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Research on safety analysis and Improvement of roundabout based on large vehicle

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Abstract

With the rapid growth of logistics transport industry, the road of large vehicles are increasing.In this paper, the known roundabout was simulated by VISSIM, and an optimization scheme was proposed based on the traffic characteristics of large heavy vehicles. Then, the optimization scheme was simulated and verified by VISSIM. Finally, the simulation operation before and after the improvement was analyzed by two evaluation indexes, namely traffic delay and traffic conflict rate.The simulation results show that the optimization scheme is helpful to alleviate the traffic situation at the roundabout.

Keywords

Large Vehicle; Roundabouts; Traffic Delays; Traffic Conflicts; VISSIM Simulation.

1. Introduction

With the continuous development of China's social economy and the increasing number of urban cars, the intersection is the throat of urban traffic and plays a very important role in the whole urban road network. The traffic congestion and traffic safety at the urban intersection is one of the problems that need to be solved urgently in urban roads.Compared with signal-controlled intersections, roundabouts can reduce unnecessary traffic delays for incoming vehicles.Improve the safety during driving; The traffic management method is simple and beautifies the city and so on merit. However, due to the unrestricted increase of urban traffic volume, there are also many problems at roundabouts. For example, vehicles with long detour distance at roundabouts are very easy to get stuck in the intersection, which will lead to congestion at roundabouts and increase traffic delays.Failure to control vehicles and vehicles entering the roundabout may result in traffic accidents. Therefore, the optimization and improvement of roundabout is imperative.

Many scholars at home and abroad have also put forward improvement plans for the problems of roundabouts.webber[1]On the basis of analyzing the problems existing in the status quo of the island circling, et al proposed an optimization scheme and used VISSIM simulation software to evaluate the optimization scheme.Bing-hong pan[2]Et al. improved the alignment of the entry and exit road at the roundabout and verified by VISSIM simulation.Su Chunmin[3]Taking the renovation project of a roundabout in Fuzhou city as an example, the optimized design scheme was verified by theoretical calculation of saturation and VISSIM simulation software.Xu junming[4]The problems of conventional ring crossings are analyzed.A new type of turbo ring crossing abroad is introducEd.According to the results of evaluation model, the traffic capacity of this type of ring crossing can be improved significantly raf-Faele Mauro and Federico Branco compare conventional ring crossings and a delay model is put forward to evaluate the traffic efficiency of intersections[5].Raf-faele Mauro and Marco Cattani proposed a potential accident rate evaluation model to evaluate the safety of ring crossings based on dynamic driving and user behavior at interchanges[6].

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This article focuses on large vehicles. First, VISSIM simulation software is used to simulate large vehicles passing through the roundabout, and data analysis is conducted on traffic delay and traffic conflict rate in the roundabout.Then, according to the traffic characteristics of large vehicles and the shortcomings of roundabout, put forward improvement Suggestions. Finally, it is verified by VISSIM software simulation.

2. Traffic characteristics of medium and large vehicles at intersections

With the rapid development of industry, logistics and transportation, there are more and more large vehicles on the road, so we have to pay attention to the impact of large vehicles on the road. Because roundabouts are usually built at the entrances and exits of the city, large vehicles often pass through them. Due to the traffic characteristics of large vehicles, such as slow start, slow acceleration, large kinetic energy and slow turning, large vehicles become the traffic hazard in roundabouts. Especially when large vehicles turn left, the long detour distance and large mass will affect other vehicles passing through the roundabout.The correlation between large vehicles and traffic delay and traffic conflict at roundabouts is verified by relevant data. Therefore, the impact of large vehicles can be expressed through traffic delays and traffic conflicts at roundabouts.

At present, the main means of traffic optimization method is to separate the vehicles passing through the intersection in time and space, that is, to reduce vehicle delays and traffic conflicts by means of dedicated road and signal light control. Based on this idea, this paper optimizes the roundabout by adding a carriage-way in the outer ring of the roundabout, and setting speed limit warning signs on each entrance way, so as to control the vehicles entering the roundabout and detouring as slowly as possible to avoid traffic accidents.

3. Optimization design of roundabout based on traffic characteristics

The optimal design of the roundabout is studied according to the above. The design of 2 lanes in the detour section at the roundabout is shown in Figure 3-1.So it increases the roundabout to three lanes. Set the outer ring lane as a road for large vehicles. Use signs or signs to indicate that large vehicles that need to turn left do not need to turn into the inner lane.

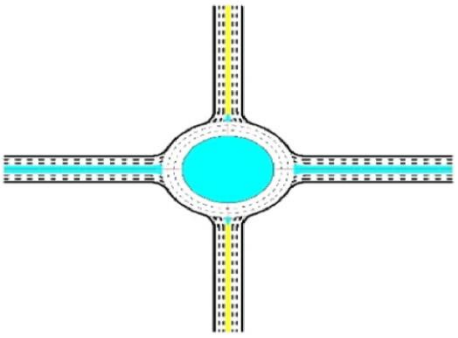

Figure 3-1. Conventional roundabouts

For the additional lane design in the periphery, the sign of the special lane for large vehicles is adopted, so as to reduce the traffic delay caused by large vehicles, especially large vehicles that need to turn left into the inner lane for detour.The vehicle passing mode is shown in Figure 3-2.The scheme is based on the impact of lane changes for large vehicles on other vehicles. This method can effectively alleviate the problem of medium and large vehicles at the roundabout.This method also brings a new problem, that is, when large vehicles take a detour, cars in the inner lane need to exit the roundabout. Therefore, this method also imposes a certain speed limit on the special lane for large vehicles, and adds a speed monitor.Reduce the impact of large vehicles on the inside of the vehicle when they detour.

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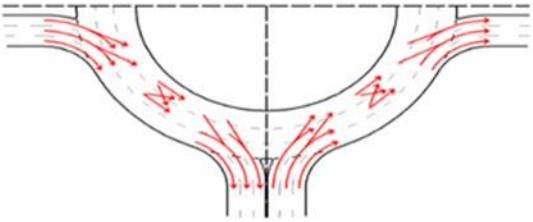

Figure 3-2 Operation mode of the improved roundabout

The design of the central road width at a roundabout depends on the traffic volume and traffic organization of the intersecting roads.Generally, 1 lane near the central island is used as a detour lane, the outermost L lane is used as a right turn lane, and the middle lane is interwoven for vehicles. A dedicated non-motorized driveway should also be set up at the same time. Practice has proved that if there are more than 4 motorways around the ring road, the traffic capacity will increase little, but it will cause traffic chaos and hinder safety.The total width of the circle island can be calculated by the following formula.Through calculation, it can be concluded that the annular passage width is 12.4m.Meet the design conditions.

Formula for the total width of the loop:

$$B_{ring} = nb + C + W$$

Where: n-- is the number of vehicle lanes on the ring road;

B -- Is the width of the widened motor vehicle lane;

C-- Is the width of the separation band;

W-- is the non-motorized lane width

4. VISSIM simulation

The previous section presents the optimal design scheme of the roundabout in this paper, which is simulated and verified by VISSIM simulation software in this section. Build a roundabout model in VISSIM traffic simulation environment (excluding non-motor vehicles).Simulation verification is shown in Figure 4-1 below

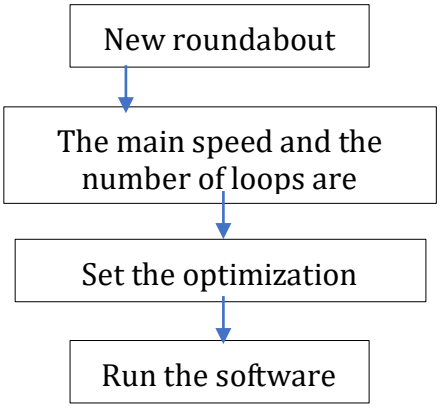

Figure. 4-1 Flow chart of simulation verification

4.1. Evaluation Index

Delay refers to the time loss caused by the failure of the running vehicle to run at the expected speed. Measured by "S" or "min", delay can reflect the traffic operation efficiency and fuel consumption, etc., and also measure the service level and traffic capacity of the

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intersection.This paper selects delay as the evaluation index of operation efficiency. As a typical non-accident indirect method, traffic collision technique is widely used because of its advantages such as high reliability, short period and accurate evaluation. If the distance between vehicles on the road and the vehicle in front is less than the distance between psychological (safety) head, then the vehicle is considered to be in a state of traffic conflict, and the ratio of the time-averaged number of traffic conflicts to the time-averaged volume of traffic conflicts. This paper selects the traffic conflict rate as the evaluation safety index.

$$f = {}^{TC}/_{Q}$$

Where: F is traffic conflict rate (secondary/PCU);TC average number of conflicts (times), VISSIM counts the number of BRAKEAX running vehicles with different Numbers;Time average traffic (PCU/H).

4.2. Simulation modeling

According to the above geometric indicators and traffic characteristics, the model was established and the vehicle addition and subtraction speed, initial vehicle speed, lane width, traffic volume, vehicle components, split ratio, simulation time and other parameters were demarcated, as shown in Table 4-2.The travel time, delay and vehicle recording modules in the evaluation parameters are selected, and the vehicle number, simulation time and interaction state are taken as configuration parameters.During simulation, in order to obtain stable traffic flow, records of a certain period of time at the beginning of simulation should be filtered out, generally starting from 600s. Therefore, simulation time is set to be 600s ~ 4200s in this paper, during which data is output once every 300s.

Table 4-2 simulation parameters table

parameter	unit	numerical value
East - West vehicle initial speed	km/h	60
North - South vehicle initial speed	km/h	50
East - West small vehicle composition ratio		0.9
North-south small vehicle composition ratio		0.9
East-west traffic volume		
North-south traffic volume		
The simulation time	s	600∽4200

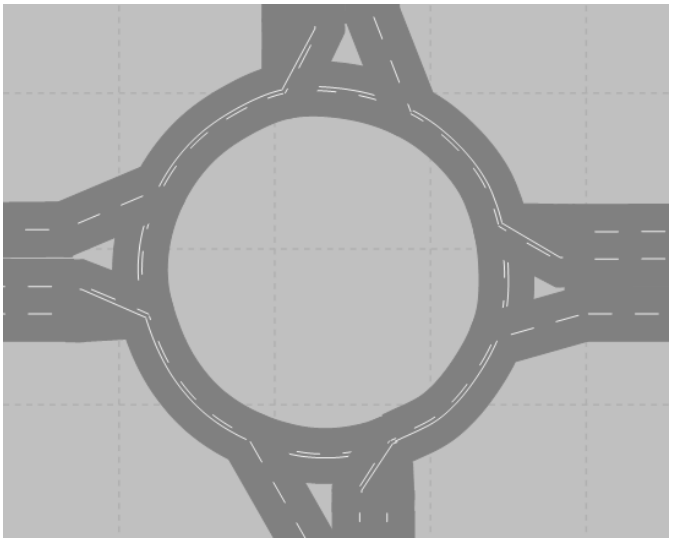

Figure 4-3 Simulation diagram before improvement

In order to ensure the stability of the data and avoid interference from random factors, the random factors were taken 41~52, and 10 simulations were conducted respectively, and the average value of the collected data was taken as the final result.The delay is directly calculated

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through the VISSIM output file, while the number of traffic collisions is the parameters of BRAKEAX interactive state filtered through the simulation output file, and then the data of the same repeated vehicle number is eliminated to calculate the traffic collision rate.

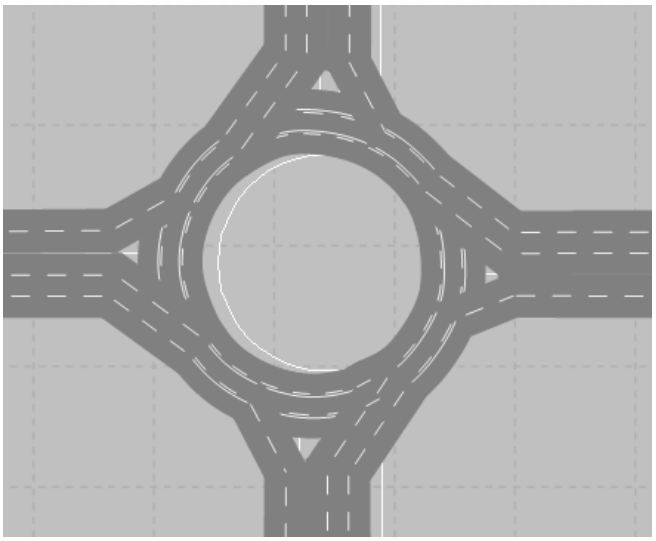

Figure 4-4 Improved simulation diagram

4.3. Simulation results

According to the results of VISSIM simulation, the improved and optimized results of the roundabout are shown in Figure 4-5, the traffic delay simulation results and Figure 4-6, the traffic collision rate simulation results.According to the above roundabout, medium and large vehicles are the main factors leading to traffic delay and traffic conflict at the roundabout. Therefore, traffic delay and traffic conflict rate can be used to respond and optimize the effect.The traffic situation at the roundabout is improved by improving the roundabout. The simulation results show that when the traffic volume is less than 2500Pcu/h, the traffic delay increases slowly before and after improvement, and there is no significant difference between the two.As between traffic flow and increase of more than 2500 pcu/h, traffic delays have increase steeply, intersection of vehicles appear crowded phenomenon, compared to before the improvement, the improved intersection traffic delays growth slow growth trends, that congestion situation be improved through the intersection, the traffic capacity of intersection get up.According to the simulation results of traffic conflict, it can be seen that although there is almost no difference in the growth rate of traffic conflict before and after the improvement, the traffic conflict rate has been significantly reduced. Therefore, based on the above conclusion, the improved roundabout is due to the improved roundabout.

Figure 4-5 Simulation results of traffic delay

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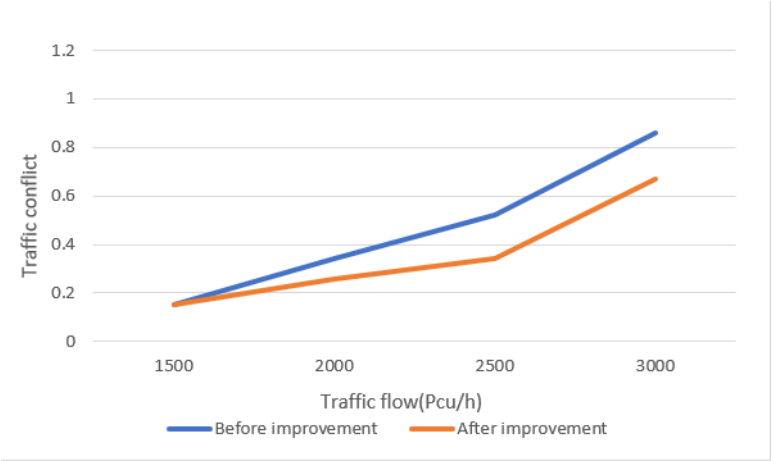

Figure 4-6 Simulation results of traffic conflict

5. Conclusion

In this paper, the traffic simulation of known roundabouts is carried out through VISSIM simulation software, and improvement Suggestions are proposed based on the traffic situation of large vehicles passing through the roundabout.Finally, VISSIM verifies the improvement effect after improvement, and the improved roundabout has better traffic capacity before improvement.This paper still has big defects. In practical engineering, it is necessary to study the influence of specific terrain and features, non-motor vehicles, pedestrians and other traffic participants. Based on the improvement of non-signal control roundabout for large vehicles, this paper provides some reference for the optimization and improvement of roundabout in the future.

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