MAIN FINDINGS OF THE FOLLOW-UP SURVEY - GRSI BEIJING PROJECT OF IMPROVING VULNERABLE ROAD USER SAFETY AT INTERSECTIONS

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ABSTRACT
The 2004-2005 road crash data of Beijing Traffic Management Bureau indicated that over 50 percent of the road crashes in the city occurred at intersections; over 30 percent of road crashes in the suburbs occurred at intersections. 43 percent of the road crashes involved vulnerable road users (Beijing Traffic Management Bureau, 2006). During 2006-2009, Beijing Transportation Research Center (BTRC), Beijing University of Technology (BJUT) and Global Road Safety Partnership (GRSP) worked together on a pilot project to improve the vulnerable road users (VRU) safety at the six selected high risk intersections in Beijing (Jifu Guo, 2011). A follow up survey was carried out by Beijing University of Technology (BJUT) and Global Road Safety Partnership (GRSP) one year after the completion of the pilot project in 2010 to review the traffic and safety situation at the six selected intersections. The purpose of the survey was to find out: a) whether or not the countermeasures/facilities taken in the project still in place and whether or not people are still using them; b) have those countermeasures helped to reduce the number of road crashes at the six selected intersections. The survey applied the following approaches: a) the 2008-2009 road crash data in Beijing was collected from the local traffic police and analyzed; b) road observations was conducted at the six selected intersections to collect the traffic information such as traffic volume, vehicle speed, traffic timing and traffic conflicts; c) the questionnaire survey was conducted at the intersections to understand the behaviours of different road users when crossing the six improved intersections. The findings of the survey show that the casualty cashes were reduced at all of the six intersections compared with the data before the pilot program during 2004-2005; most of the countermeasures used in the pilot project are still in place and still being used by people; though some of them were converted into different form or moved to other places (such as the some road signs were moved from the roadside barrier to median barrier) when the road maintenance was conducted. However, it was also found that the countermeasures at a couple of selected intersection have been removed.

This paper provides the general information of the pilot project, the background and method used in the follow-up survey; and using two of the six intersections as the example to
show the problems at the intersections, the countermeasures used to address the issues, and
the data comparison at the three different stages (before the countermeasures taken in 2006,
after the countermeasures taken in 2008 and findings of the follow-up survey in 2010). The
findings of the survey provide the road safety professionals some interesting information for
reference and consideration as well as some food for thought.

Key words: Vulnerable Road User Safety, high Risk Intersections, Low Cost Engineering
Countermeasures, Road Safety, Follow up Survey

1 BACKGROUND

As understood, pedestrians, bicyclists and motorcyclists are the “vulnerable road users”
( VRUs) in many of the countries in the world; China is no exception. A large proportion of
the road crash victims in low-income and middle-income countries are pedestrians and
cyclists ( Margie Peden, et.al, 2004). There are many vulnerable road user related researches
in the world, which provides great amount of information with cost-effective countermeasures
(gTKP Theme Page-Pedestrians and Cyclists, and iRAP Road Safety Toolkit - Pedestrians
Center (BTRC), Beijing University of Technology (BJUT) and Global Road Safety
Partnership (GRSP) worked together on a pilot project to improve vulnerable road user
(VRU) safety at the six selected high risk intersections in Beijing. The project went through
the process of the data collection and analysis to identify the high risk intersections and
related problems (2006-2007); design and implement low cost engineering countermeasures
to address specific issues at each intersection (2007-2008) and evaluate the effectiveness of
the used countermeasures through before and after analysis (2009). The outcome of the
project evaluation showed that the traffic conflicts were reduced at the selected intersections
(since the time was too short to make the crash data comparison, the traffic conflict was used
for project outcome evaluation); and the pedestrians feel safer when across the intersections.
In addition, as an output of the project, a manual of “Design and Operational Guide for
Vulnerable Road User Safety at Intersections” was developed in both Chinese (Jifu Guo et.al,
2010) and English (Yanyan Chen et.al, 2011) by the partners, which using the project as the
case study but provide the general and specific solutions of improving VRU safety at
intersections from a much broader aspect.

Six high risk intersections were selected for improvement in the pilot project. Most of them
are located in the central of the city. The table 1 below shows the general information of each
intersection; and the fig. 1 is a map which shows the location of the six intersections.
Table 1: General Information of the six selected intersections

<table>
<thead>
<tr>
<th>Name of Intersections</th>
<th>Numbers of Casualty Crashes at the Intersections (2004-2005)</th>
<th>Types of Intersection</th>
<th>Existing Safety Facilities at Each Intersection before the countermeasures taken</th>
<th>Main type of road crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xidan</td>
<td>12</td>
<td>4-leg at-grade intersection</td>
<td>Underpass in North-south Zebra lines in East-West</td>
<td>Bicycle and pedestrian</td>
</tr>
<tr>
<td>Dongdan</td>
<td>3</td>
<td>4-leg at-grade intersection</td>
<td>Underpass in North-south Overpass in East-west</td>
<td>Bicycle and pedestrian</td>
</tr>
<tr>
<td>Jiangzhai</td>
<td>6</td>
<td>4-leg at-grade intersection</td>
<td>Overpass for four directions</td>
<td>Bicycle</td>
</tr>
<tr>
<td>Dongsishitiao</td>
<td>11</td>
<td>Roundabout intersection</td>
<td>Underpass for east entrance, zebra lines for the other three entrances</td>
<td>Bicycle</td>
</tr>
<tr>
<td>Chaoyang Park</td>
<td>2</td>
<td>3-leg at-grade intersection</td>
<td>Zebra lines</td>
<td>Pedestrian</td>
</tr>
<tr>
<td>Dawang</td>
<td>9</td>
<td>4-leg at-grade intersection under an interchange bridge</td>
<td>Zebra lines</td>
<td>Pedestrian</td>
</tr>
</tbody>
</table>
By data collection and analysis, it was found that the right-turn vehicles were most dangerous for bicyclists and pedestrians, especially at non-peak hours. Traffic rule violation by road users was the main reasons for the crashes. Targeting on the specific problems at each intersection, a series of low cost engineering countermeasures were designed and implemented to reduce the traffic conflicts and road crashes. The table 2 shows the specific countermeasures undertaken at each of the six selected intersections.

Table 2: The Countermeasures taken at the selected 6 intersections

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Countermeasures undertaken during 2007 - 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xi dan</td>
<td>1) Set up waiting line for left-turn bicycles for two stage crossing</td>
</tr>
<tr>
<td></td>
<td>2) Install the road signs and barriers to guide pedestrians using the underpass as requested</td>
</tr>
<tr>
<td>Dong dan</td>
<td>1) Remove the taxi station at the north entrance</td>
</tr>
<tr>
<td></td>
<td>2) Install road signs and barriers to guide pedestrians using underpass and overpass</td>
</tr>
<tr>
<td></td>
<td>3) Set up waiting line for left-turn bicycles for two stage crossing</td>
</tr>
</tbody>
</table>
### Intersection Countermeasures undertaken during 2007 - 2008

**Jiang zhai**

1) Set up waiting line for left-turn bicycles for two stage crossing
2) Extended barriers to guide pedestrians using overpass

**Dong si shi -tiao**

1) Modify the length and radian of the barriers to guide cyclists using the bicycle lane
2) Set up refuge island for pedestrian’s two stage crossing at west entrance

**Chao yang park**

1) Set up waiting line for left-turn bicycles for two stage crossing (west intersection)
2) Set up refuge island for pedestrian’s two stage crossing (east intersection)

**Da wang**

1) Build a pt platform in south entrance
2) Install the barriers in the platform and painting zebra between platform and walkway.
3) Install road sign and barrier to guide pedestrians using zebra line
4) Set up waiting line for left-turn bicycles for two stage crossing
5) Install right-turn traffic signal in south entrance
6) Construct the bus bay in south east corner

Nowadays, the vehicle volume has increased significantly in China compared to 2006 when the pilot project first started. Particularly in Beijing, the motor vehicle fleet have reached to 4.81 million by the end of 2010 according to the data released by the Beijing Traffic Management Bureau. The traffic situation changed, are the countermeasures used at the six intersections still in place? Whether or not people still use them? Have those countermeasures helped to reduce the number of road crashes at the intersections? In order to find those answers, Beijing University of Technology and GRSP carried out a follow up survey in 2010.
2 OBJECTIVES

The objectives of the survey are to find out a) if the number of road crashes at the six selected intersections have been reduced after the countermeasures taken in the pilot project; b) if those countermeasures/facilities still in place and still in use; c) if those countermeasures helped with reducing the traffic conflicts and changing behaviour of road users at the six intersections; d) make recommendations to the municipal government for further improvement, if necessary.

3 METHODS

3.1 Survey Preparation

Before the physical activities of the survey starts, a couple of planning meetings were conducted between partners to review the methods and evaluation indicators as well as to identify the work load and timeline. The historical crash data during 2008-2009 was collected from the local traffic police in order to understand if the road crashes at the six selected intersections were reduced after the countermeasures taken.

3.2 On Site Survey

Most of the on-site survey activities were carried out in the month of December 2010. The road observations and behaviour surveys were conducted during Dec. 21-22 at 8:30-10:30 a.m. and 2:00-6:00 p.m. which covered both peak hours and non-peak hours. Video cameras, time counters and radar guns were used to collect the traffic data including traffic volume, vehicle speed, traffic timing and traffic conflicts at the six selected intersections. 150 pedestrians were interviewed at the intersections at the non-peak hours during the two days in order to understand their behaviours of crossing the intersections and get their views of the current facilities at the intersections.

3.3 Evaluation

Based on the international research, both qualitative and quantitative methods can be used to evaluate effectiveness of the different road safety countermeasures. Examples are qualitative analysis (Tanaboriboon Y., 1994), quantitative analysis (Rouphail, N.M., 1984), regression model (Li, G.Q., 2000) before-after analysis (Cairney, P., 1999), and follow up survey (Campbell, B.J., Zegeer, C.V., Huang, H.H., and Cynecki, M.J., 2004).

Both qualitative and quantitative methods were used in the survey. Based on the specific problems identified at the six selected intersections, the indicators were set for each individual intersection to evaluate the effectiveness of the used countermeasures. The main indicators include the number of serious conflicts per hour occurred between motor vehicles and left-turn bicycles at the intersections; the proportion of left-turn bicyclists using the waiting line to make the two stage crossing; the compliance rate of bicyclist for using the bicycle lane at the roundabout; mean speed and 85-percentile speed of the right-turn vehicles at the intersections; proportion of the right-turn vehicles that yield to bicycles per signal phase at the intersections; the number of pedestrians per hour not to use the safety facility as required (such as underpass or overpass) when crossing the intersection; the average walking speed of pedestrians when crossing the intersection; the proportion of pedestrians who use the refuge island after it was installed; and the proportion of passengers who use the zebra line to cross the street when got off the bus.
4 MAIN FINDINGS

4.1 The Crash Data Comparison between Before and After the Countermeasures Taken

From the road crash data of 2004-2005 and 2008-2009 collected from the local traffic police, people can clearly see the numbers of casualty crash were reduced at each of the selected intersections after the countermeasures taken. The Table 3 shows the outcome of the data comparison between 2004-2005 (before the countermeasures taken) and 2008-2009 (after the countermeasures taken).

Table 3: Crash Data Comparison of the Six Selected Intersections

<table>
<thead>
<tr>
<th>Name of the Intersections</th>
<th>Number of Casualty Road Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xidan</td>
<td>12</td>
</tr>
<tr>
<td>Dongdan</td>
<td>3</td>
</tr>
<tr>
<td>Jiangzhai</td>
<td>6</td>
</tr>
<tr>
<td>Dongsishitiao</td>
<td>11</td>
</tr>
<tr>
<td>Chaoyang park</td>
<td>2</td>
</tr>
<tr>
<td>Dawang</td>
<td>9</td>
</tr>
</tbody>
</table>

The data in Table 3 shows the casualty crashes were reduced at all of the six selected intersections. However, the information from the road observation also indicated that the outcome was partly because of the countermeasures undertaken at the intersections; and partly due to the increase of the traffic volumes (both vehicles and pedestrians) at some of the intersections – the busier the road is, the fewer casualty cashes occur.

4.2 Main Findings of the On-site Survey
GRSP and the partners of the Beijing University of Technology (BJUT) visited and reviewed the facilities at each of the six intersections during the survey. It was found out that most of the countermeasures used in the pilot project are still in place and still being used by people; though some of them were converted into different form or moved to other places (such as the some road signs were moved from the roadside barrier to median barrier) when the road maintenance was conducted. Since the page is limited for the paper, we can only choose two examples to show the main findings. The chosen examples are with general information of the intersections (location and basic traffic situation); the identified problems at the intersections and specific countermeasures undertaken to address them; and the pictures taken at the three different stages (2006 before the countermeasure taken, 2008 after the countermeasure taken and 2010 during the follow-up survey) as well as the tables and chart which shows data
comparison between those three different stages. The two examples are one for success and the other one for “food for thought”.

4.2.1 Example of Success: Setting up the Waiting Line for Left-turn Bicycles for Two Stage Crossing at Xidan Intersection

Located at the end of the West Changan Street (one of the busiest roads in the city), Xidan intersection has many shopping centers and banks around. The width of the intersection from east to west is 40m; while from north to south is 60m. Underpasses are in place for the North-South direction, hence no pedestrian is allowed to cross the street on the pavement; while the zebra lines are painted on the ground for the East-West direction, which allows pedestrians crossing on the pavement. Both volumes of bicycles and pedestrian are high at the intersection. The fig. 2 shows the bird’s-eye view of Xidan intersection.

During 2004-2005, 12 casualty crashes were occurred at the intersection; 8 of them involved left turn bicycles(Beijing Traffic Management Bureau, 2004 & 2005). Due to lack of channelization, the left turn bicycles either tried to cross the street at one stage or waited anywhere in the middle of the street for the two stage crossing. As the result, it generated a lot of conflicts between the left turn bicycles and the through motor vehicles at the intersection. The countermeasure taken to address the problem was to set up the waiting line for left turn bicycles in order to cross in two stages. The Fig. 3,4, 5 and the chart below shows the difference of the three different stages in 2006 (before), 2008 (after) and 2010 (follow up survey).
Fig. 3 picture before the countermeasure taken (2006)

Fig. 4 picture after the countermeasure taken (2008)

Fig 5 picture taken in 2010

The indicators used to evaluate the effectiveness of the countermeasure are:

a) *The proportion of cyclists making a left turn in two stages* - the chart below shows the data comparison at the three different stages in 2006, 2008 and 2010 at each of the entrance of Xidan intersection:
By setting up the waiting line for left-turn bicycles, the proportion of two stage crossing has been greatly increased as the chart shown. In 2008, nearly 80% left-turn bicycles were using the waiting line to finish the two-stage crossing. By 2010, it was reached to 100% which shows the behaviour change of people.

b) The number of conflicts between left turning bicycles and motor vehicles (the information was collected by the video at the intersection). Table 4 blow shows the data comparison at the three different stages in 2006, 2008 and 2010.

Table 4: Conflicts between the Left–turn bicycles and Through Motor Vehicles (per hour) at the Three Different Stages between 2006, 2008 and 2010

<table>
<thead>
<tr>
<th></th>
<th>non serious conflicts per hour</th>
<th>proportion</th>
<th>serious conflicts per hour</th>
<th>proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>10</td>
<td>45%</td>
<td>12</td>
<td>55%</td>
</tr>
<tr>
<td>2008</td>
<td>11</td>
<td>69%</td>
<td>5</td>
<td>31%</td>
</tr>
<tr>
<td>2010</td>
<td>9</td>
<td>64%</td>
<td>5</td>
<td>36%</td>
</tr>
</tbody>
</table>

The conflict data shows the decline of the total number of the conflicts in 2008 and 2010 comparing with the numbers of 2006. However, in consideration with serious conflicts as potential crashes, the reduction of such conflicts is more important to the safety at the intersections.

c) Mean speed and 85-percentile speed of right turn motor vehicles (the information is collected by radar gun). Table 5 blow shows the data comparison at the three stages in 2006, 2008 and 2010.
Table 5: Mean speed and 85-percentile speed of right turn motor vehicles at 2006, 2008 and 2010

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean speed</td>
<td>16.5 km/h</td>
<td>15.4 km/h</td>
<td>14.4 km/h</td>
</tr>
<tr>
<td>85% speed</td>
<td>22 km/h</td>
<td>20.7 km/h</td>
<td>19.6 km/h</td>
</tr>
</tbody>
</table>

The speed reduction of the right-turn vehicles was a by-product of the countermeasure. Due to high volume of left-turn bicycles waiting for the 2nd stage crossing, it makes the usable space for right-turn vehicles smaller. As the result, the right-turn vehicles have to slow down when approaching the waiting line, which in fact helped with the safety at the intersection.

The information in the section of 4.2.1 shows the success and effectiveness of the countermeasure, which serves the purpose of reducing the traffic conflicts and improving the safety of the bicyclists.

4.2.2 Example of Food for Thought – Barrier at Jiangzhai Intersection

Jiangzhai is a four-leg intersection located between the north second ring road and the north third ring road, connecting the Andingmen and Ping’ Anli Streets. It is a signalized crossing with five traffic phases. Signal cycle is 188 seconds. As an arterial road, the traffic volume of Andingmen Street is very high. To across the intersection, pedestrians are requested to use the 4-direction overpass bridge setting at the intersection (please see the Fig. 6 below).

Fig. 6 Jiangzhai Intersection

Barriers were installed at intersection to guide pedestrians using the facility. However, it was found out in 2006 that due to a barrier opening at the west entrance (see the picture 7 below), many pedestrians took advantage to cross the street on the pavement, which resulted in the traffic mix and generated traffic conflicts.
As the countermeasure taken in 2008, the opening was closed by the extended barrier. (see the picture 8 below).

However, 4 openings were found at the intersection in the follow-up survey in 2010 (see the Fig. 9, 10, 11, 12 blow).
Fig. 9 and 10 Pictures taken in 2010

Fig. 11 and 12 Pictures taken in 2010

As the result, almost no one use the overpass as requested at the intersection. The table 6 shows the data comparison at the three different stages in 2006, 2008 and 2010.

Table 6: Data Comparison between 2006, 2008 and 2010

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of pedestrians not using the overpass as request per hour</td>
<td>27</td>
<td>18</td>
<td>83</td>
</tr>
</tbody>
</table>

This example provides us some food for thoughts. The issue is not as simple as expected. The question to road safety professionals is that how to provide the system/facility which meets the requirements for both safety and the needs for convenience.

5 CONCLUSION:
Pedestrians and bicyclists are vulnerable on the road and they make up the majority of road crash victims in China (Ministry of Public Security, 2010). How to improve the safety of vulnerable road users is a challenge to the road safety professionals. Many researches are conducted in this area and many engineering countermeasures have been proven cost-effective. The pilot project conducted by GRSP and its partners in Beijing during 2006-2009 was one of the evidence based intervention that put those countermeasures in practice.
The follow-up survey described in the paper was conducted by GRSP and Beijing University of Technology (BJUT) in 2010, one year after the pilot project completion. The findings of the survey brought both good news and much food for thought. It proves again the importance of evaluation and let known which countermeasures work and which needs improvement. It also raises the questions to the government officials and road safety professionals about how to maintain the effective countermeasures and make the improvement sustainable; and how to provide the system/facility which meets the requirements for both safety and the needs for convenience. Besides, the follow-up survey itself proves a systematic way of conducting project; authors think important to promote the responsible attitude of the project partners, as only few such surveys were carried in the countries.

REFERENCE

http://www.gtkp.com/themepage/pedestrains
Follow up Survey Report on Improving Vulnerable Road Users’ Safety at Urban Intersections A joint written report by the partners on the project which is submitted to GRSP management in Geneva, Switzerland.