicycle travel[5]. Therefore, as the basic component of urban traffic, it is of great significance to improve the travel environment and facilities to study the fine design method of the slow traffic system and reasonably improve the traffic efficiency and facilities level.

1 The basic idea of fine design of intersection

The fine design of the intersection is designed to guide the safe and smooth operation of the intersection containing walking and non-motor vehicles by setting up isolation belts, safety islands, canal islands, traffic marking and other ways.By analyzing the existing problems of intersections under China's slow traffic system, comparing and analyzing the advantages of foreign intersection design, combined with the actual situation of China, we follow the people-oriented idea for the intersection fine design.

1.1 Crossing design under the Chinese slow traffic system

China's urban intersection traffic composition is complex, traffic behavior is casual and uncertain, and the intersection design is not comprehensive, resulting in serious traffic flow interference with each other, resulting in low traffic efficiency, traffic safety is not guaranteed and other problems. By comparing the road intersections containing walking and non-motor vehicles in Hangzhou, Shanghai, Shenzhen, Chengdu, Beijing and Dalian and other cities (Figure 1-6), the problems are mainly reflected in the following aspects:

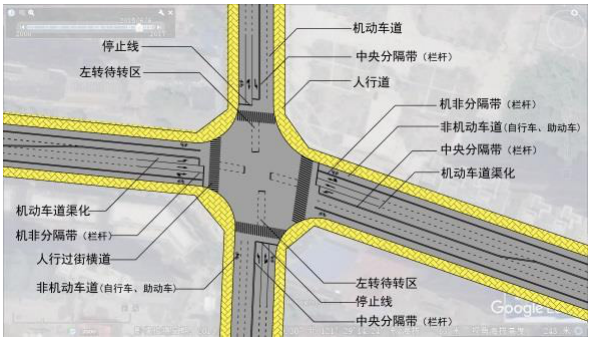

Figure 1 An intersection in Hangzhou

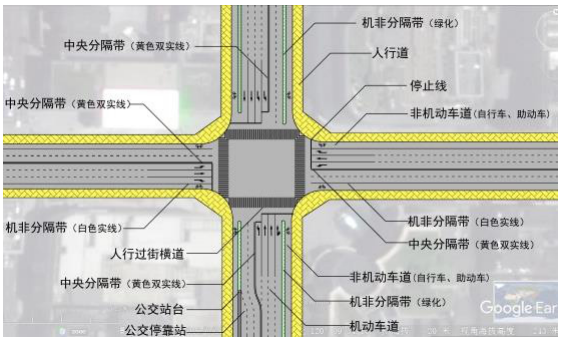

Figure 2 An intersection in Shanghai

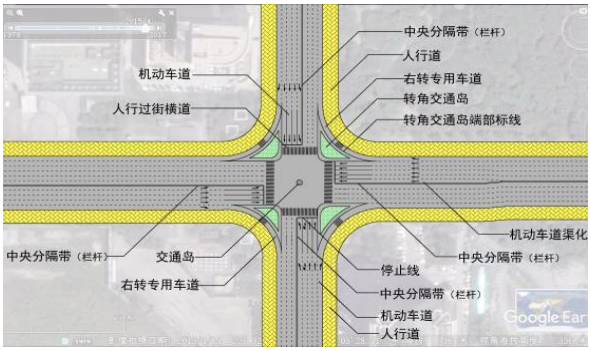

Figure 3 An intersection in Shenzhen

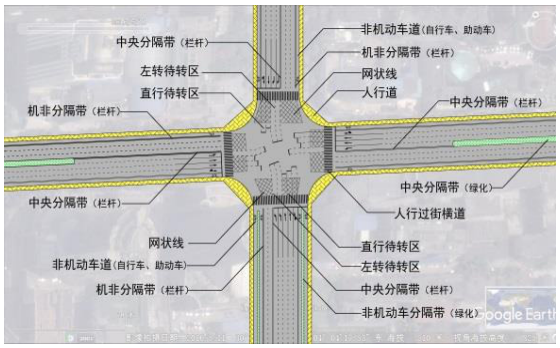

Figure 4 An intersection in Chengdu

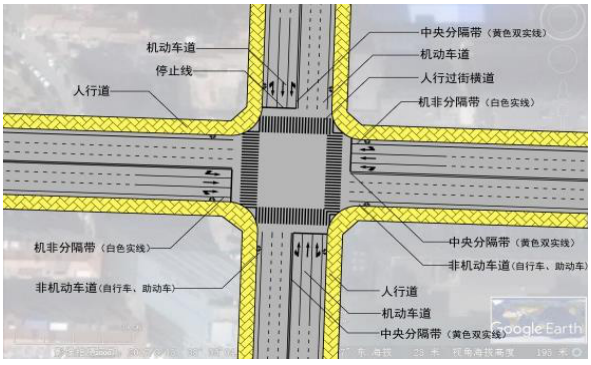

Figure 5 An intersection in Dalian

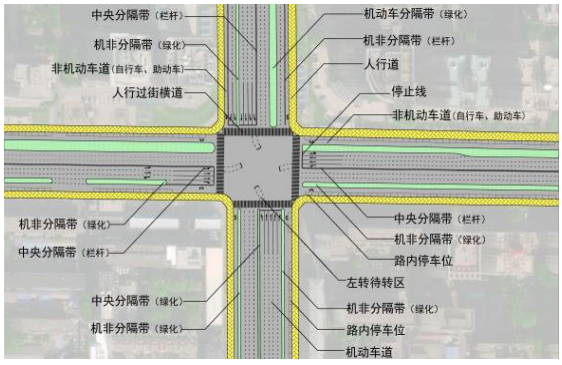

Figure 6 an intersection in Beijing

1.1.1 The division of traffic space is not clear

The lack of clear division between the traffic space of motor vehicles and bicycles at the intersection leads to the mixing of various modes of traffic within the intersection, which seriously affects the traffic efficiency and safety. In Fig. 3, a bicycle and a right-turning motor vehicle at an intersection in Shenzhen share one lane. In Fig. 5, an intersection in Dalian adopts a white solid line. This non-physical isolation measure is not conducive to the safety of bicycles and pedestrians.

1.1.2 The entrance road at the intersection is not channelized or channelized widening is insufficient

China's urban intersections are less channelized to import roads, resulting in a reduction of traffic efficiency and a decrease of road capacity.In the picture above, only an intersection in Chengdu uses the green belt to add a lane to the east entrance, and Beijing uses the width change of the green belt to widen the lane.

1.1.3 Physical traffic island, safety island, green belt and marking channelization signs lack or set up non-standard

In Figure 1-6, the interior of each intersection is basically blank, and there are almost no detailed guide line, traffic island and other signs to guide the traffic flow, which will increase the time for the motor vehicle, non-motor vehicle driver and pedestrians to determine the path, and it is easy to cause the generation of traffic accidents and the waste of traffic time.In addition, Chinese specifications require that when the length of the crosswalk is greater than 16m (excluding non-motorized lanes), a pedestrian crossing safety island should be set up at the crosswalk near the partition belt or the center line of the road. The width of the safety island should not be less than 2.0m, and not less than 1.5m in difficult cases[6]. However, few intersections in China have set up safety islands according to the specifications.

1.1.4 Humanized design is not reasonable

The intersection and section crossings shall be flat and continuous, and the curb shall be treated with slow slope. Some intersections in China have not been barrier-free across the streets, and lack of attention to humanized facilities. In addition, the lack of pedestrian street crossing facilities planning, the lack of consideration of the non-motor vehicle street crossing space planning, and most non-motor vehicles turn left to adopt the one-street crossing mode with the same phase as the motor vehicle traffic.In the six intersections above, there are no special crossings set up for bicycles. bicycles often share the crosswalk with pedestrians, resulting in serious interference between motor vehicles, non-motor vehicles and pedestrians.

1.1.5 The kerb radius is set improperly

The large curb radius increases the distance of the pedestrian crossing, which increases the pedestrian crossing time and the motor vehicle waiting time; and reduces the space for the pedestrian to stop and wait, and reduces the traffic efficiency.

1.1.6 Too many other facilities near the intersection

Some intersections in China set up kiosks, kiosks and other buildings at the corner to cause interference to drivers' sight, but also affect pedestrian traffic, and pose safety threats to non-motor vehicles and pedestrians.

1.2 Crossing design under the foreign slow traffic system

Foreign urban intersection design and development is relatively mature, which is of reference significance to China. The proportion of green transportation in the Netherlands, Germany and Denmark is at the forefront in the world, and the intersection design under the slow transportation system is relatively perfect. The analysis of its design methods and the learning of its excellent practical experience can lay a foundation for the optimal design including walking and non-motor vehicle intersections in China.

1.2.1 Principles of Intersection Design

Foreign intersection design not only considers the traffic capacity of motor vehicles, but also fully considers the safety needs of pedestrians and non-motor vehicles. By balancing the conflicts of interest between the two, pedestrians and non-motor vehicles give sufficient space for road use.

1.2.2 Design of bicycle lane at intersection

The rapid development of urbanization, China gradually from the bicycle kingdom to motor vehicle traffic development mode, and foreign developed countries in the process of mobility, pay more attention to sustainable slow traffic system, bicycle traffic system is more perfect, in the

intersection design, mainly reflected in the following aspects: 1) bicycle lane using color pavement, give people a clear path, guide the bicycle through the intersection.The stop line or bicycle waiting area of the 2) bicycle is set before the motor vehicle stop line, as shown in Figure 7 and 10, to facilitate the motor vehicle drivers to better notice the bicycle waiting or starting, and to reduce the clearance distance of the bicycle, and try to avoid the impact on the road capacity.Most 3) bikes turn left in two street crossing mode in the same phase with pedestrian traffic.Left-turn bicycle is in the same phase as the left-turn vehicle, cross the street twice, and set up the left-turn bicycle waiting area at the intersection. When the bicycle goes straight with the green light, the bicycle will enter the waiting area and pass the intersection when the left turn is green[7]。

1.2.3 Key points of Intersection Design

The main design points of foreign intersections mainly include the following 6 points: 1) The appropriate channelization and width of the import road of the intersection, matching the traffic capacity of the road section.The channelized expansion of the intersection, as shown in Figures 7-12, is conducive to the evacuation of traffic flow and improving the traffic efficiency of the intersection. In essence, space for time. Therefore, in the urban road net-

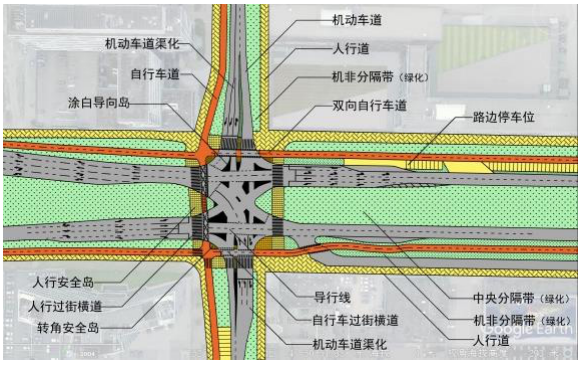

Figure 7 Intersection of Amsterdam, Netherlands

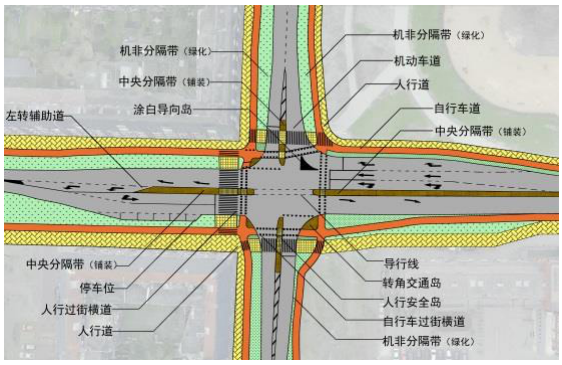

Figure 8 Intersection of Amsterdam, Netherlands

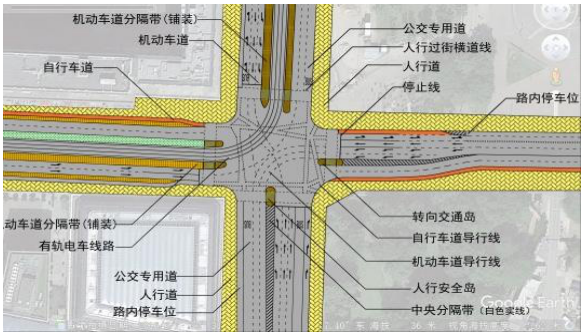

Figure 9 Intersection of Grolingen, the Netherlands

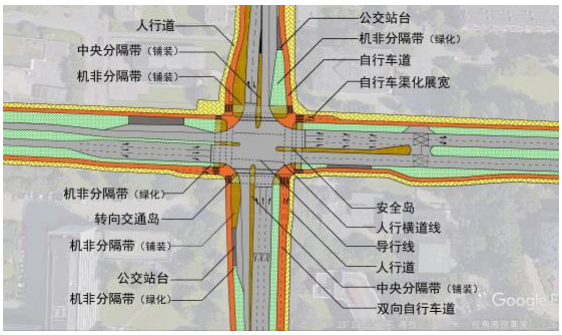

Figure 10 Intersection of Berlin

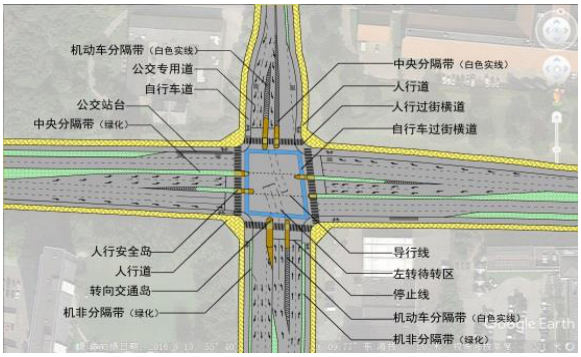

Figure 11 An intersection in Munster, Germany

Figure 12 Copenhagen, Denmark

work planning, the red line of the intersection must consider the widening of the intersection.2) rationally plans the curb radius to reduce the vehicle waiting time and the time of pedestrians crossing the street.The 3) has set up canalization islands, traffic islands and safety islands to ensure smooth traffic flow and reduce traffic accidents. Its main role is to guide the traffic flow, so do not stick to a specific form.As shown in FIG. 7, the intersection has a corner traffic island for right turning vehicles and street passage for pedestrians and bicycles; a water drop traffic island is set in the center of each road (Figure 8-12), which can well guide the safe and smooth operation of vehicle traffic flow.4) designs detailed and clear guide lines inside the intersection to simplify path identification.The guide line and guide island in the center of the intersection can give vehicle drivers a clear driving line and direction, simplify their thinking, observation and identification process, improve the driving comfort and smoothness; on the other hand, improve the intersection safety, the guide line can effectively guide the vehicle into the right lane, and clear the driving path of pedestrians and bicycles, reduce mutual interference and avoid traffic accidents.5) sets up dedicated bike crossings.Two signs are often used in the crosswalk: a zebra crossing with priority, and motor vehicles must let pedestrians go first (Figures 7,8,12); the other is the crosswalk width drawn by two white solid lines (Figures 9,10,11), and pedestrians are only allowed to pass with the green signal.6) rationally allocates intersection greening, and pays equal emphasis on function and landscape.

Foreign traffic engineering research started earlier in our country, more attention to traffic design, compare intersection design at home and abroad, and combined with our relevant design specification, found that the geometric design of traffic intersection construction for more detailed, make the intersection of each mode of traffic path clear, less interference with each other.And China's urban traffic facilities are rough, traffic flow mixing is serious. The defects in traffic design lead to many existing foreign traffic capacity research results are not well applicable to China, mainly manifested in the incomplete detailed design of the intersection, such as guide line, safety island, lane channelization, etc.

2 Basic steps of optimal design of bicycle lane at intersection

The channelized design of the intersection bicycle traffic can ensure the convenient and safe bicycle passage through the intersection.The traffic organization of bicycles at the intersection is an important part of the channelization of the intersection. European developed countries have done more delicate in this regard. Usually, color asphalt lays bicycle lanes to guide bicycles through the intersection, especially in several directions with large bicycle flow.The left turn problem of bicycle is to solve the most headache problem of bicycle traffic crossing at the intersection. We should choose different channelization design according to the different amount of bicycle traffic and the different phase of the signal lights.There are two main organizational forms at home and abroad: first, the left-turn bicycle is in the same phase as the left-turn vehicle, cross the street twice, set the left-turn bicycle waiting area at the intersection, the bicycle in the green light into the waiting area, until the left-turn green light through the intersection; the intersection with large left-turn bicycle flow and small motor vehicle flow, set between the left-turn bicycle lane (Figure 13).Second, it is the same phase twice with pedestrian traffic, non-physical separation measures, in the intersection along the track outside edge of the non-motor vehicle prohibited area, left-turn bicycle traffic in the green cycle to the waiting area in the intersection first in the green cycle, and then through the vertical green cycle (Figure 14). This channelization way is suitable for two-phase signal control intersection.

Urban roads at different levels give different priority to different modes of traffic, with bicycle and pedestrian traffic priority decreasing step by step from branches to expressways, while the opposite is true for motorized traffic. The nodes in the road network with reasonable layout and perfect hierarchy shall be channelized according to their priority.Bicycle lanes should be heavily laid on branches and secondary trunk roads to reduce bicycle flow on the main roads.Most main urban roads in China use three road sections, motor vehicles, bicycles and pedestrians interwoven at the intersection, the bicycle lanes at the intersection cannot solve the problem; the encryption network should transfer bicycles and pedestrians to the surrounding branch roads and secondary trunk roads, more trunk roads are to serve motor vehicles.For the problem that the main roads in many cities are increasingly congested and cannot meet the needs, first of all, the density of the surrounding road network should be increased, and the bicycle and pedestrian traffic should be transferred out as far as possible.The best way for road sections is to maintain

Figure 13 Intersection Bicycle Road Design 1

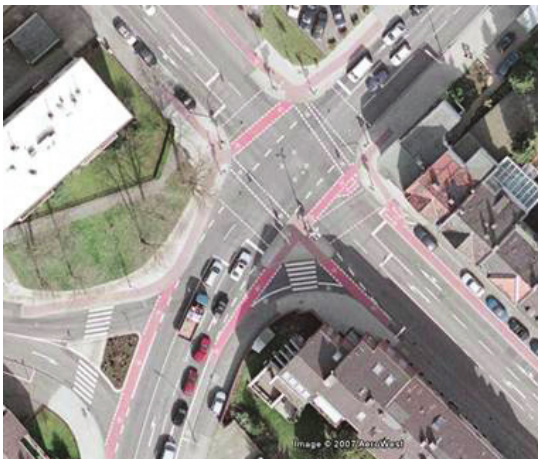

Figure 14 Intersection Bicycle Road Design 2

the original section form on the section, do not destroy the greening, the original bicycle lane into a bus lane, bicycle lane outward, can be set with pedestrians; the intersection, compression or eradicate greening, provide space for import road expansion and additional pedestrian crossing safety island, reasonable channelization design combined with the actual situation.The practice of many cities in China is to broaden and transform the whole road, which involves pipelines and greening, not only the huge project, but still can not solve the problem well; while the encrypted road network and channelized intersection, it can spend less money to do better things.

In the bicycle intersection, the right turning vehicles have the biggest impact on the bicycle. When the bicycle crosses the street, the most worried thing is whether the appearance of the right turning vehicles can be avoided in time.There are many foreign design techniques for this problem, including making the bicycle lane change to the left side of the right turn lane in the middle of the road, entering the middle of the motorized lane, and setting up a special non-motorized lane (Figure 15).Foreign scholars think this practice can solve the conflict between the road intersection bicycle in straight and right turn vehicles, actually this practice is just the conflict in advance, reduce the conflict at the intersection, but this practice has its disadvantages, such as right turn motor vehicles to turn to the right turn lane, for the right side to drive left into the bicycle lane of vehicle observation is inconvenient, need to judge through the rearview mirror, there is no best perspective to timely find non-motor vehicles.Similarly, if a non-motor vehicle has to go left in front of the car, it needs to turn its head to observe whether there is a motor vehicle to row right at the rear side. This move will not only cause traffic delays and jams, but also have safety problems (Figure 16).Such problems can be solved in this way.Take out a regular road intersection, at the intersection of the two street bicycle lanes, its radius and the existing control line, the car should also be around the control line outside, when the motor vehicle, non-motor vehicle drivers wherever, can be seen by motor vehicle driver, and pedestrians under the boundary protection only need to see whether a motor vehicle past, do not need to look back, improve the safety of non-motor vehicle drivers.Expand the middle of the connection to protect the traffic island for cyclists to go straight and turn right.The original stop line can then easily be moved back and empty enough space to set pedestrian zebra crossings giving pedestrians a better space to pass through the intersection (Figure 17,18,19,20,21,22).

Now analysis how the intersection to improve safety, a situation, when the motor vehicle to the intersection, can easily see whether there are pedestrians or non-motor vehicles to go straight across the street, see can stop at the turn, waiting for pedestrians or non-motor vehicles after crossing the street, the design in turning space can reserve a motor vehicle suspension space, when the motor vehicle stays in this space waiting, will not affect the vehicles straight, or improve the efficiency of right vehicles.Case 2, when the motor vehicle has turned right to the intersection, non-motor vehicles can easily see the driving track of the motor vehicle, and can determine the time and position of the motor vehicle will be passed in advance, which can produce corresponding countermeasures, slightly slow down or stop to wait.This also greatly improves the safety of non-motor vehicles and pedestrians in crossing this intersection (Figures 3-20).This design not only solves

Figure 15 Design Case of Foreign Bicycle Road Crossing

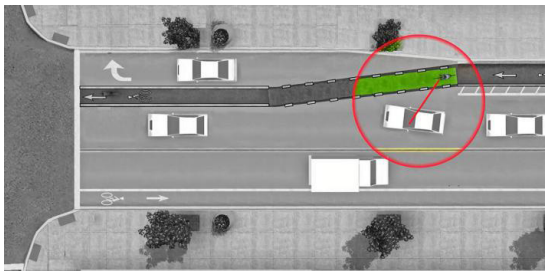

Figure 16 Analysis of Bicycle and Motor Vehicle

Figure 17 Intersection Bicycle Road Design Figure 1

Figure 18 Intersection Bicycle Road Design Figure 2

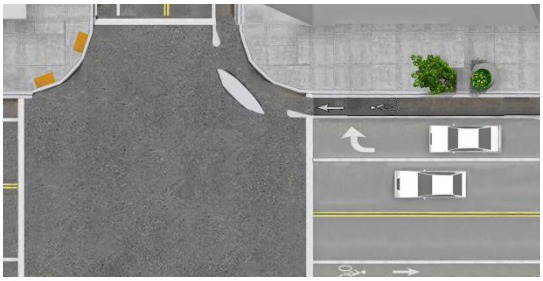

Fig. 19 Intersection Bicycle Road Design Figure 3

Figure 20 Intersection Bicycle Road Design Figure 4

Figure 21 Design of Bicycle Road

Figure 22 Design of bicycle crossing at intersection

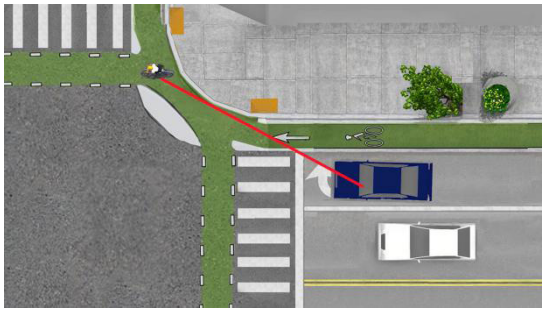

Figure 23 Analysis of the sight of motor vehicles and non-motor vehicles at the intersection

the safety problem arising from the conflict between the motor vehicle and the non-motor vehicles during the right turn, but also solves the waiting space for the right turn, improving the traffic efficiency and use safety of the intersection. This design is not theoretically, but has actually been used in the Netherlands.

3 Conclusion

Through the intersection design comparison of home and abroad, draw on the excellent experience of foreign countries, take slow intersection, as an example, from the perspective of the basic design of urban road intersection, finally proposed intersection optimization design strategy, which contributes to the deepening research and practice of road intersection design under the background of sustainable slow traffic system.

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