Research on a non-motor vehicle-friendly design at signalized intersection with channelized island

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Abstract: Current traffic organization and channelization design of signalized intersections is not intensive, which cannot adapt to the traffic demand of non-motor vehicles, such as unclear traffic rules and poor visibility, thus the traffic safety of non-motor vehicles is not optimistic. Therefore, it is necessary to do some research on traffic organization method based on the demand of non-motor vehicles, which can provide certain theoretical basis for traffic administrative department to make policy and traffic design. This paper focuses on a non-motor vehicle-friendly design at signalized intersection with channelized island.

1. Introduction
With the rapid development of non-motor vehicle, the traffic order, traffic efficiency and traffic safety at signal control intersection is not optimistic. From the perspective of intersection traffic management, traffic organization and channelization design is extensive, without consideration of the characteristics of electric bicycle. How to give full play to the advantages of non-motor vehicle, and regulate the traffic order, improve the traffic efficiency and traffic safety level has become a major problem for traffic managers. Therefore, it is necessary to analyze the characteristics of non-motor vehicle, and propose the method of traffic space optimization, which can adapt to the current non-motor vehicle traffic.

2. Analysis of traffic characteristics of non-motor vehicle

2.1. Queuing Characteristics
During the red light, non-motor vehicles slow down and queue before the stop line. But non-motor vehicleless tend to staggered together, which are different from motor vehicles. According to the actual observation, it is very common for non-motor vehicles to line up across the crosswalk line. Figure 1 shows the queue of non-motor vehicles at signal intersection.
2.2. Passing through the Intersection
Electric bicycle is very flexible, and its instantaneous starting speed is faster than motor vehicles. According to the actual survey, the speed of most electric bicycles through the intersection is relatively close and moderate. The average starting time of the first line of a queue is less than 0.5 seconds. The average speed of straight line electric bicycles is about 14km/h, and the average speed of left-turn electric bicycles is about 13km/h.

2.3. Traffic Violation Characteristics
As the electric bicycle is very flexible, start faster than motor vehicle, its illegal behavior at signal control intersection is very common, such as turning off the priority order, do not take non-motor vehicle lanes, reverse driving, and so on.

Based on the traffic characteristics of non-motor at signal control intersection, it is practical to study on the traffic organization and management of the non-motor traffic. It is necessary to optimize the design of intersection, the timing of the signal and the supporting management facilities to protect the safety of non-motor at signal control intersection, and regulate the traffic order. Based on the characteristics of non-motor vehicle, this paper focus on the optimization of non-motor vehicle traffic space organization at the signalized intersection of channelizing island design pattern.

3. Traffic characteristics at signalized intersection with channelized island

3.1. Intersection Classification
According to the external form, channelized Island can be divided into physical island and marking Island. Physical Island is fixed, higher than the physical facilities. While marking island is made up of marking lines. In recent years, many domestic cities began to set up intersections with physical island. Physical islands is set up at each corner of the intersection in order to separate traffic flow and provide a dedicated lane for right-turn traffic to drive away from the intersection before the stop line[2]. Figure 2 shows an example of a typical intersection with a physical island.

Figure 1 Queue of non-motor vehicles at signal intersection
3.2 Adaptability Analysis of Physical Island

However, it is often not fully considered whether it is necessary to set the right-turn lane, which may result in the inefficient use of the right turn lane, and the non-motorized vehicles and pedestrians crossing the street are often threatened by high-speed motor vehicles. In this paper, we focus on the non-motor vehicle space optimization method for the signalized intersection with physical island. In the physical island design mode, a special turning lane is provided for right-turn motor vehicle, thus the drivers tend to pass through the lane with a high speed which is dangerous for pedestrians and non-motor vehicles. Non-motor vehicles are usually organized to pass through the intersection with pedestrians, which increases the distance for left-turn motor vehicles. Based on the psychological characteristics of the riders that they are generally eager to cross the street, it is very common to see that non-motor vehicles park after the stop line or violate traffic signal and other traffic violations. In particular, when the area of the island is not enough to accommodate the non-motor vehicles, it is easy to lead to non-motor vehicles waiting outside the island which will prevent the right-turn motor vehicles and pedestrians to pass through.

4. A Non–motor-vehicle-friendly Design Method

According to the above analysis, a non–motor-vehicle-friendly design method based on the traditional non-motor vehicle traffic organization. The purpose is to reduce the crossing distance and waiting time of non-motor vehicles, and improve traffic efficiency and safety of the intersections with channelized island. The design method is illustrated as following with practical examples.

4.1. Typical Intersection Present Situation

The intersection with physical island is very important of some city. The intersection uses four-phase control, and the non-motor vehicles follow the motor vehicle. Figure 3 shows the present situation of typical intersection.

According to the actual research, the following points can be improved:

First, there is a street pole in the intersection, which has some impact on the trajectory of the left-turn and right-turn non-motor vehicles and motor vehicles.

Secondly, the physical island is not big enough to accommodate the non-motorized vehicles and pedestrians.
Thirdly, Intersection is very large, the pedestrians should walk a long distance to cross the intersection without any pedestrian refuge island.

![Figure 3 Typical intersection present situation](image)

**4.2. Improvement plan**

The non-motor vehicle queuing waiting space can be greatly increased, then the efficiency of non-motor vehicles can be improved. However, when the non-motor vehicles enter the pending area, they are possible to intersect with pedestrians who are crossing the street.

Based on traffic characteristics of the intersection, some improvements can be done as follows:

- The street lamp in the intersection should be removed to avoid its influence on the left-turn motor vehicles and non-motor vehicle.
- The physical island should be removed, and the unused area can be used to set up marking island at each corner of the intersection.
- The internal space of the marking island can be painted green with color asphalt technology for color road.
- Some traffic columns should be installed besides the marking islands to protect non-motor vehicles.
- Special passages for non-motor vehicles are designed for non-motor vehicles to cross the street and turn left, as well as non-motor vehicle graphic markings[3][4]. Besides the passages can be painted to be green to make them more visible.
- And it is very important to install special signal lights to guide non-motor vehicles to turn left or cross the intersection in the correct phase.
- At last, pedestrian refuse islands must be set at the middle at the road to protect the pedestrians who are waiting for the green light.

Figure 5 shows the improvement plan for the intersection.
Figure 4 Improvement plan for the intersection

4.3 Evaluation of the Improvements
Compared with the present situation of the intersection, the optimization effect of the improvement plan are as follows:

Four marking islands are set instead of the original physical islands, which greatly reduces the crossing distance for the non-motor vehicles and pedestrians.

The street light bar is removed, and special passages are set for non-motor vehicles to turn left and cross the intersection, then left-turn non-motor vehicles do not need to bypass.

Besides, with the application of color asphalt technology, the passages can be painted to be green, which makes the passages more visible and different modes of transport can be separated reasonably.

Special signal lights are installed, which clears the right of passage for non-motor vehicles.

Pedestrian refuge islands are set in the road, which provide safe area for pedestrians to wait for signal, making pedestrians safer.

5. Conclusions
Based on the analysis of typical traffic characteristics of non-motor vehicles, a non-motor vehicle-friendly design at signalized intersection with channelized island is put forward, which aims to support the traffic channelization design of signal controlled intersections and improve the operation environment of non-motor vehicles. The future research will focus on the space and time integrated optimization method which fit for the operation demand of non-motor vehicle crossing.

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