Design of Intersection----A Case Study Between Xinhua Road and Jinguang Street from Shijiazhuang

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Abstract. Intersection, where every kinds of traffic merge, commute and pass over, which is the traffic control of management and organization, the key of the urban traffic, which is the difficult and important points of the road design and traffic management, is an important part of the road network. The intersection of Xinhua Road and Jinguang Street is the design object. Firstly, according to the design of traffic, road grades, related specifications and other conditions，the paper gives the preliminary design of the intersections. Secondly, the cross-sectional design of the intersection is designed, including road width selection, calculate the number of lanes and lane width and so on. Thirdly, graphic design for the intersection, including the intersection widening design, the traffic island design and the radius of curbs and so on. Finally, signal timing design is going for, and service level evaluation is conducted.

Introduction

Many researches show that the general obstruction and congestion does not occur on the road. There is no obstruction on the road because of the insufficient capacity. so the congestion phenomenon is the intersection of the main sticking point. For urban roads, the intersection is an important part of the urban road network, connecting to the road in all directions constituted of network. City intersection is the main interchange of people and cars. Because of the traffic flow unite, mingle and diverse at the intersection, in addition to factors such as non-mixing machines, complex traffic intersection features make it easy to become confused and sustained traffic accident-prone and reduces the capacity of the road network, to become the bottlenecks of the city roads.

The vehicle can only change the direction of travel at the intersection, so there is the intersection to improve the flexibility and accessibility of road transport, thereby it has increased the vitality of the road network and improved the traffic function.

Proper design of road intersections and effectively organize transportation is beneficial for full use of the intersection of time and space resources, reduce or eliminate the conflict points ensure traffic safety reduce vehicle delay improve the capacity of the intersection ensure smooth traffic, Thereby enhancing the capacity of urban road network.

The intersection of Xinhua Road and Jinguang Street is the design object whose details are as follows:

i) The intersection of cross-sectional sections, including the arrangement of the cross section, and the number of the lane width, and the width of the cross section of each part.

ii) The intersection of graphic design, including broadening the horizon lane design, the radius of curbs, diversion island design.

iii) The intersection signal timing design, including lane division, phase sequence, the signal cycle, each phase time and service levels.

Cross-sectional design of intersection

Composition and arrangement of the intersection

Intersection consist of motor and non-motorized vehicles lanes, sidewalk, minutes drive belts, facilities belt, green belt and so on. According to "Code for design of urban road engineering" (CJJ37-2012) which provides that the intersection can be divided into single-way, two-way, three-way, four-way and special forms of cross-section, trunk roads should adopt the four-way or three-way. For the road which setting bus lane, cross-sectional layout should be take the location and the type of bus lanes whole section into account, and bus lanes should be arranged in priority.

This design uses four main trunk road, its cross-section in the form shown in Figure.1.

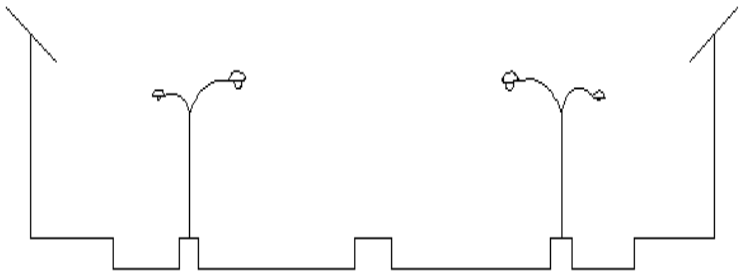

Fig.1: Cross-section of four-way

The width and number of motor vehicle road

The width of the motor vehicle road

The width of vehicle lane depends on the width of the design of vehicle body, the lateral safety distance (the lateral spacing between edge of the body and its adjacent portions),and the swing width of the vehicle when driving. According to "Code for design of urban road engineering" (CJJ37-2012),the minimum width of a vehicle road shall comply with Table1.

Table1: The minimum width of a motor vehicle lane

Type of vehicle and lane	Designed speed（km/h）	
	＞60	≤60
Large car or mixed lane (m)	3.75	3.50
Small passenger car lanes (m)	3.50	3.25

This paper of the design speed is 50km/h, and it is shared lane, so I chose to meet the above requirements and the vehicle lane width will be design as 3.5m.

The number of the motor vehicle road

The traffic volume forecasting of each entrance road intersection in 20yaers are as shown in Table 2.

Table2: The traffic volume forecasting of each import road intersection

	left	Straight	right	total
East entrance	200	500	494	1194
West entrance	247	468	486	1201
South entrance	233	390	597	1220
South entrance	190	482	531	1203

The basic capacity of single lane should be complied with Table 3.

Table 3: The basic capacity of single lane

Design speed(km/h)	60	50	40	30	20
The basic capacity [pcu/(km.ln)]	1800	1700	1650	1600	1400

The basic capacity of the intersection is 1700pcu/(km.ln).The number of lanes which crossing each intersection is determined on traffic Control Strategy, traffic volume, the capacity of the lane and the use of the intersection. On urban roads we should also take the needs of a large number of non-motorized transport into account.

The design capacity of single lane is calculated as follows:

$$n = \frac{N_h}{N_d}$$

$$N_d = N_b \times \alpha_a \times \alpha_l \times \alpha_n$$

In the formula:

N_H -The designation of hour traffic volume. N_d -The designation of traffic capacity of single lane.

α_a - the influence coefficient of the intersection; it is 0.38

α_l - the classification coefficient of the road; the trunk road is 0.8

α_n - the reduction coefficient of the number of lanes. The first lane is usually closed to the road of center line, its capacity is 1 (that is to say 100%), the capacity of the second lane is 0.8 to 0.9times of the first one, the third lane capacity is 0.65 to 0.8 times of the first one, and the fourth lane capacity from 0.5 to 0.6 times of the first one.

The design capacity of the first lane is largest and it is shown as follow:

The trunk road of the east-west direction

$$n = \frac{1201}{517} = 2.3$$

$$N_d = N_b \times \alpha_a \times \alpha_l \times \alpha_n = 1700 \times 0.38 \times 0.8 \times 1 = 517[\text{pcu}/(\text{km}.\text{ln})]$$

Therefore, the east-west direction is designed as two-way six lanes.

Similarly, the east-west direction is designed as two-way six lanes.

The width of non-motor vehicle lane

According to "Code for design of urban road engineering" (CJJ37-2012), the width of non-motor vehicle lane should be in accordance with Table 4.

Table 4: The width of non-motor vehicle lane

Vehicle type	Bicycle	Tricycle
width (m)	1.0	2.0

The width of sidewalk

The sidewalks and lanes should be vertical and skew only in special circumstances. The width of the sidewalk is 4 ~ 8m, the length is longer than 30m.when there are 6 lanes or more, it should be located a safety island not less than 1m in the middle of the road. The stop line should be arranged at least 1m behind the zebra crossing. The design of safety island is shown in Figure 2.

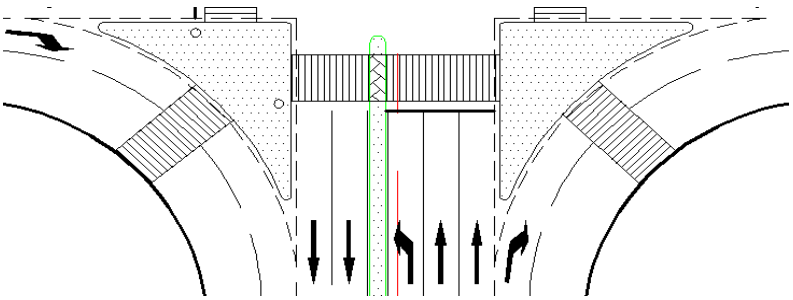

Figure 2. The design of safety island

The graphic design of intersection

The design of lane broadening

i) Right turn driving: On the right side of the entrance lane, or both on the exit lane widen the right turn driving.

ii) Left turn driving: when there is a wide intermediate zone(usually not less than 4.5m), Compressing the width of the intermediate zone in order to opened up a left turn driving.

According to "Code for design of urban road engineering" (CJJ-2012) Provisions on Urban Road about the red line plan are as follows:

Table5: Urban Road about the red line plan

intersection	The length of broadening(m)			The length of broadening gradual change segment(m)		
	M	A	B	M	A	B
M+M	80-120			30-50		
M+A	70-100	50-70		20-40	20-40	
M+B	50-70		30-40	20-30		15-30

Attentions: M means main road, A means arterial road and B means branch

According to the specification, broadening segment length can be determined that the intersection is 120m, and the length gradual broadening segment of 50m. Gradual change segment design shown in Figure 3.

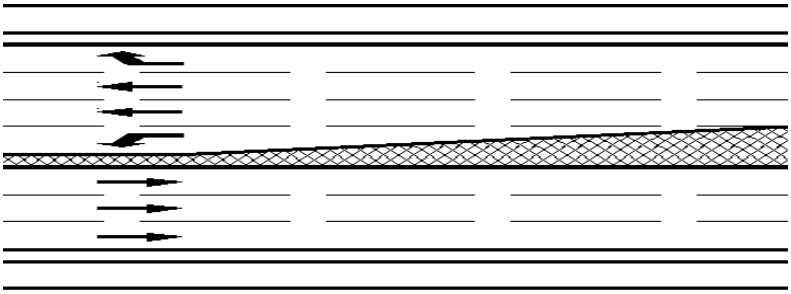

Figure 3. The design of gradual change segment

The design of intersection visual range

In order to ensure traffic safety on the intersection, before the driver entered the intersection, he should be able to see the traffic situation on the intersection, in order to take measures in time to pass through smoothly or to park safely. This necessary distance should be longer than or equal to the stopping sight distance S_S .

$$S_S = \frac{v \cdot t}{3.6} + \frac{v^2}{245(\varphi + \phi)}$$

In the formula:

S_S ——the stopping sight distance (m);

v ——the intersection vehicle speed computing(km/h);

t ——brake reaction time,2.5s;

φ ——moist coefficient, 0.4;

ϕ ——roughness coefficient,its value range is 0.03-0.05, take the middle value 0.04.

craspedodrome speed

$V_S = 0.7 \times 50 = 35$ km/h

So when straight ahead the stopping sight distance is:

$$S_S = \frac{35 \times 2.5}{3.6} + \frac{35^2}{245 \times (0.4 + 0.04)} = 35.67\,\text{m}$$

left turning speed and right turning speed

$V_l = V_r = 0.5 \times 50 = 25$ km/h

So when turn left or turn right the stopping sight distance is:

$$S_S = \frac{25 \times 2.5}{3.6} + \frac{25^2}{245 \times (0.4 + 0.04)} = 23.16 \text{ m}$$

Sight distance triangle: consist of the stopping sight distance of intersection lanes. Within its scope there can not be any obstacles to block the driver's line of sight, shown at Figure 4.

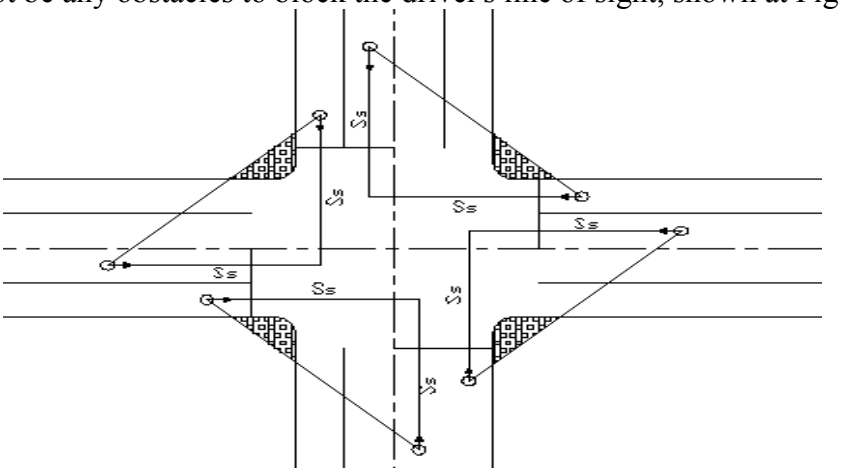

Figure 4. Sight distance triangle

Radius of curbs

radius of curbs R_1

$$R_1 = R - (\frac{B}{2} + F)$$

in the formula:

R ——the circular curve radius of right turn lane centre line, m;

B ——the width of Vehicle single lane,Generally use 3.5m ;

F ——the width of the concealed bend of intersection of non-motor lane and the width of separate belt and the width of the street curb.

$F = 3.5 + 1.5 + 0.25 = 5.25$m.

R is calculate according to the following formula:

$$R = \frac{V^2}{127 \times (\mu \pm i)}$$

In the range of intersection, the design speed of the main road V still use the road section regulations value, arterial road can adopt 0.7 times of the road section regulations value.

μ -transverse coefficient the buses use0.1—0.15,the cars use 0.15—0.2;

i -the intersection transverse slope, Generally not be longger than 2%。

$$R = \frac{25^2}{127 \times (0.15 + 2\%)} = 29 \text{ m}$$

$$R_1 = 29 - (\frac{3.5}{2} + 5.25) = 22 \text{ m}$$

R_1 is about25m.

The design of channelization island

the radius of channelization island R_2 is:

$$R_2 = R + \frac{B}{2} = 29 + \frac{3.5}{2} = 31 m$$

The offset and inward extension of the channelization island is shown as follows:

Table6: The offset and inward extension of the channelization island

Design speed	offset (m)			inward extension (m)	
	S_1	S_2	S_3	Q_3	Q_2
Below 50	0.50	0.50	0.50	0.50	0.50

The radius of the end portion of channelization island as Table7 shows.

Table7: The radius of the end portion of channelization island (m)

R_0	R_1	R_2
0.5	0.5—1.0	0.5—1.5

The design of channelization island is shown as follows:

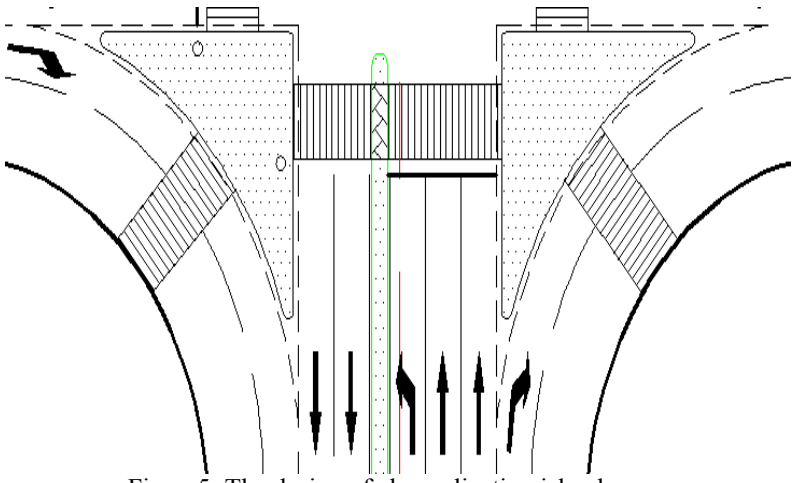

Figure5: The design of channelization island

The design of intersection signal scheme

According to the traffic volume forecasting of each import road intersection as above and the design of the traffic volume of intersection. the channelization scheme of intersection as follows.

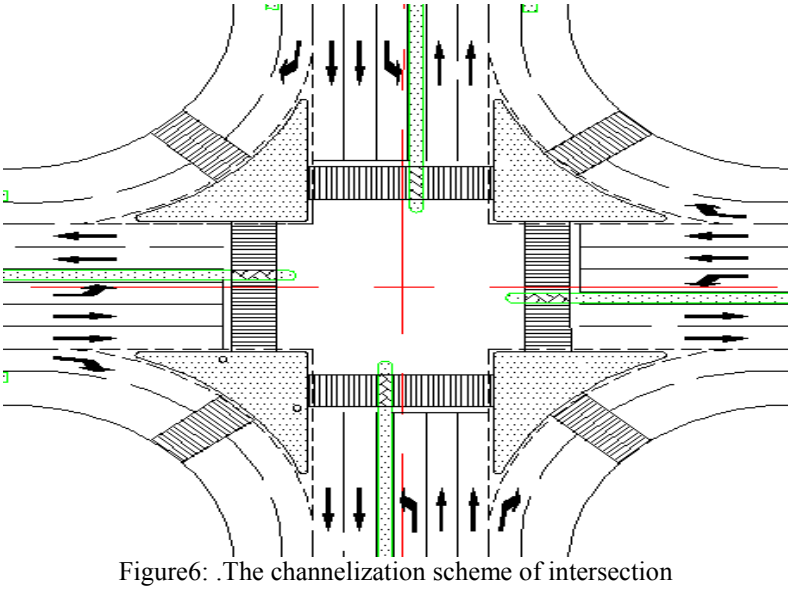

Figure6: .The channelization scheme of intersection

The design of signal phase of intersection as follows.

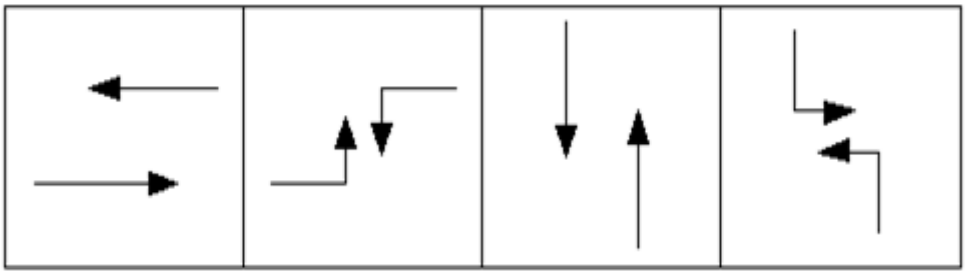

Figure7: The design of signal phase of intersection

Conclusions

The design of intersection should ensure that the vehicle at the intersection pass through in the shortest time, so that the capacity of the intersection can adapt to the requirements of the lanes of traffic.

This paper reference the intersection around it when designing, based on a series of norms and standards about intersections. While focusing on the design in order to ensure safety, minimize delays, improve service levels on the intersection.

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Thank you for putting forward any improvements in this paper and I will cherish these views and improve myself when learning something else or writing papers in the future.

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