

Research on vulnerable road user's traffic safety design at city intersection

Wang Shuling, Guo Jifu, Chen Jinchuan, Chen Yanyan & Wang Zhenhua

Beijing Transportation Research Center
Room411, No.9 Beibinhe Road, Xuanwu District, Beijing
100055 Beijing, China
Phone: 86 10 63372730
Fax: 86 10 63372715

E-mail: wangsl@bjtrc.org.cn, guojf@bjtrc.org.cn, chenjc@bjtrc.org.cn,
cdyan@bjut.edu.cn, zhwang@emails.bjut.edu.cn

Abstract

With rapid development of road construction and passenger car entering family, it leads to the traveling convenience as well as the serious traffic accidents and greater economic loss in China. Intersection is the traffic accident prone location in city, where car, bicycle and pedestrian conflict at many points. Moreover there's little consideration of the vulnerable road users' right and safety during intersection design and operation, so it is dangerous for bicyclist and pedestrian crossing intersections. Based on mass traffic reports of recent years, the traffic accidents data was classified, character and reasons of vulnerable road users' accidents were analyzed in this paper. Then this research proposed design principles and factors for vulnerable road user's traffic design at intersection considerate the balance between road safety and capacity. Finally an intersection named Da Wanglu was selected as an example to illustrate how to realize vulnerable road user's traffic design.

Key words: City Intersection, Vulnerable Road User, Safety Improvement, Design

1 Background

Pedestrian and bicyclist, compared with automobile drivers are unprotected or semi-protected, they are vulnerable road users (VRU). During 1990s in 20 century, pedestrian and bicyclist accounted for 50.45% of all deaths. After entering the 21st century, the proportion of VRU traffic death has declined, but they remained the main victims of traffic accidents in 2005 National Survey, pedestrian deaths is 24451, accounting for 24.76.% of deaths number. 15,250 Bicyclist were killed, accounting for 15.45% of the number of deaths [1]. Intersection is the traffic accident prone location in city, where car, bicycle and pedestrian conflict at many points. Therefore it is necessary to analyze traffic demand of pedestrians and bicyclists to realize the concept of "people-oriented" design, and take appropriate safety measures to improve the traffic environment.

2 Traffic Demand of VRU

Walking and cycling as the best tool for short-distance travel, has many advantages : First, walking and cycling are green mode of transport, no emissions, no pollution to the environment; Meanwhile they are also healthy transport tool, walking and cycling in the process, people can do exercise; Besides walking and cycling can achieve "door-to-door, proceeding directly from arriving at the destination, as well as flexibility, less restrictions in route, will be in a narrow alley Lane;

Bicycles need small space for driving and parking, operating bicycles needs nine square meters in size in road, the average space size required by the operation cars in the road is 40 square meters and is about as high as 4.5 times of the bicycle. Bicycle parking area is about 1.6 square meters, while car needs 22 square meters of parking area, which is 14 times bigger than bicycle. Therefore, bicycle traffic will be useful for saving road space resources.

Bicycle is an economical transport, for the short distance trip less than 8 km, the energy Per km per kg (moving objects weight) bicycle needed is only one of nine of automobile cars mobile energy; in addition bicycle is always cheap, ordinary people have the ability to buy; and bicycles that do not require a high level of skills of all ages.

For the above advantages of walking and bicycle, walking and bicycle are the major traffic tools in China. According to the Beijing Municipal Traffic comprehensive survey in 2005 it shows that there are about 29.2 million trips daily in Beijing, The proportion of walking is 31% bicycle accounts for 20.9%. Taken them together walking and bicycle have reached 51.9%, that means in Beijing 15.15 million trips per day are VRU trips.

Currently, cars grow very rapidly with the rate of almost 1,000 vehicles per day, by the end of 2006, the vehicles number reached 2.85 million, an increase of 90% compared with the year of 2000. Facing with the increasing traffic jams, worsening traffic environment, the experience of developed countries shows that the most fundamental solution is to develop public transport. "Beijing urban master plan" also brought forward "Traffic development objectives and strategic task are to establish modern comprehensive transport system to meet with the function of modern international city and the state capital, establish sustainable development, people-oriented public transport to meet traffic demand "[2]. Walking and cycling as access to public transport, especially the MTR and the short-distance travel convenient tool for building a modern integrated transport system is an indispensable part of traffic. According to the current development trends, residents will travel by foot and bicycle modes, maintain basic share of around 50%.

3 VRU Traffic Accidents Analysis

VRU accounts for 50% of total daily trips in Beijing, walking and bicycle are indispensable traffic modes for residents travel. The safety of VRU is worrying. According to statistical data of traffic accidents in Beijing in 2004, 1024 accidents happened at intersection, accounted for 12% of total traffic accidents. Especially in the city center, VRU traffic accidents accounted for as high as 57%. In 2004 there happened 931 bicyclist involved accidents, 865 people hurt, 149 people died and the direct economic loss is 2.02 million RMB. Therefore, this research has important practical significance.

The main reasons of VRU traffic accidents can be summarized as three aspects: traffic infrastructure, right of way and VRU traffic safety consciousness.

1) Traffic Infrastructure

Traffic infrastructure is build and set to ensure traffic activities. It should meet the traffic needs of different road users. However, in reality, company with the continuous urban mechanization, the number of vehicles continues to increase, and the continuous deterioration of traffic jams, too much attention was focused on the motor traffic. Usually road design and extension firstly consider how to improve the road capacity, and allow more vehicles running fast, then pedestrians and bicycles were drop in on. As a result, the vehicle lane becomes winder and wider, bicycle lanes was continued to be occupied. Bicycle lane was changed into right turn vehicles lane, motor vehicle parking spaces and bus stops, which add more additional weaving and conflict between VRU and motor vehicles.



Bus stop was setting on the right side of bicycle lane, bus vehicles occupy bicyclist space when buses pick up and drop passengers.



Motor vehicles occupy bicycle lane especially in traffic jam, which leading to mixture traffic.



Parking in the bicycle lane



Obstruct on the walking lane



Pedestrian refuge island on wide intersection



Inconvenience for bicyclist on over pass

Figure1 problems on the road

Meanwhile, with road reconstruction, a lot of overpass and under pass were built for VRU crossing, although it is helpful to reduce the conflict between motor vehicle and VRU, but it increased VRU crossing difficulty, particularly for the elderly and disabled, it brought a lot of inconvenience to their travel.

2) Right of Way

Right of Way in fact includes four rights: right of trip, right of wayleave, right of priority and right of occupied. Here right of priority is discussed, when different traffic flows or different road users conflict at one point where both of them have the right of wayleave, it should be firstly to define who has priority to use road resource. Why the right of priority is focused, because in the traffic accident survey, it is founded that many accidents happened on the pedestrian crosswalk, especially the crash of right turn vehicle and pedestrian or bicyclists. New road traffic safety law has defined pedestrian has the priority on crosswalk, vehicle should slow down, and when there pedestrian crossing, vehicle should park and yield. However in reality, major vehicle drivers do not obey this regulation, then when a pedestrian has strong sense of right of priority but vehicle drivers do not yield, it is easy leading to accidents

3) VRU Traffic Safety Consciousness

Statistics show that VRU is the major group to disobey traffic regulation. The top three behaviors are: violate turn, opposite running and traverse motor vehicle lane. This is because of poor safety awareness of VRU.

4 Countermeasures for improving VRU Safety

First of all, the design concepts should pay full attention to VRU. "clothing, food, accommodation, and trip " is the four elements of life. Trip must generate traffic. Road infrastructure, traffic management both services for each trip.

According to the comprehensive investigation of traffic in Beijing in 2005, VRU accounted for 51.9% of all kinds of trips, motor vehicles accounted for (including taxis) 25.8%. Public transport (including MTR) accounted for 20.6%,and others accounted for 1.7%. It is indicated that vulnerable groups is the main component of road traffic, therefore there is no reason to ignore their safety. Then in order to truly embody a people-centered concept, from all the viewpoints including the traffic policy formulation, traffic planning, traffic engineering design and traffic management organizations, all aspects of the rights of every traveler must be fully considered.

Secondly, safe and comfortable transportation infrastructure and facilities should be provided for vulnerable groups to improve their traffic security, which includes special bicycle lanes, reasonable intersection signal, pedestrians and bicycles facilities for crossing the street, the rational traffic management and so on. For instance, special bicycle lanes have been widely applied in many countries. Rotterdam, the Netherlands second largest city, built the first bicycle tunnel allover the world, which links the new and old district in the city. Especially, five automatic elevators have been installed in the entrance of the tunnel to facilitate the bicyclists. As to facilities for VRU crossing the street, for the larger crossings (width exceeding 15 meters), setting up the best refuges should be considered [3]. And for the bicycles turning left, the secondly crossing the street facilities had better be taken into account to reduce the conflict with motor vehicles. At the same time, attention should be paid to remove the obstacles to the line of sight of drivers and vulnerable groups, keeping them from colliding.

At last, safety education to improve traffic safety awareness of the VRU groups must be emphasized. To enhance VRU group's awareness of traffic safety is important for improving traffic safety.

Because pedestrians and bicyclists do not have to receive the traffic training and test for the motor vehicle drivers, they are mostly short of the awareness of observing traffic regulations. According the statistic data from relevant departments, most traffic violation in the main streets came from pedestrians and bicyclists in 2004.

And in bicycle accidents, illegal occupation of motor vehicle lanes, turning left or right suddenly and illegal crossing motor roads are the main reasons for deadly accidents. Without the awareness of traffic and observing traffic regulations, no transportation infrastructure can play a good role. So it is most important that pertinent safety education should be carried out timely in order to enhance the VRU groups awareness of traffic safety [4].

5 Case Study---Dawanglu Intersection

5.1 Basic Information

Dawang Bridge is a 4-leg interchange intersection, locates in the middle of east 3rd ring road, and east 4th ring road. It is the only north –south artery road between the east 3rd ring roads and 4th ring road, and the east boundary of CBD. Traffic volume here is very high. There is a subway station and over 20 bus lines, many passengers transferred here. SOHO building and a market also caused many traffic attraction. Mixed traffic flow of vehicle, bicycle and pedestrian caused many delay and conflicts. The traffic volume and signal cycle are shown as the following table.

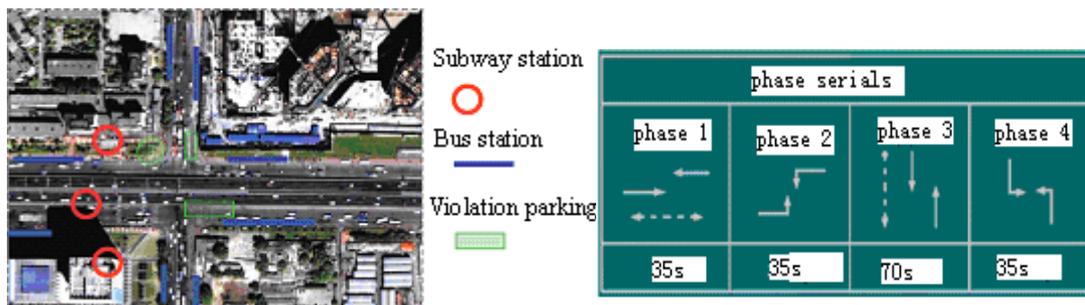


Figure 2 Basic Information of Dawanglu Intersection

Table1 Survey Traffic Volumes of Dawanglu Intersection

	Type	Left turn	Through	Right turn
East	Motor vehicle	222	1404	226
	bicycle	300	840	460
	pedestrian	310	540	320
South	Motor vehicle	222	270	218
	bicycle	312	523	326
	pedestrian	368	497	332
West	Motor vehicle	234	1632	245
	bicycle	334	810	432
	pedestrian	370	510	290
North	Motor vehicle	246	310	241
	bicycle	300	512	297
	pedestrian	377	432	346

There are 9 accidents happened at this intersection during 2004 and 2005. Within the 9 accidents, there are 5 accidents recorded detailed. 3 accidents were caused by the crash between right turn vehicles and pedestrian, bicyclists. 2 accidents were caused by the crash between through vehicle and pedestrian, bicyclists. The main reason is unclear bicycle region and confusion track.



Figure 3 Traffic Accidents at Dawanglu Intersection

5.2 Current Situation Analysis

1) Channelization

The main issues are: entrance and exit lanes do not match, which lead to vehicle weaving within intersection, Streamline confusing, and conflict; Across Regional is not clear, which leading pedestrians and bicycle streamline confusion, especially the northwestern a chaotic months more serious situation.



Figure 4 Current VRU crossing situation

2) Signal control

Pedestrian and bicyclist wait too long under red signal, which lead to many pedestrian violation behaviors

3) Infrastructure

The main problem is lacking of barrier between vehicle lane and bicycle lane; lacking of protection facilities for U-turn underneath; long-distance (70 meters) crossing under bridge, pedestrian signals visibility is poor.



Figure 5 Traffic Infrastructure Problems

5.3 Countermeasures

Traffic Channelization	Bicycle two-stage crossing; U-turn vehicle radius; pedestrian refuge; optimize crosswalk location; intersection driving track
Traffic Control and Management	Signal control for U-turn vehicle, signal control for right turn vehicle, signal coordination optimization, signal control of pedestrian and bicycle two-stage crossing
Infrastructure	Add barrier, add glisten sign, add speed sign, add light under bridge, clear up obstacle, add nearside signal lamb

1) Traffic Channelization

VRU crossing type: pedestrian cross underpass from south to north, crosswalk on road from east to west, the pedestrian refuge island area is 2 meters in width. Bicycle cross by two-stage, the waiting area for two stage crossing bicycle is shown.

Table 2 left turn bicycle waiting area calculation and evaluation

	Northeast corner	Southeast corner	Southwest corner	Northwest corner
Waiting area(meters square)	50	50	50	50
Required area(meters square)	24	42	24	48
evaluation	satisfied	satisfied	satisfied	satisfied

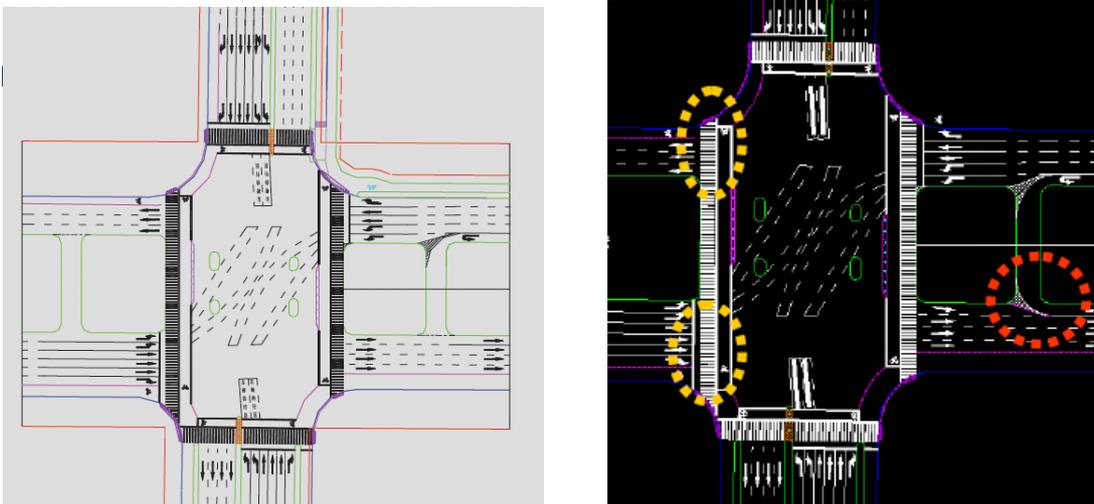


Figure 6 Channelization design of Dawanglu Intersection

2) Signal control

Set two signal lamps for pedestrian crosswalk, and add pedestrian green time using the gap of different vehicle phase; set U-turn signal lamp to protect U-turn vehicles

3) Infrastructure

- Median Barrier
- No obstruct
- Bump of median refuge
- Speed limited sign
- Add pedestrian and bicycle signal lamp facility

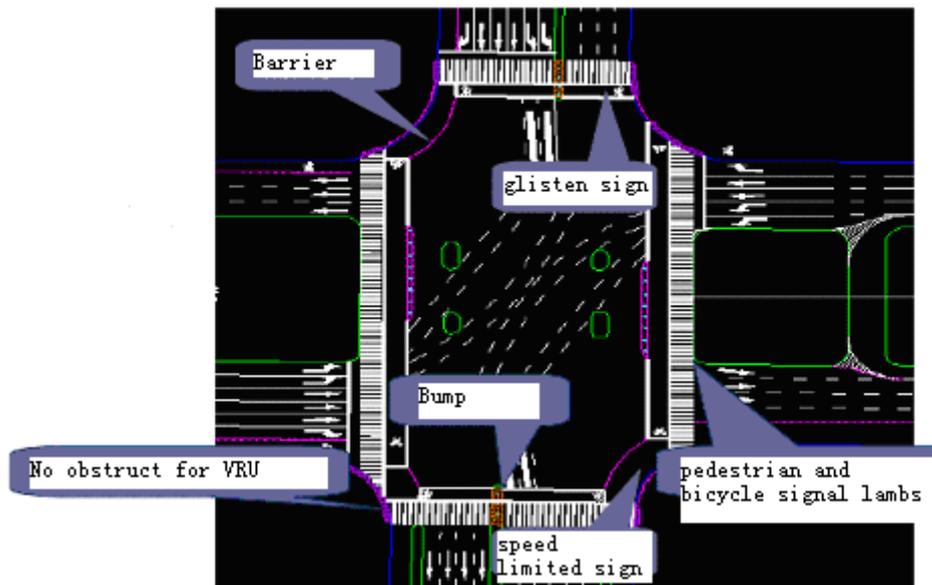


Figure 7 Infrastructures designed of Dawanglu Intersection

6 Conclusion

VRU is the major traffic group in road. But with rapidly mobile developing, people gradually neglected the interests and security of VRU, too much attention was given to the interests of motor vehicles. This paper based on the study of urban intersection of VRU, detailed analyzed the existing problems, bright forward the corresponding countermeasures, and make a case study of Dawanglu intersection, put forward a comprehensive safety Design. The research aims at gradually arouse the relevant departments attention of the safety of VRU, embody a people-centered approach and establishment of a harmonious society.

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