Traffic accident influence in freeway tunnel simulation analysis based on the VISSIM

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Abstract: In order to study traffic accident influence in long freeway tunnel, a traffic simulation model is established by using VISSIM. It's taken the Jiulingshan Tunnel which is the first long tunnel in Jiangxi Province as the research object. Under different levels of traffic flow and different proportion of truck traffic conditions set up, it has obtained vehicle queue length and delay time after traffic accident happened in the long freeway tunnel. Further, it has analyzed traffic accident influence in long freeway tunnel on vehicle traffic capacity and achieve driving safety in tunnel to a greater extent.

Jiangxi Province is a province with typical southern terrain that nearly two-thirds of it is covered by mountains, hills and rugged areas. As an important part of freeway, tunnel is one of the important projects of freeway, which determines the integrity and controlling of a freeway. Many uncertain factors exist in vehicle operation in tunnel, which increases the probability of occurrence of various accidents and may bring great risks and severe accident consequences. Besides, the aftermath of accident is rather difficult, causing rather great impact on the traffic in tunnel. Based on the actual situation, it is very important to study the traffic safety in the tunnel.

VISSIM simulation software

VISSIM can provide three kinds of follow-up model and adjust the basic parameters of driving behavior to achieve the secondary development of the software. What' more, it can rather realistically simulate the driving environment in the long highway tunnel by setting the size of car ratio,traffic volume, speed, slow down to give way area. VISSIM can also output the results of the transit time, the queue length, the number of stops, evaluate the performance and nodes of the tunnel section and analyze the relevant survey data timing quantitatively.

Tunnel traffic simulation model

Compared with other ordinary freeway tunnel, mountain freeway has the following characteristics. Many unsafe factors affecting the driver's normal driving exist in it ,including

rugged mountainous terrain, bad local weather and long duration of rainy season in Jiangxi Province that the tunnel section is often covered with fog so that vehicle driver's sight is relatively poor with road visibility less than 50m. Once traffic accident occurs inside the tunnel, it may result in blocking inside tunnel, easily leading to congestion; Also, due to the frequent changes of terrain, it is difficult for drivers to adapt in a short time, which may have some impact on drivers' physiology and psychology so that it is harm to safe driving inside the tunnel.

This paper uses the Jiulingshan Tunnel as the simulation object, setting up 5000m simulation length and four lanes. According to the investigation of the actual vehicle operating conditions in the tunnel, average speed of small vehicles is 55-65km/ h and of large vehicle is 35-50km/ h. Thus, in simulation model, set average speed of small cars 60km/ h and that of large cars 40km/h.

Simulation results of traffic accidents inside tunnels

Characteristics of traffic flow in the tunnel

The impact of the accident occurrence on the tunnel is mainly divided into two stages.

Phase 1 is the growth phase of the accident occurrence impact. At the time point of the accident, because the accident vehicle occupies a lane, the access rate is reduced in this lane, and the passing time, queue length and delay time all increase. After the completion of the handling of the accident vehicle, the access rate of traffic lane will gradually pick up, but the other lanes vehicles will have a buffer stage.So the passing time, and delay may still increase .

Phase 2 is phase dissipation of accident occurrence impact. After the accident vehicle being cleared, traffic access rate recovers to normal level and impact of the accident on the tunnel will gradually disappear. The passing time and delay of the tunnel will decrease gradually, reaching the normal opening level in the tunnel and queue length dropping to zero. Note : in reality, the queue length in the tunnel is gradually reduced , while rapidly in the VISSIM.

Traffic accident influence of long freeway tunnel under different scenarios

Based on the data output by VISSIM, the simulation analysis of each docking time of the accident vehicle is made, and the traffic time, queue length and average delay time of traffic flows in each scene are compared. Data analysis is as follows.

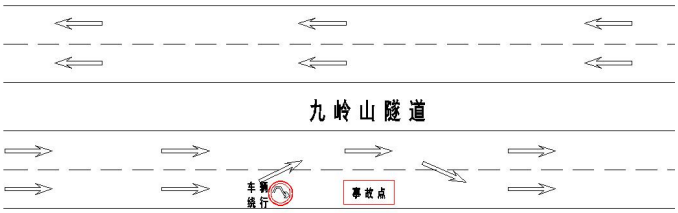

Figure 1 Schematic diagram of the simulated section and the accident point of the long tunnel of the freeway

Traffic impacts under different processing time

1. The time for vehicle spent in passing through the accident point

Through the simulation of Jiulingshan tunnel, a time counter is set up at the beginning and the end of the distance selected before and after the accident, and then transit time of the vehicle is simulated by software simulation. According to the table of the output data that accident vehicle are docked 5min, 10min, 20min, 30min,, as well as the passage of time histogram, traffic capacity in tunnel is lower and lower with the increase in transit time of the vehicle. Because the longer the processing time of the accident is, the greater the impact on the tunnel traffic is. This results in the time for vehicles through the tunnel longer,and even forming a vicious circle.

Table 1 Vehicle traffic time

Vehicle' s docking time（min）	5min	10min	20min	30min
vehicle traffic time（s）	19.8	23	25.6	26

2. Average queue length of the vehicle

For the simulation of the tunnel, a queue length detector is set up at the accident site, and the corresponding queuing length is output by simulation software.According to the table of the output data that accident vehicle are docked 5min, 10min, 20min, 30min, as well as the passage of time histogram,traffic capacity in tunnel is lower and lower with the increase in transit time of the vehicle. Because the longer the processing time of the accident is, the greater the impact on the tunnel traffic is. It results that the queue length of vehicles in the tunnel behind the accident vehicle turns longer and longer and even forms a vicious cycle and a poor driving environment.

Table2 Average queue length

Docking time of accident vehicle（min）	5min	10min	20min	30min
Queue length（m）	0	11	18	21

3. Average number of stops of the vehicle

Tunnel simulation experiment is that in the rear of the accident vehicle set delay detector, then according to the different time of the accident car docking time, output the average delay time. According to the above data and chart analysis, it can be concluded that an accident in the tunnel has a great influence on the traffic inside the tunnel. If the processing time is relatively short, the delay time in the tunnel is relatively small and the impact on the traffic inside the tunnel is relatively small; On the contrary, the delay time of the vehicle will be relatively increased, resulting in traffic congestion inside the tunnel, increasing the probability of traffic accidents. Thus, proper and timely treatment of such incidents can minimize the impact.

Table3 Average vehicle delay time

Docking time of accident vehicle（min）	5min	10min	20min	30min
Delay time（s）	4.4	7.4	9.9	10.4

Traffic impact under different traffic volume

1.The time it takes for the vehicle to pass through the accident point

For traffic accident simulation of long freeway tunnel, a time counter should be set up before and after the accident point in the VISSIM to measure the time of the vehicle passing the accident point in the tunnel. According to the output data and graphs of the different traffic volumes in the tunnel, it can be known that the more the number of vehicles in the tunnel is, the greater the effect on the traffic in the tunnel, the longer the passage time and the traffic capacity of the tunnel would become lower. Because greater traffic volume and traffic saturation inside the tunnel would cause greater impact of loss and longer passing time for vehicles through the tunnel after the accident.

Table4 Vehicle traffic time

Traffic volume in the tunnel（pcu/h）	1000	1500	2000	3000
Traffic time（s）	18.9	25.6	35.4	39.7

2. The average vehicle queue length

For the traffic accident simulation inside the tunnel, average queue length of the accident point is needed to be measured and the queue length detector should be set at the accident point in the VISSIM. Based on the output data and graphs under different traffic volume in the tunnel (1000,1500,2000,3000pcu / h), it is seen that the more the traffic volume inside the tunnel is, the longer the queue will be after the traffic accident, causing the necessary congestion and the

decreasing internal road traffic rate. Because large traffic volume and poor driving environment inside the tunnel, can bring great loss caused by the accident and make the queue length behind the accident vehicle even longer.

Table5 Average vehicle queue length

Traffic volume in the tunnel（pcu/h）	1000	1500	2000	3000
Queue length（m）	1	18	204	243

3. Average number of stops of the vehicle

Based on the simulation experiment of the tunnel, a delay detector is set up behind the accident vehicle, and the average delay time is output according to the different traffic flow inside tunnel. According to the above data and chart analysis, it can be concluded that once a traffic accident occurs inside tunnel, the delay of the tunnel with relatively large traffic volume is relatively large and the impact of small traffic volume is relatively small. For the occurrence of traffic accidents inside tunnel, to handle it as soon as possible is necessary to minimize traffic safety impact inside tunnel.

Table6 Average vehicle delay time

Traffic volume in the tunnel（pcu/h）	1000	1500	2000	3000
Delay time（s）	3.2	9.9	19.8	24.1

Traffic accident prevention measures

To reduce accidents in tunnel requires us to do the following three points: Firstly, make positive publicity of safe driving inside the tunnel, through setting up warning signs, producing promotional animation, distributing books related to tunnel safety. What' s more, set some publicity points in the service ares close to tunnel, by the use of LED large screen to remind the driver. Secondly, improve some security infrastructure in the tunnel. Actively report to relevant departments about improving the lighting inside the tunnel to enhance the driving safety inside the tunnel. Besides, some traffic signs(such as speed limit, ban and slow sign) flash lamp and sirens are set up inside the tunnel to remind drivers into the tunnel to slow down, control speed. Thirdly, strengthen the control of vehicle speed inside the tunnel.Set up some speed equipment for speeding vehicles in entrance, exit and inside of the tunnel so that we can carry out fine points deduction system for some over-speed vehicles.

Conclusion

This paper uses Jiulingshan freeway tunnel in Jiangxi Province as the research object, and use VISSIM to simulate 500m of the middle tunnel section. The results show that traffic accidents inside the tunnel have some impacts on vehicle traffic inside the tunnel. The shorter the solution time of the traffic accident inside the tunnel is, the little the loss to the tunnel is; on the contrary, the longer the solution time is, the greater the loss to the tunnel is.

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