International Core Journal of Engineering Volume 6 Issue 12, 2020
ISSN: 2414-1895 DOI: 10.6919/ICJE.202012_6(12).0003

# Malformed Intersection Analysis and Improvement Research

Gao Yuan

School of Shanghai Maritime University, Shanghai 201306, China.

## Abstract

**Combined with the investigation and research method, it summarizes the status quo of a deformed intersection in Yangzhou City and raises questions for analysis. Then the detailed design of the intersection from different directions mainly involve motor vehicle lanes, non-motor vehicle lanes, signal control, pedestrian crossings, slow traffic and so on.**

## Keywords

**Intersection; Analysis; Detailed design.**

## 1. Introduction

The intersection next to Subei People's Hospital in Guangling District, Yangzhou City is the central area of Yangzhou City. Its traffic demand is growing rapidly and the contradiction between supply and demand has intensified, but the expansion of road resources at the intersection is limited. Practices at home and abroad have shown that under the condition of limited road resources and prominent contradiction between traffic supply and demand, optimizing the structure of traffic demand, optimizing traffic organization, and optimizing the efficiency of facilities are of great significance to alleviating the contradiction between traffic supply and demand at intersections. Therefore, integrating existing planning results, organizing intersections traffic at a strategic height scientifically and rationally, optimizing and adjusting the traffic structure, adjusting the time and space distribution of traffic, and giving full play to the effectiveness of existing facilities, have has important practical significance for forming an efficient, smooth and orderly intersection traffic system.

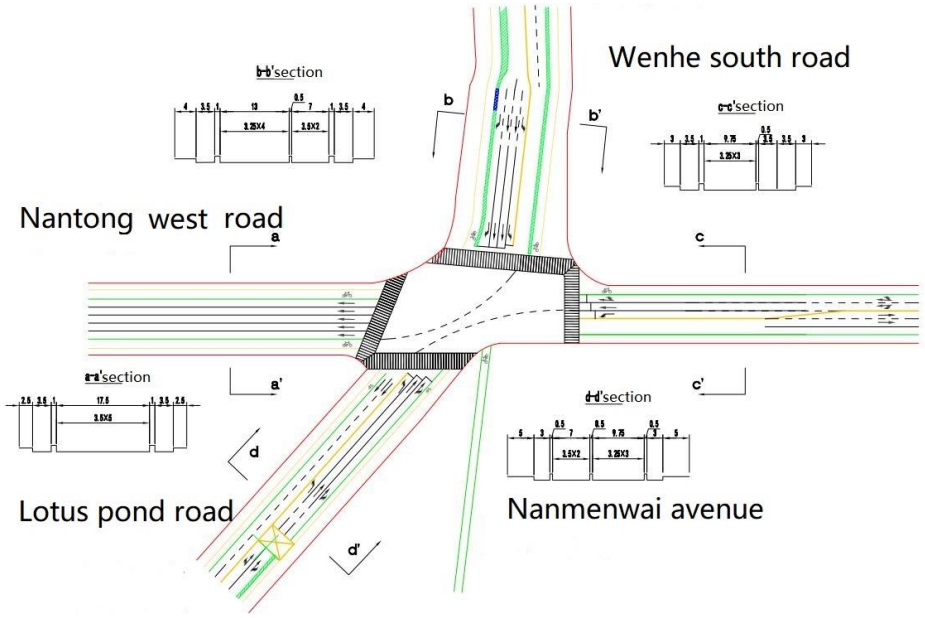


Figure 1. Current situation of the intersection

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# 2. Intersection analysis

## 2.1 Intersection overview

### 2.1.1 Road conditions

The intersecting road, Wenhe South Road, is a four-slab road with a width of 47m and two-way six-lane, with independent non-motor vehicle lanes and no independent sidewalks; Lotus Pond Road is also a four-slab road with a width of 38m and five-lane in both directions. There are independent non-motorized vehicle lanes and sidewalks. The opposite traffic flows of motor vehicles are separated by fences, and the green belts are used to separate motor vehicles and non-motor vehicles. Nantong West Road is a three-slab road with a width of 25m and the east entrance is two-way four-lane, separated by green belts between motor vehicles and non-motor vehicles, west entrance is a one-way road with one-way five-lane, motor vehicles can only enter; Nanmenwai Avenue is a living road in the form of a slab, motor vehicles are forbidden on this road.

### 2.1.2 Current situation of intersection channelization

(1) The three entrance roads at the intersection, namely Wenhe South Road, Nantong West Road, and Lotus Pond Road, all increase the left-turn lanes by widening the entrance roads, thereby improving the traffic capacity of the road.

(2) The three entrances of the intersection are equipped with left-turn waiting areas and special signals for left-turn, which improves the running speed of vehicles and the traffic capacity of the intersection and ensures the safe driving of vehicles.

(3) The intersection is equipped with non-motorized vehicle lanes and sidewalks with a width of not less than two meters, and both are equipped with separation belts for motor vehicles and non-motor vehicles, which achieves the separation of motor vehicles and non-motors, improves the running speed of the road, and ensures the safe driving of non-motor vehicles and the safety of pedestrians.

(4) Except for the west one-way street, all entrances at intersections are equipped with central isolation fences to separate the oncoming traffic, avoid the impact of onward traffic, and improve the capacity and capacity of vehicles passing through the intersection. safety.

### 2.1.3 Traffic control conditions at intersections

The intersection is controlled by three-phase signals, the signal period is 125s, the green signal ratio is shown in table 1, and the phase and phase sequence are shown in figure 2.

Table 1. Green signal ratio

| | $\phi_1$ | $\phi_2$ | $\phi_3$ |
|---|---|---|---|
| green signal ratio | 0.2 | 0.24 | 0.44 |

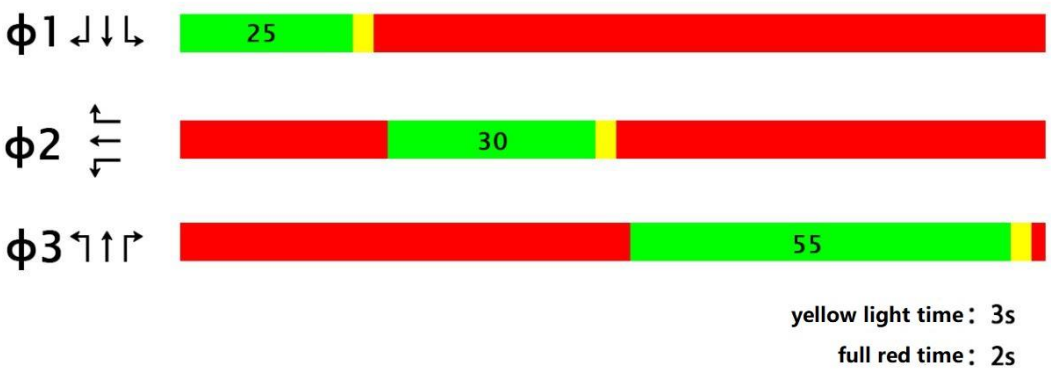


Figure 2. Phase and phase sequence diagram

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## 2.2 Problem analysis

(1) Insufficient capacity and serious queuing of vehicles. As the northwest corner of the intersection is the Subei Hospital, there is too much demand for the lotus pond parking lot, the right-turning motor vehicle queues at the north entrance of the intersection is too long. There is the Subei Hospital bus station at the north entrance with many lines, the semi-harbour stop makes the vehicles wait behind the bus when the bus is getting on and off passengers, and the maneuverability of the bus is not as good as that of the car, which hinders the normal operation of the vehicle. The queued vehicles dissipate slowly, and the parking line of the entrance road to the upstream section forms a long-distance vehicle queue, even affecting the traffic operation state of the upstream crossing day, there were two or more queues.

(2) The traffic order is poor and chaotic, and there are hidden traffic hazards. Through investigations, there are vehicles with left-turn traffic turning illegally at each entrance, pedestrians failing to obey signals to control red lights to cross the street, and vehicles that have changed lanes. The poor traffic order and traffic violations at intersections not only reduce the traffic operation efficiency and capacity of the intersection, but also cause serious traffic safety hazards. The lane demarcation line at the north entrance has had a certain degree of negative impact on the smoothness of the north through vehicle trajectory. After entering the interior of the intersection, north-travel vehicles need to drive to the right in order to align their running track with the lanes of the south exit. Manually designed lane markings have poor ride comfort, fail to properly regulate the traffic order of vehicles, reduce the speed of vehicles in the conflict zone, and reduce the efficiency of vehicle operation during the north straight green light period, weaken the channelized design of the intersection and increase the queue length of imported vehicles from the north.

(3) The signal timing is unreasonable and the queue length of vehicles is not balanced. Through the analysis and research of the current signal timing schemes at intersections, the current signal cycle time and green light time distribution at intersections are unreasonable, resulting in uneven saturation, severely insufficient capacity of the north-south entrances, and serious queuing of vehicles. Among them, the peak traffic queue length of the south entrance road is close to 500m, and the vehicle queue length of the north entrance road is 400m, and the traffic delay is extremely high. The traffic capacity of the east and west entrances is relatively high, and the vehicle queue length is about 50m. On the whole, there is a serious imbalance in the queue length of the four entrance lanes, which reflects that the signal timing plan needs to be optimized.

(4) There are too many signs for individual support poles in the juxtaposition of signs. At the exit of Wenhe South Road, four prohibition signs for speed limit, no whistle, no U-turn and no parking are set up on the same support pole at the same time, and part of the signs are obscured by tree branches. To ensure visibility, there are generally no more than two prohibition signs set on the same support pole; the variable guidance lane signs at the north entrance are not obvious, and the variable guidance lanes are rarely used.

(5) There is no length or insufficient space between adjacent crosswalks, and it is impossible to ensure that right-turning motor vehicles can have waiting space for pedestrians to cross the street. There are no isolation facilities such as greening or separation fences at the corners of the intersection, causing pedestrians and non-motor vehicles to cross the street illegally.

(6) The signal light countdown will induce the driver to accelerate through the intersection at the end of the green light, or the driver's response time is shortened and the lead vehicle at the beginning of the green light arrives at the conflict point at high speed ahead of schedule, causing serious conflict; secondly, in order to improve the traffic safety at intersections with countdown devices, longer intervals between green lights are required, resulting in an increase in lost time during the signal cycle and a decrease in traffic capacity.

(7) There is no safety island on the crosswalk, and pedestrians cannot cross the street twice, which is not safe.

(8) The road is cracked and the driving experience is poor.

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# 3. Detailed design

## 3.1 Design of entrance and exit

The variable guidance lane of the north entrance of the intersection is changed to a straight lane; the straight lane is changed to a variable guidance lane, which is set to a straight lane, a right-turn dedicated lane or a straight-right shared lane at different time periods; a straight-right shared lane is changed to a right-turn dedicated lane. The number of motor lanes on the remaining entrances remains unchanged. When the entrance lane of the intersection is multi-lane, each lane should be marked with a clear arrow line according to the traffic flow; when the flow of right-turning traffic at the north entrance fluctuates greatly over time, corresponding to the time change, the variable information board with advanced prompts dynamically displays the lane function instead of the ground function marking of the variable guide lane [1].

Ensure that the location of the intersection has a good line of sight, and clear out some obstacles that block the signs and markings in time to allow drivers to better observe the line of sight.

## 3.2 Determination of signal control plan

The driving speed v of the vehicle on the entrance road is taken as the limit speed of 50km/h, and the driver's reaction time is 1s, so the yellow light duration of each phase is

$$A_{1,2,3} = 1.0 + \frac{50}{3.6 \times (2 \times 3.0 + 0)} \approx 3s \tag{1}$$

Full red time is

$$\begin{aligned} r_1 &= \frac{47}{50/3.6} \approx 3s \\ r_2 &= \frac{25}{50/3.6} \approx 2s \\ r_3 &= \frac{38}{50/3.6} \approx 3s \end{aligned} \tag{2}$$

The green light interval time of each phase is

$$\begin{aligned} I_1 &= 3+3=6s \\ I_2 &= 3+2=5s \\ I_3 &= 3+3=6s \end{aligned} \tag{3}$$

Signal loss of each phase is

$$\begin{aligned} L_1 &= 3+3=6s \\ L_2 &= 3+2=5s \\ L_3 &= 3+3=6s \end{aligned} \tag{4}$$

The total signal loss time in one cycle is

$$L = L_1 + L_2 + L_3 = 17s \tag{5}$$

Signal period is

$$C_P = \frac{L}{1 - \frac{Y}{PHF \cdot \frac{v}{c}}} = \frac{17}{1 - \frac{0.697}{0.95 \times 0.95}} = 74.7s \tag{6}$$

Take the signal period of 130s, the effective green light duration of each phase is

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$$g_{E,1} = (130-17)\times\frac{0.258}{0.697} \approx 41.8s$$
$$g_{E,2} = (130-17)\times\frac{0.232}{0.697} \approx 37.6s \quad (7)$$
$$g_{E,3} = (130-17)\times\frac{0.207}{0.697} \approx 33.6s$$

The green light display time of each phase is

$$g_1 = g_{E,1} + l_1 - A_1 \approx 42s$$
$$g_2 = g_{E,2} + l_2 - A_2 \approx 37s \quad (8)$$
$$g_3 = g_{E,3} + l_3 - A_3 \approx 34s$$

There is a demand for pedestrians to cross the street during phases 1, 2, and 3. Therefore, the shortest green light display time to meet the pedestrian crossing needs is

$$g_{\min}^{(1)} = 7 + \frac{47}{1.2} - 6 = 40s < g_1$$
$$g_{\min}^{(2)} = 7 + \frac{25}{1.2} - 5 = 23s < g_2 \quad (9)$$
$$g_{\min}^{(3)} = 7 + \frac{38}{1.2} - 6 = 33s < g_3$$

The green light display time of each phase meets the pedestrian crossing demand. Therefore, the signal control scheme is feasible and the design is over.

### 3.3 Pedestrian crossing design and Integrated design of slow traffic

Since the width of the road in each direction is greater than 16m, it is difficult for pedestrians to cross at one time, so it is necessary to set up pedestrian crossing safety islands.

In the intersection range, pedestrians and non-motorized vehicles are on the same plane, and non-motorized vehicles cross the street in the same way as pedestrians. Motor vehicle traffic and slow traffic travel on high differential roads, and are physically separated by green belts or partitions.

### 3.4 Left-turn non-motor vehicle traffic second crossing design and Barrier-free design

In the integrated design of slow traffic, the left-turning non-motor vehicles will pass through the intersection twice, which can greatly reduce the number of conflicts in the mixed traffic flow at the intersection and improve the orderliness and safety of mixed traffic flows and the capacity and efficiency of various traffic flows.

In order to facilitate the passage of pedestrians, especially the elderly, the weak, the sick, and the disabled, barrier-free design is required at both ends of the pedestrian crossing.

### 3.5 Marking design of intersection gradient

In order to achieve an orderly transition of traffic flow between the lanes of the road section and the turning lanes at the intersection, fish-maw traffic channelized zone can be set, the entrance lane widens to the right and the left-turn lane separates from the straight lane.

The length of the fish maw line is the same as the length of the widening gradient, $l_d = \frac{v\times\Delta w}{3} = \frac{50\times3.25}{3.6\times3} = 15m$, the highest point is at 1/2 of the fish maw line, and the height should be tangent to the right side line of the left turn lane.

### 3.6 Diversion line design

Reasonably designing diversion lines to improve turning efficiency. Due to the widening of the entrance lane and the misalignment of the opposing motor vehicle lanes, in order to make the vehicle

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trajectory smoother, left and right turning diversion lines are added to clarify the turning vehicle trajectory. Canceling the left-turn waiting area to improve the overall traffic efficiency, and make vehicles at the intersection to pass through the intersection faster [2].

### 3.7 Left-turn waiting area design and Right-turn traffic flow channelization design

Due to the three-phase signal control scheme of the intersection, the left, straight and right of the north entrance, south entrance and east entrance are respectively released at the same time, so there is no need to set a left-turn waiting area inside the intersection, and a left-turn diversion line should be set.

A space of about 6m (a right-turn car is waiting) is reserved between adjacent pedestrian crossings to ensure that right-turn motor vehicles can give way to pedestrians who cross the street. In order to prevent pedestrians and non-motor vehicles from illegally passing through the street, isolation facilities such as greening or separation fences should be set up at the corners of intersections.

### 3.8 Design of dividing markings for entrance and exit lanes

Optimizing guidance markings and strengthening traffic guidance. Increasing the length of the canalization section, improving the traffic carrying capacity of the intersection, setting up guiding markings in front to guide the driver to choose the lane in advance and prepare for the intersection. Continuing to maintain the stepped parking line at the north entrance to increase vehicle traffic at the intersection [5].

### 3.9 Bus stop design

The bus stop at Subei Hospital is set from the entrance road to the exit road, and as far away as possible from the intersection; or the stop at the entrance road is set as a secondary station with only a few bus lines, and the main station is located upstream of the intersection.

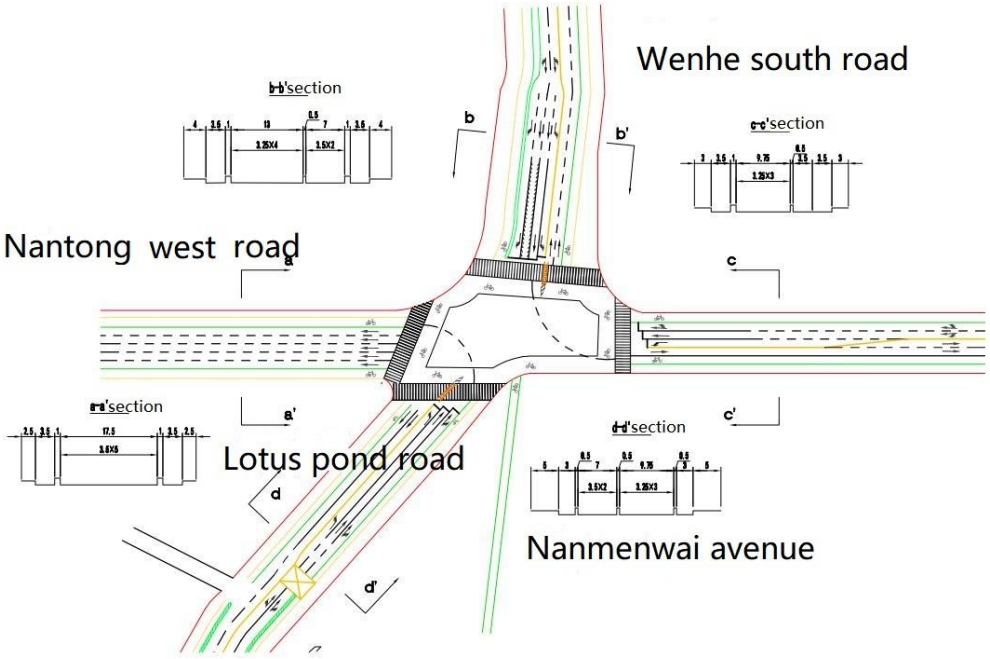


Figure 3. Intersection design

## 4. Conclusion

After traffic improvement, road resources are more fully utilized, and the length of queue at intersections during peak times is alleviated; the traffic organization for import and export is more reasonable, and the impact of vehicles entering and leaving the branch road on the main line traffic is reduced; the ease of waiting at bus stations has been greatly improved, and the harbor-type bus

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stations have been more fully utilized; noise, waste gas and other pollution are controlled to a certain extent, and the impact on surrounding residential areas is reduced; traffic signs and markings tend to be perfect, and the settings are more reasonable and effective.

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