

Traffic Simulation and Improvement Analysis of Typical Intersections in Hefei

Wenni Xiao¹

¹Traffic Engineering College of Anhui Sanlian University, Hefei, Anhui, China
151989247@qq.com

Abstract

Intersection is an important node of road network. Optimizing the signal timing scheme of intersection is an effective measure to improve its traffic efficiency. In this paper, taking the intersection of Yulan Avenue and Wangjiang West Road in Hefei as an example, the signal timing scheme of the intersection is optimized, the VISSIM simulation model is established, and the simulation results before and after the optimization of road capacity are comprehensively evaluated. The results show that, in terms of road capacity, the service level of the optimized intersection in the peak period has increased from D to C, and the road traffic situation has been effectively alleviated.

Keywords: Intersection; improvement design; Vissim

1 FOREWORD

Signalized intersections play a vital role in the road network, where various traffic flows gather and pass frequently. Due to the rapid development of the city, the increase of the number of motor vehicles, and the unreasonable setting of road channelization and signal timing, traffic congestion, congestion or traffic accidents occur frequently, especially during the rush hour. Therefore, it is extremely important to control the traffic congestion at urban signalized intersections and

make scientific and reasonable optimization research on it.

2 STATUS QUO OF THE DISTRIBUTION

Wangjiang West Road is a two-way eight-lane urban road with a right-turn exit lane, a left-turn exit lane and a mixed left-turn and straight-ahead exit lane. Yulan Avenue is a city road with 7 lanes from north to south, of which 3 are straight entrance lanes, 2 are left-turn exit lanes and 2 are right-turn exit lanes, as shown in Figure 1.

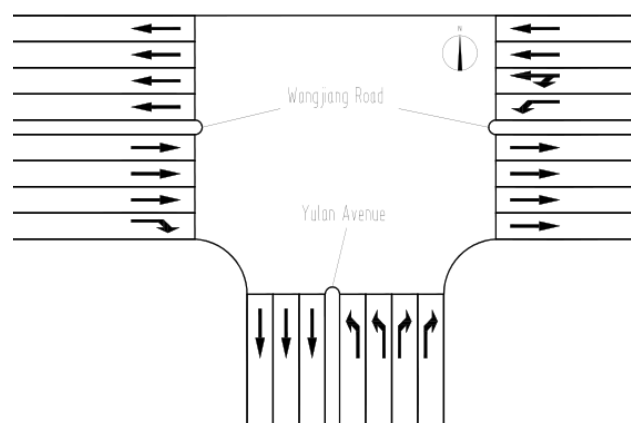


Fig. 1 Distribution of intersection of Wangjiang West Road and Yulan Avenue

2.1 Peak hour traffic survey results

Hourly traffic volume refers to the traffic flow through the intersection during the rush hour ^[8] Hourly traffic volume is of great significance to signal timing at intersections ^[5]. The optimal signal timing depends on the intersection.

The peak hour traffic volume, the survey peak hour traffic volume is usually calculated by 15min flow rate. The author chose two hours of traffic in the afternoon off-peak period (14:00-15:00) and peak period (17:00-18:00) to conduct the survey. Check and survey data are shown in Table 1 and Table 2.

Table 1 Statistics of peak traffic volume of Wangjiang West Road and Yulan Avenue

Imported	direction of a current	Peak (17:00-18:00) flow (pcu/h)			
		car	passenger train	truck	Standard car
East import	go straight ahead	1504	148	65	1856
	left-handed rotation	240	16	20	304
South import	dextroversion	160	2	5	173
	left-handed rotation	200	8	8	228
West import	go straight ahead	1000	96	50	1244
	dextroversion	100	2	0	103

From Table 1, it can be seen that during the peak period, the traffic flow is mainly concentrated in the east-west straight line, with the least number of right-turn vehicles, cars and trucks as the main traffic flow; from Table 2, it can be seen that the east-west

straight traffic flow in off-peak period is relatively average and the distribution is balanced, but the number of truck traffic in off-peak period is slightly higher than that in peak period. The traffic flow is still dominated by cars, with the least number of buses.

Table 2 Off-peak flow statistics of Wangjiang West Road and Yulan Avenue

Imported	direction of a current	Off-peak (14:00-15:00) flow (pcu/h)			
		car	passenger train	truck	Standard car
East import	go straight ahead	1000	65	100	1297.5
	left-handed rotation	150	0	15	180
South import	dextroversion	80	0	0	80
	left-handed rotation	103	2	5	116
West import	go straight ahead	936	84	75	1212
	dextroversion	100	0	0	100

2.2 Investigation of signal timing scheme

2.2.1 Signal phase distribution

There are three signal phases at the intersection of Wangjiang West Road and Yulan Avenue, all of which turn right and are all green, allowing free passage ^[2]. In the first phase, only vehicles on Yulan Avenue are allowed to turn left, and vehicles on Wangjiang West Road are forbidden to go straight or turn left; In the

second phase, the east entrance of Wangjiang West Road is allowed to go straight and turn left, and the vehicles on Yulan Avenue are forbidden to turn left; in the third phase, the east and west entrances of Wangjiang West Road are allowed to go straight, while the left turn of Yulan Avenue and Wangjiang West Road are prohibited. The specific phase is shown in Figure 2.

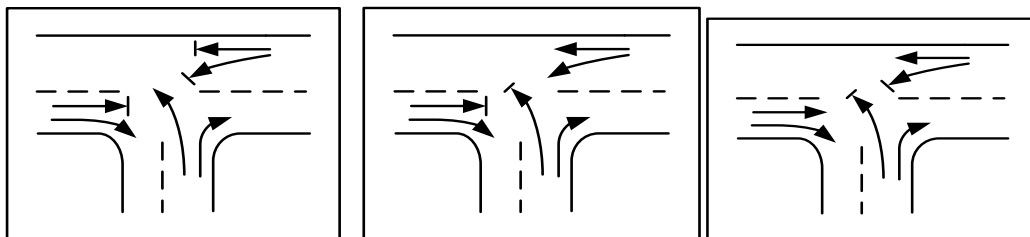


Fig. 2 Signal phase diagram of intersection

2.3 Intersection signal timing scheme

The signal period at the intersection of Wangjiang West Road and Yulan Avenue is 110s, with three phase

periods. The right turn of two roads at the intersection is all green and unrestricted. See Table 3 for the specific timing scheme.

Table 3 Signal timing scheme of intersection (unit: s)

project	Phase 1 Yulan boulevard left turn	Phase 2 Wangjiang West Road East Entrance Go straight+turn left.	Phase 3 Wangjiang west road east-west traffic	Two right turns all green.
cycle	110	110	110	∞
Phase duration	25	30	55	∞
Green light duration	22	27	52	∞
yellow light time	3	3	3	without
Red light duration	85	80	55	without

3 VISSIM SIMULATION

3.1 Basic Steps of VISSIM Simulation at Intersection

Setting road network information: according to the road information of field investigation, it is transferred to the software vissim; time information is calculated; the effective period is calculated, and the result is shown in Figure 3.

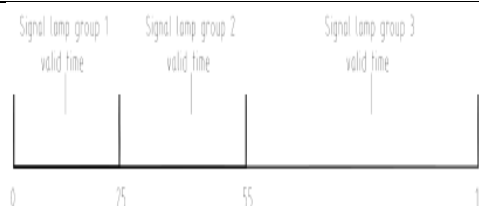


Fig. 3 Time period diagram of each phase (unit: s)

The duration of the red and green lights was calculated, and the results are shown in Table 4.

Table 4 vissim traffic signal parameter table (unit: s)

serial number	Signal lamp group	End time of red light	End time of green light	Yellowlight endtime length
1	Signal lamp group 1	0	22	3
2	Signal lamp group 2	25	52	3
3	Signal lamp group 3	55	107	3

Definition of vehicle composition: the vehicle composition of Wangjiang West Road and Yulan Avenue can be obtained from Table 1 and Table 2, in which the expected driving speed of cars, buses and trucks is calculated by the ideal vehicle speed, and the vehicle composition of the corresponding lane is entered.

Route decision: assign traffic in different directions to corresponding lanes.

Setting conflict area: determine the driving priority of two conflicting traffic flows in the conflict area.

Set detector: use node detector to collect six parameters, including average queue length, delay time, maximum queuing time, direction of traffic flow, nodes, total number of vehicles, per capita delay, total delay, total parking time and average number of vehicle stops.

Simulation operation: simulate the traffic situation in the peak period and observe the traffic flow change at the intersection.

Peak traffic flow: through the animation simulation, the intersection mainly uses the direction of congestion.

In the east-west and East-South directions, the vehicle queuing is serious. In the first two cycles (about 220s), the traffic flow is small, and the intersection can bear the traffic pressure of the intersection. Only a small number of vehicles queue up twice, but after the third cycle, the traffic flow increases gradually. The signal timing of intersection can not meet the traffic demand. In the simulation, due to the long waiting time, some vehicles give up queuing.

3.2 Evaluation parameters obtained after simulation

After vehicle simulation calculation, the average delay, average parking time, average queue length and average parking times of vehicles are obtained. Further referring to the relationship table of service level and delay time of signalized intersection, it can be concluded that the level of service of intersection at peak hours is d-level approaching unstable traffic flow.

3.3 Evaluation of signal timing scheme

The capacity of intersection is calculated manually $C = \sum_{i=1}^n ci$ Formula and $c_i = \sum_{j=1}^k c_j$ the traffic capacity of the intersection of Wangjiang West Road and Yulan Avenue is

$$C = 4526.94(\text{pcu} / \text{h})$$

The traffic capacity of the intersection of Wangjiang West Road and Yulan Avenue can be obtained as follows:

$$C = 4062.37(\text{pcu} / \text{h})$$

According to the formula, the capacity of the entrance road is 4526.94 pcu / h, and the capacity of the exit road is 4062.37 PCU / h. The capacity of the entrance road is greater than that of the exit road. The design of the road capacity meets the requirements and there is no congestion in theory.

3.4 Evaluation of intersection traffic conditions

With the increasing of traffic flow, especially in the east entrance lane of Wangjiang West Road, all vehicles can not be released in one signal period, which makes the vehicles queue up one by one and finally leads to the deterioration of the traffic environment at the intersection.

After calculation, it can be found that the designed traffic capacity of the intersection of Wangjiang West Road and Yulan Avenue is greater than the peak traffic flow, so congestion should not occur in theory. However, the simulation results of VISSIM software show that the traffic capacity of the intersection can not meet the traffic demand [2]. In further observational studies, it can be found that, This phenomenon is mainly caused by the unreasonable traffic timing of the intersection. The excessive traffic right is given to the section with less traffic demand, which leads to the traffic congestion of the road section with large traffic demand, which makes the actual traffic capacity of the overall intersection decline and wastes the road resources.

4 TO IMPROVE THE DESIGN

4.1 Optimization scheme design

(1) Determine the best period

$$C_o = \frac{1.5L + 5}{1 - Y} \quad (1)$$

Where:

C_o —Optimal period

L —The total lost time in a cycle (s), the lost time of the intersection $L = 3 \times 3 = 9\text{s}$;

Y —Each phase of intersection Y The sum of the values, Y Is the ratio of flow to saturation flow, $Y = \sum y$;

Saturated flow(Ma 2018):

$$S = \frac{3600}{\sum \frac{h}{n}} (\text{pcu} / \text{h}) \quad (2)$$

Where:

h —Headway after the fourth vehicle of queuing vehicle;

n —The number of data, $n = 12$;

After calculation: $Y = \sum y = 0.812$

therefore $C_o = \frac{1.5L + 5}{1 - Y} = 18.5 / 0.188 = 98.4\text{s}$

At this time, the actual cycle time should be slightly larger than the optimal cycle time, so the delay growth is small, so the cycle time is taken as 110s.

(2) Effective green time allocation

The traffic congestion of the intersection is mainly concentrated in the east entrance of Wangjiang West Road. We can optimize the timing of the east entrance of Wangjiang West Road in the peak period, and then calculate whether the improved timing scheme improves the service level of the intersection through VISSIM software simulation. The optimized signal timing is shown in Table 5.

Table 5 optimized intersection phase timing

Optimized VISSIM traffic signal timing table (unit: s)				
serial number	Signal lamp group	End time of red light	End time of green light	Yellow light end time length
1	Signal lamp group 1	0	22	3

2	Signal lamp group 2	25	62	3
3	Signal lamp group 3	65	107	3

4.2 Simulation and evaluation of optimization scheme

According to the parameters obtained by VISSIM simulation, show in Table 6, the relationship between LOS and delay time of signalized intersection can be obtained. It can be found that the service level of intersection in peak hours is increased from D to C, and the overall traffic efficiency of the intersection has been significantly improved.

Table 6 Comparison of simulation results before and after optimization

parameter	Before optimization	After optimization	benefit
Average vehicle delay	36.39s	25.7s	29.4%
Average parking time	27.81s	19.2s	31%
Average queue length	45.3m	27.8m	38.6%
Average parking times	0.75	0.6	13.3%

5 CONCLUSION

In this paper, based on the current traffic data obtained from field investigation, combined with the actual situation of intersection, the signal timing scheme of the intersection of Wangjiang West Road and Yulan Avenue in Hefei city is optimized. Based on VISSIM simulation platform, the intersection simulation model is established, and the signal timing scheme before and after optimization is simulated. The goal of optimizing traffic and easing traffic congestion has been achieved. This method can effectively reduce the delay of driving, reduce the number of parking vehicles while driving, and improve the efficiency of road transportation.

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