

Optimization Design of Traffic Channelization at Intersections

Pengfei Han

School of Shanghai Maritime University, College of Transportation, China

562357606@qq.com

Abstract

In order to alleviate a series of traffic problems such as traffic congestion delay caused by increasing number of vehicles, and improve the traffic capacity and safety of intersection vehicles, based on the investigation and analysis of the traffic conditions at the intersection of Yanchun Yingchun Street and Shuanghe West Road, this paper studies the traffic delay and the number of parking times to design the traffic channelization of the intersection, and compares the traffic conditions of the intersection before and after the channelization through VISSIM simulation software so as to show the necessity of optimizing the intersection design.

Keywords

Intersection; traffic channelization; optimization design; VISSIM simulation.

1. Introduction

At present, the number of motor vehicles in China is increasing. With the further development of China's economy, the number of motor vehicles will continue to rise. Therefore, the traffic pressure at road intersections will become larger and larger, and the optimization design of road intersections is indispensable. Through the field investigation of the intersection of Yingchun Street and Shuanghe West Road in Laishan District, Yantai, this paper concludes that the intersection is heavily congested and has frequent traffic during peak hours. It is suggested that the traffic channelization should be used to change the existing traffic conditions. Road traffic channelization is the use of traffic markings, signs, traffic islands and other methods to control and separate the traffic flow in different states within the intersection. so that let the traffic in all directions travel along their respective traffic markings without affecting other vehicles, and achieve the purpose of separating and controlling traffic flow ^[1].

Nowadays, more and more vehicles have brought people great convenience. At the same time, more and more vehicles are putting a lot of pressure on road traffic, and traffic congestion is becoming more and more serious. The traffic congestion problem needs to be solved urgently. If there is no rapid handling of the congestion at the intersection, it will be related to the road network of other streets, and the congestion at the intersection will become more and more serious. This reduces the traffic efficiency of roads and intersections, slows down the speed of vehicles, and greatly prolongs the time required for vehicles to pass through intersections and roads, not only wasting energy, but also polluting the environment and increasing the probability of traffic accidents.

The capacity of intersections often determines the capacity of the entire network. Compared with the general roads, there are more complicated traffic conditions at the intersection, and there is a traffic environment with a variety of people, so the accident is more likely to occur at the intersection. Optimized design of intersections can better deal with the relationship between vehicles and pedestrians, improve the speed of traffic flow, enhance the efficiency of traffic flow, relieve the pressure of urban road network, and have great practical significance for reducing traffic accidents

[2]. In order to enhance the traffic capacity of the intersection, maintain the traffic safety order at the intersection and maintain the smoothness of the urban road network, it is very urgent and necessary to optimize the design of the intersection.

2. Intersection Analysis

2.1 Intersection Status

The location of the intersection of Yingchun Street and Shuanghe West Road in Laishan District of Yantai is shown in "Fig. 1".



Fig. 1 Location of the intersection of Shuanghe West Road and Yingchun Street.

The intersection of Yantai Yingchun Street and Shuanghe West Road is formed by the intersection of Yingchun Street in the northeast-southwest direction and Shuanghe Road in the east-west direction. It is a typical "十" intersection. Yingchun Street is an entrance road with four lanes, which are two straight lanes, one left turn and turnaround channel and one straight line plus right turn channel. The entrance road has three lanes. There are non-motorized roads. There is guardrail isolation for the opposite lane. There are six lanes at the intersection of Shuanghe West Road, which are one left turn and U-turn channel, one left turn channel, two straight lanes and two right turn lanes. There are only two exit roads in Shuanghe West Road. There is no marker line at the intersection of Shuanghe East Road and there is no specific lane.

The characteristics of the "十" type intersection are shown in "Fig. 2".

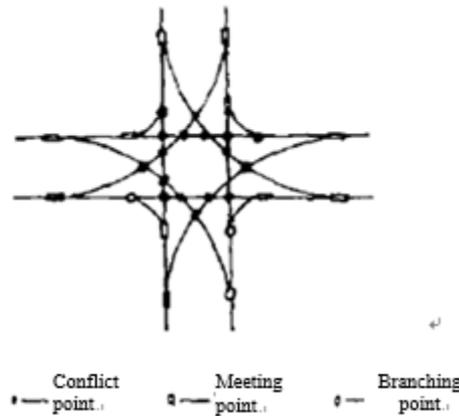


Fig. 2 Features of the "+" intersection.

2.2 Signal Period and Phase Position at the Intersection of Shuanghe West Road and Yingchun Street

Signal period and phase position at the intersection of Shuanghe West Road and Yingchun Street:

The signal period of the intersection of Shuanghe West Road and Yingchun Street is 121s, and the signal phase position adopts the two-phase setting method. Separately, Phase 1: Yantai Laishan Shuanghe West Road and Yingchun Street north-south direction go straight and turn left, 75s; Phase 2: Yantai Laishan Shuanghe West Road and Yingchun Street go straight in the east-west direction and turn left, 40s. The yellow light of the signal light is 3s. The right turn signal light at each intersection is always yellow.

2.3 Traffic Flow Survey at the Intersection of Shuanghe West Road and Yingchun Street

After a period of observation at the intersection of Shuanghe West Road and Yingchun Street in Laishan District, Yantai, it was found that the traffic flow reached the peak between 7:30am-8:30am and 17:30pm-18:30pm, so this design took the period of 7:30am-8:30am as the morning rush hour at the intersection of Shuanghe West Road and Yingchun Street, took the period of 17:30pm-18:30pm for the evening peak time at the intersection of Shuanghe West Road and Yingchun Street, and the flat peak time of the intersection of Shuanghe West Road and Yingchun Street is 15:00pm-16:00pm. The survey method uses manual observation method, in which the peak traffic volume takes the average of the morning and evening peaks.

There are many different types of vehicles at the intersection of Shuanghe West Road and Yingchun Street in Laishan District, Yantai. The different vehicles are converted into standard units for recording. According to the "Code for Urban Road Design" (cjj37-2012), cars are used as the basic unit and other vehicles are converted to car as the basic unit (pcu). Vehicle conversion factor is shown in "Table I".

Table 1. Table of Conversion Factors for Vehicles at the Intersection of Shuanghexi Road and Yingchun Street in Yantai (Unit: PUC)

Motorcycle type	Cars	Small trucks	Motor buses	Big trucks	Motorcycles
Conversion factor	1	1.5	2	2.5	0.5

From the observation data, the traffic volume survey "Table II" at the intersection of Shuanghexi Road and Yingchun Street in Yantai can be obtained.

Table. 2 Traffic Volume Survey at the Intersection of Shuanghe West Road and Yingchun Street

Inbound direction	East			West			South			North		
	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right
Peak	113	315	126	658	221	541	457	568	178	122	646	617
Flat peak	64	113	55	335	138	221	245	321	63	79	336	325

From the observation data, the average number of stops and the average delay at the intersection of Shuanghe West Road and Yingchun Street in Yantai can be obtained (see "Table III").

Table. 3 Average Number of Times and Average Delay Schedule at the Intersection of Shuanghe West Road and Yingchun Street

Inbound direction	East			West			South			North			The total average
	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	
Average number of stops	1.72	2.20	1.82	2.34	1.81	2.33	2.45	2.55	1.33	1.67	2.56	3.12	2.16
Average delay time	70.2	76.3	65.4	89.6	65.9	90.7	98.7	104.8	88.6	77.9	104.7	108.3	86.76

3. Channelization Design of the Intersection

3.1 Channelization Design of the Intersection

The investigation found that the traffic markings at the intersections are seriously worn, and the function and number of lanes are not clearly defined. Now a new design for the import and export roads is applied. The entrance roads are designed as four lanes: two straight lanes, one left turn lane and one right turn lane. The exit road is designed as three exit lanes. The transformation is shown in "Fig. 3".

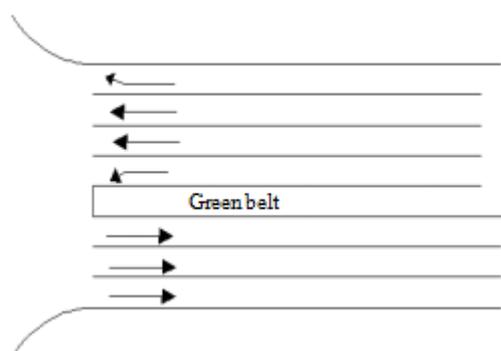


Fig. 3 East entrance and exit transformation map.

3.2 Intersection of the West Entrance and Exit Channelization

The import of the original vehicles in the west import was inefficient, so an exit road is added for it, and then it is changed to the three exit roads [3]. The transformation is shown in "Fig. 4".

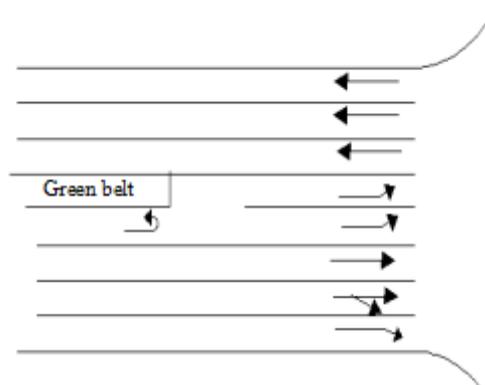


Fig. 4 West entrance and exit transformation map.

3.3 Intersection South Exit Intersection Widening Channelization

After investigation, it was found that the road exit of the south exit is narrow. Therefore, the channelization method of widening the exit road is adopted, which can effectively alleviate the traffic pressure of the exit road. The transformation is shown in "Fig. 5".

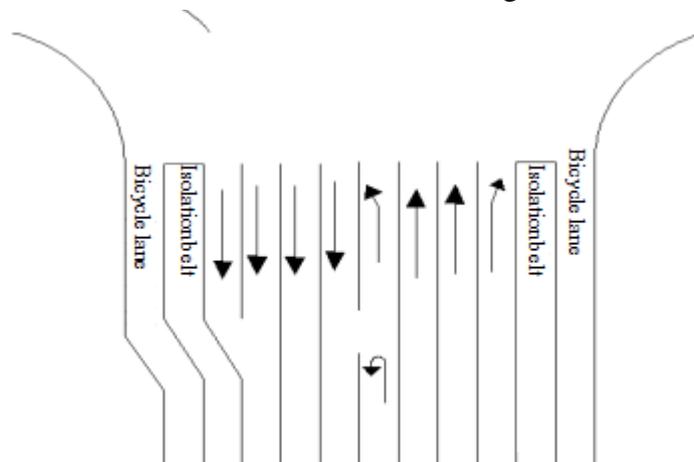


Fig. 5 South exit road width map.

3.4 Intersection Guide Line Channelization

Some intersections are large in area, and driving in all directions is arbitrary, resulting in chaotic and disorderly driving of vehicles. In this case, the area of traffic conflict will increase, which is not conducive to safe driving. The channelization of the intersection guide line can effectively avoid the disorder of the vehicle^[4]. By setting the guide line and specifying the travel trajectory of the vehicle, the safety of the intersection can be effectively improved. The intersection guide line is shown in "Fig. 6".

There are several main situations in the guide line setting:

When going straight, the number of lanes on the entrance and exit lanes is inconsistent, and this may cause the vehicle to travel unevenly. At this time, a straight-line diversion line can be set, which can be set, which can improve the order of the driving and can reduce the interference between the vehicles.

Some intersections are too large, and the vehicles at the intersections are very casual. Setting the guide line to stipulate the trajectory of the vehicle can improve the safety of the road.

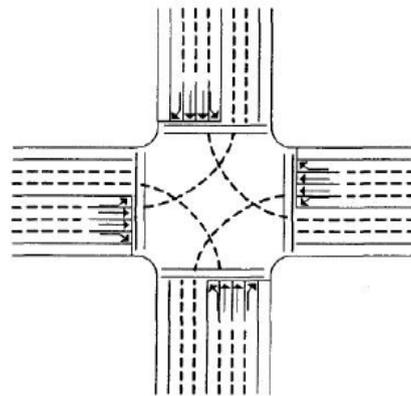


Fig. 6 Intersection guide line.

3.5 Non-Motorized and Pedestrian Channelization

3.5.1 Non-motorized channelization

Bicycle parking line moves forward: The bike starts fast and some riders are in a hurry through the intersection. It can be considered to move the bicycle line forward as appropriate, while the motor vehicle parking line does not change. In this way, non-motor vehicles can pass through intersections more quickly, reducing interference to motor vehicles, and can effectively improve road capacity [4].

Turn left bicycle twice to cross the street: When the bicycle is turned left with the motor vehicle at the intersection, the interference between them is serious. It is easy to collide and a traffic accident may occur, which is very unsafe for bicycles. It is necessary to let the bicycle turn left after passing two traffic lights [5]. It not only reduces the mutual interference between bicycles and motor vehicles, but also helps to improve the safety of bicycle riders. It is necessary to set the left-turn non-motorized vehicle waiting area. A left-turn bicycle can first cross the street once, and then wait for the next street lamp to cross the street again to realize the left turn [6]. The second street crossing pattern of non-motor vehicles is shown in "Fig. 7".

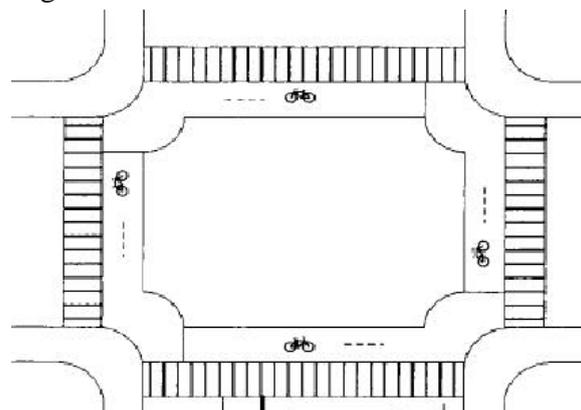


Fig. 7 Secondary street channelization of non-motor vehicles.

3.5.2 Pedestrian channelization

In the middle of the road, there is an area for pedestrians to wait. When the pedestrian does not completely pass the crosswalk in a traffic signal, he needs to wait in the middle of the road and at this time, the vehicle at the intersection can pass, and then the pedestrian passes through the green light of the next pedestrian crossing. This greatly reduces the conflict between pedestrians and vehicles at the intersection [7].

3.6 Overall Channelization at the Intersection

Combined with the channelization design of each entrance and exit road, the intersection of Shuanghe West Road and Yingchun Street after the canalization is shown in "Fig. 8".

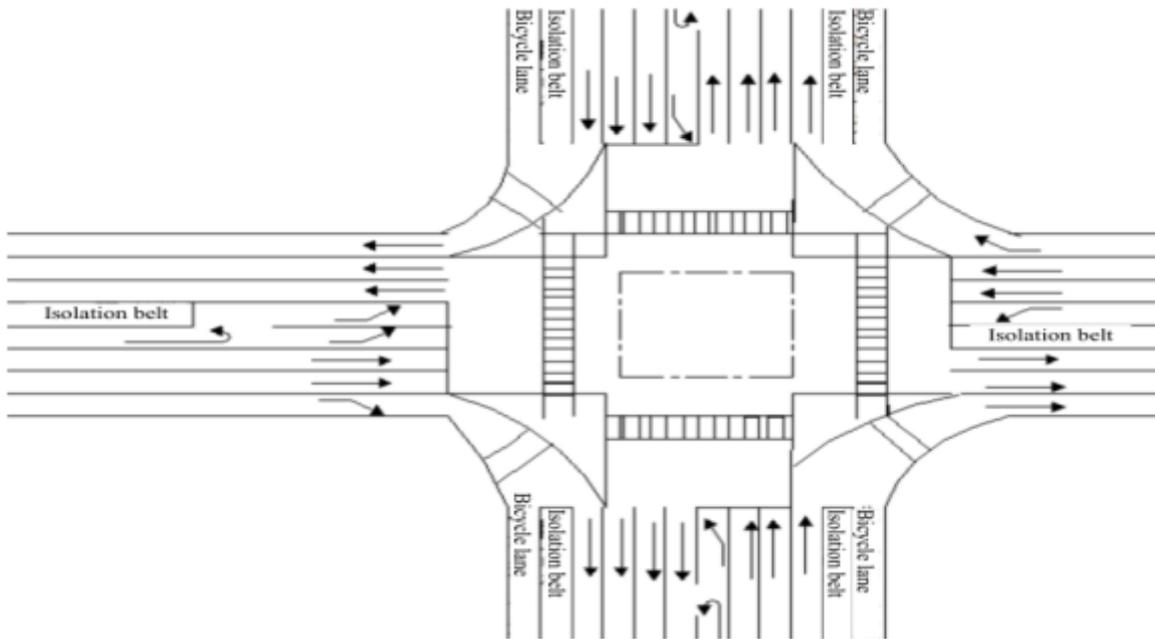
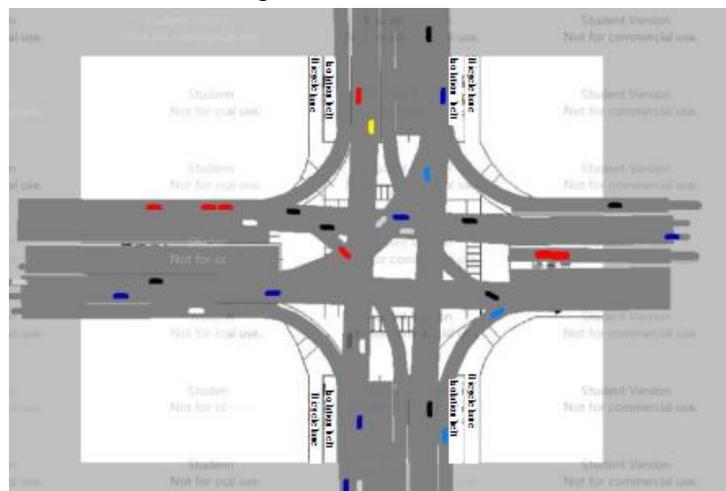


Fig. 8 General plan of the channelization at the intersection of Shuanghe West Road and Yingchun Street.

4. Analysis Before and After Optimization Based on VISSIM

The traffic volume and signal phase of each intersection are input into the simulation software VISSIM to obtain the simulation diagram of the channelized vehicle at the intersection of Shuanghe West Road and Yingchun Street. (See "Fig. 9")



Simulation of channelized vehicles at the intersection of Shuanghe West Road and Yingchun Street.

The average number of parking stops and the average delay after optimization at the intersection of Shuanghe West Road and Yingchun Street are shown in "Table IV".

Table. 4 The Average Number of Parking Stops and the Average Delay After Optimization at the Intersection of Shuanghe West Road and Yingchun Street

Inbound direction	East			West			South			North			The total average
	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	Turn left	Go straight	Turn right	

Average number of stops	0.42	0.78	0.82	0.34	0.61	1.03	0.43	0.85	0.73	1.07	0.96	1.12	0.76
Average delay time/s	50.2	45.3	50.4	59.3	45.9	80.7	88.7	94.1	68.2	54.1	74.7	97.3	63.2

By analyzing and comparing the average parking delays and average parking times of the traffic flow in each of the entrance lanes in Tables 3 and 4, it can be seen that the total average number of parking stops before the intersection is 2.16 times, and the total average delay is 86.76s. After re-channelization optimization, the average number of stops is 0.76 time, and the total average delay is 63.2s. Through comparison of data before and after optimization, it can be found that the traffic conditions have been greatly improved.

5. Conclusion

With the rapid development of China's economy, automobiles have become a necessity for every family, and more and more cars will inevitably bring more and more pressure to traffic. In view of the traffic congestion problem frequently occurring at the intersection, this paper uses the traffic simulation software VISSIM to optimize and reconstruct, and solve the existing congestion problem gradually. Through traffic channelization and optimization simulation, a reasonable traffic channelization design is obtained to alleviate the traffic pressure at the intersection. It is of great significance to improve the capacity of intersections.

References

- [1] Tan Zhibin, Yuan Hua. Study on the Design Method of Traffic Channelization of Urban Road Composite Intersection [J]. *Journal of Highway and Transportation Research and Development*, 2006, 23(6): 132-136. (in Chinese)
- [2] Zhang Shuichao, Ren Gang, Zhang Haoran. Analysis of Channelization Methods for Urban Road Intersections [J]. *Transportation Science and Technology*, 2009(2). (in Chinese)
- [3] Zhang Xiaolong. Considering the Signal Control of Single-point Supersaturated Intersections in the Widening Section [D]. Kunming: Kunming University of Science and Technology, 2015. (in Chinese)
- [4] Zhai Zhongmin. Road Traffic Optimization Organization [M]. Beijing: China Communications Press, 2004. (in Chinese)
- [5] Chen Xiaoming, Shao Chunfu, Yao Zhisheng. Typical Signal Intersection Left Turn Non-motor Vehicle Secondary Crossing Study [J]. *Journal of Civil Engineering*, 2008, 41(7): 76-81. (in Chinese)
- [6] Dion F, Hesham R, Kang Y S. Comparison of Delay estimates at Under-saturated and Over-saturated Pre-timed Signalized Intersection [J]. *Transportation Research Part B*, 2004, 38: 99-112. 2004, 38: 99-112.
- [7] Jiao Leizhi. Pay Attention to Pedestrian Crossing Facilities [J]. *Transportation*, 2004(5). (in Chinese)