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A STUDY ON THE TRAFFIC ORGANIZATIONS OF RING ROAD EXPRESSWAYS UNDER EMERGENCY SITUATION

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ABSTRACT

According to the physical and traffic flow characteristics of ring road expressways, the road section elements classification and numbering have been conducted, and three types of traffic organization such as diversion, evacuation and rescue under emergency situation have been studied. Taking the road section between Hongqitai Bridge and Beiliguan Bridge of Shenyang third ring road expressway as an example, the specific diversion, evacuation and rescue routes have been proposed.

1 INTRODUCTION

With the rapid development of road networks in megacities, ring road expressways have become the traffic artery and played a vital role in transportation systems. Ring road expressways, which locate at the outer ring of urban road network, serve not only urban traffic but also inbound/outbound or through traffic. It could avoid the traffic interference of through traffic to urban traffic. Considering the feature of ring road expressways, the combination of ring road expressways and urban road network will improve the efficiency of urban traffic.

Since the significance of ring road expressways mentioned above, the positive operation statuses of ring road expressways is critical to whole urban road network as well as the connected highways. If no effective countermeasures such as emergency traffic organizations are conducted to mitigate the traffic congestion under emergency situation of ring road expressways, the queue may spread to connected roads and highways, and lead to the severe traffic paralysis. Therefore, several researches are applied to guide the emergency traffic organization operation (Waugh, 2000; Barbarosoglu, 2004; Wang, 2006.)

Although emergency traffic organizations which include diversion route, evacuation route and rescue route are essential parts of emergency management, in practical emergency management procedures, emergency traffic organizations always be conducted arbitrary based on managers' experiences. Especially in China, despite almost every road management department has made the emergency plan, this plan only refer to the administrative processes instead of the specific emergency traffic organizations.

In light of the background information provided above, the primary objective of this research is to propose a practicable method to generate the emergency traffic routes such as the diversion, evacuation and rescue routes, and validate this method in the 3rd ring road of Shenyang, China.



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2 CLASSIFICATION OF EMERGENCY TRAFFIC ORGANIZATIONS

When traffic incident or other emergency situation occurs in a certain road section of the ring road expressway and the capacity of this road section drops to 0, the queue will generate and the traffic congestion will spread to the upstream road sections. In order to maintain normal traffic operations, the emergency traffic organizations should be conducted. Generally, the traffic organization under emergency situation could be classified into three categories:

(1) Diversion

Define the road section in one direction between two adjacent interchanges as the basic road section. When blocking event occurs in this basic road section, the traffic measure which implement to vehicles in upstream road sections to avoid these vehicles driving to this basic road section is called diversion.

(2) Evacuation

The traffic measure which implement to vehicles in the blocked basic road section for the purpose of guiding these vehicles leave this blocked road sections is defined as evacuation. The start point in space of the evacuation is the place of the blocking event, while the end point is the start point of this blocked basic road section.

(3) Rescue

The route which guides the rescue vehicles (e.g. ambulance, wrecker, etc.) reach to the place of the blocking event as soon as possible is called rescue route.

3 TRAFFIC ORGANIZATIONS UNDER EMERGENCY SITUATION

3.1 Principles of emergency traffic organizations

Considering the physical and traffic flow characteristics of ring road expressways, in order to select the reasonable emergency routes for diversion, evacuation and rescue, following principles should be obeyed:

(1) According to the structure of ring road expressways, the points which could be used to conduct the emergency traffic organization include interchanges and median openings, since in ring road expressways new routes could be created only between these points.

(2) Generally the distance between two adjacent interchanges in ring road expressways is shorter than that in highways. Therefore, the traffic routes which wouldn't change the original driving direction should be selected firstly since the detour distance of vehicles won't be too long.

(3) Safety should be strictly considered during the emergency traffic routes selections. Temporary traffic safety isolations and related traffic signs should be laid in accordance with certain rules.

(4) The diversion should be implemented firstly, and then evacuation follows. The rescue could be conducted from the very beginning.

3.2 Diversion

Under the road section blocking situation, mandatory diversion from off-ramp of interchanges is frequently used to prevent vehicles driving into the blocked road section. Vehicles in upstream road sections need to leave the ring road expressway from the start point (interchange) of the blocked road section, use the alternative road and then return back to the

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ring road expressway by the end point (interchange) of the blocked road section or downstream interchanges.

Under normal circumstances, the first-level diversion could effectively divert traffic. If the traffic volume is large enough and the queue already spill back to the second interchange upstream, the second-level diversion could be applied to speed up the diversion. The schematic diagram of mandatory diversion from off-ramp of interchanges is shown in Figure 1.

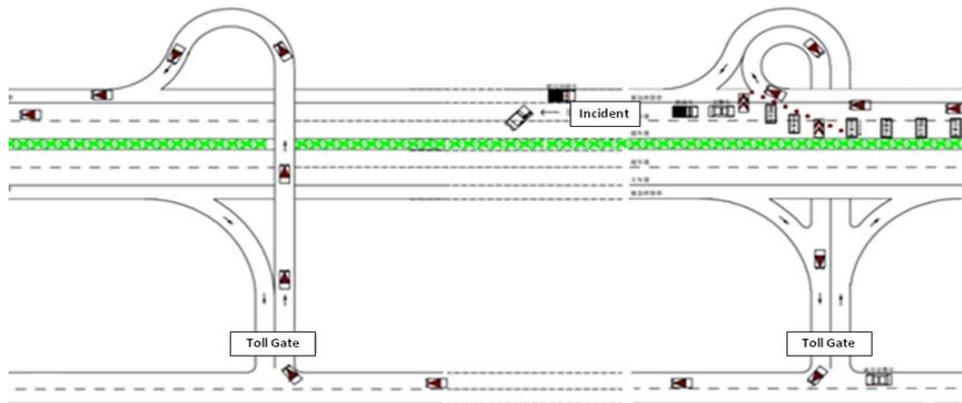


Figure 1: Schematic diagram of mandatory diversion from off-ramp of interchanges

3.3 Evacuation

As mentioned above, the objects of evacuation are the vehicles which are driving in the blocked road section. According to the position of the emergency event and the closest evacuation point upstream such as interchange and median opening, the evacuation object could be divided into two types: Type-A evacuation vehicles and Type-B evacuation vehicles, which are shown in Figure 2.

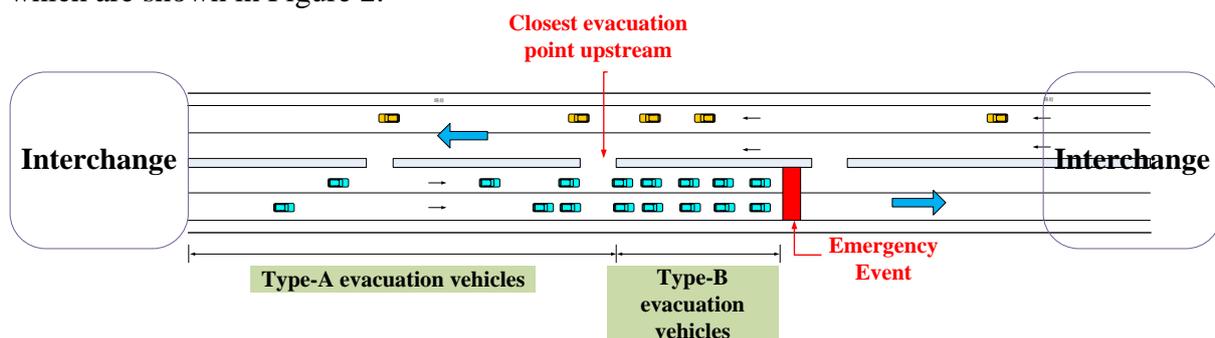


Figure 2: Two types of evacuation vehicles

Type-A evacuation vehicles are vehicles which located between the start interchange of this blocked road section and the closest evacuation point upstream of the emergency event. The character of type-A evacuation vehicles is that the evacuation points exist along with the driving direction. There is no need to change the driving direction when they evacuates. According to this character, the recommended evacuation route of type-A evacuation vehicles is: make a U turn using median opening, driving to the opposite lane and then back to the start

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interchange of this blocked road section, finally leaving the ring road expressway. This route is shown in Figure 3.

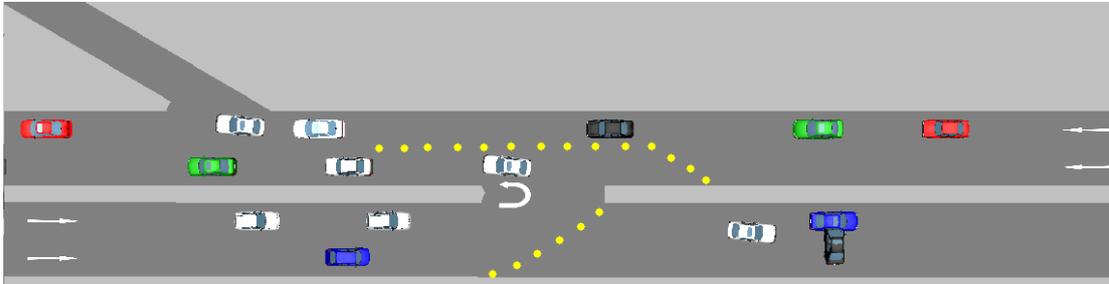


Figure 3: Recommended evacuation route of type-A evacuation vehicles

Type-B evacuation vehicles are vehicles which located between the position of emergency event and the closest evacuation point upstream of the emergency event. The character of type-B evacuation vehicles is that the evacuation could only be implemented when these vehicles make a U turn and then drive reversely to the evacuation point. Consequently, the recommended evacuation route for these vehicles is making a U turn in this blocked road section, driving reversely back to the start interchange, and then leaving the ring road expressway. This route is shown in Figure 4.

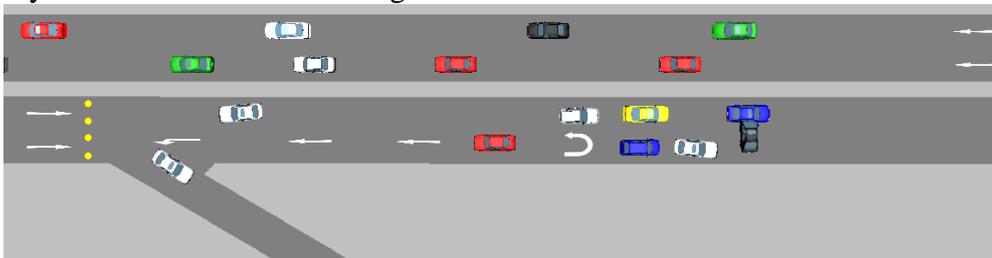


Figure 4: Recommended evacuation route of type-B evacuation vehicles

3.4 Rescue

After the emergency event occurs, the rescue vehicles (e.g. ambulance, wrecker, etc.) should arrive to the place of the emergency event as soon as possible. Two alternative rescue routes are as follows:

(1) Rescue Route 1: The rescue vehicles drive from the start interchange of the blocked road section to the place of emergency event using emergency lane of the blocked road section.

(2) Rescue Route 2: The rescue vehicles drive from the end interchange of the blocked road section to the place of emergency event using the opposite lane and the closest median opening.

These two rescue routes are shown in Figure 5.

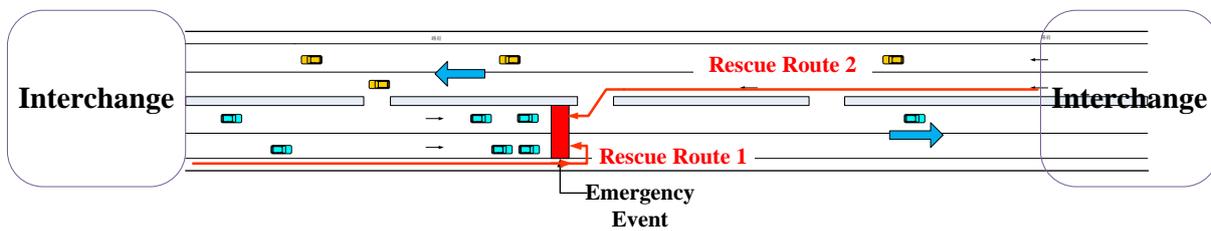


Figure 5: Alternative rescue routes

4 CASE STUDY

In order to apply the proposed emergency organization methods in a case study, the 3rd ring road expressway of Shenyang, Liaoning Province, which includes 21 interchanges, is selected. The structure of this ring road expressway and the number of each basic road section in both directions are shown in Figure 6. Since the length limitation of the paper, the basic road section 1A and 1B between the interchange of Hongqitai and interchange of Beiliguan are selected as objects of emergency organization implement.

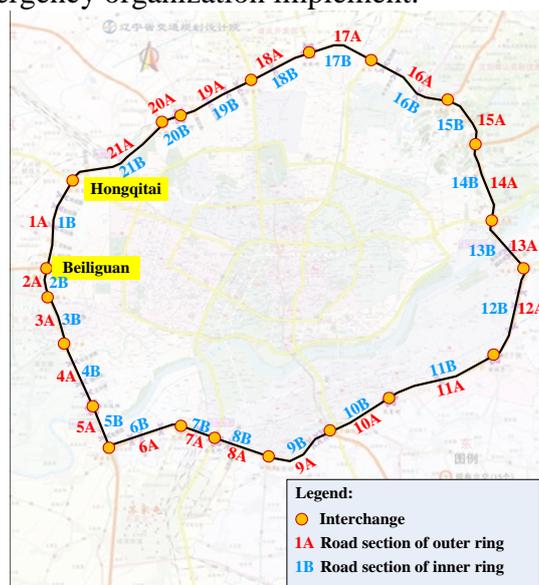


Figure 6: 3rd ring road expressway of Shenyang

Road section elements classification and numbering should be conducted firstly. Besides the basic road section (namely 1A and 1B), the sub-unit of road section should be classified according to the position of interchange and median openings. There are three median openings, which numbering “1-1”, “1-2” and “1-3” respectively, in the road sections between Hongqitai and Beiliguan. Consequently, the basic road sections (1A and 1B) between these two interchanges could be divided into four sub-units in each direction: 1A-1, 1A-2, 1A-3, 1A-4 in outer ring and 1B-1, 1B-2, 1B-3, 1B-4 in inner ring. The road section elements classification and numbering is shown in Figure 7.

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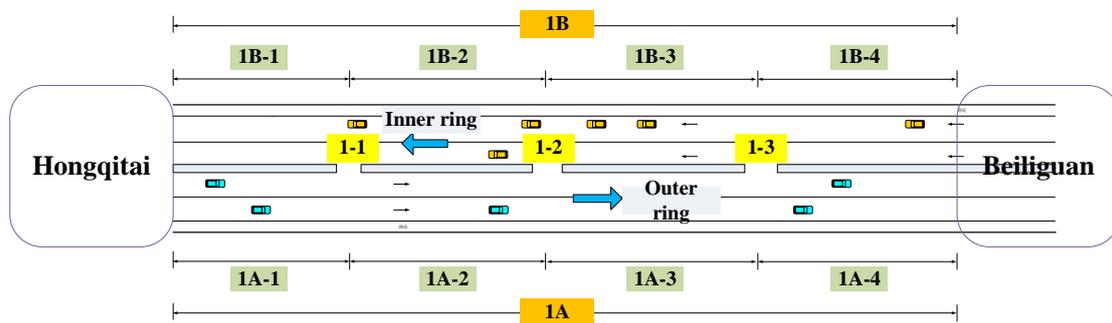


Figure 7: Road section elements classification and numbering

Based on the road section elements classification and numbering, in accordance with the principle proposed above, the emergency organization which includes diversion routes, evacuation routes and rescue routes is making when each sub-unit of outer ring road blocked. The detail routes are shown in Table 1.

Table 1: Diversion, evacuation and rescue routes of outer ring of Shenyang 3rd ring road expressway

Blocked Road Section					
Number of Road Section	1A	Start Interchange	Hongqitai	End Interchange	Beiliguan
Diversion Routes	First-level Diversion	Ring Road Diversion	Divert from Hongqitai Interchange		
			①Hongqitai-Western Guangye Road-NorthernZhonggong Street- Shenda Road-Beiliguan ②Hongqitai-Western Guangye Road-Dongpinghu Street- Shenda Road-Beiliguan		
		Intersecting Road Diversion	Divert from Danhuo Highway		
			Danhuo Highway- Xincai Highway- Jingha Highway- Shenda Road-Beiliguan		
	Second-level Diversion	Ring Road Diversion	Divert from Xijiangjie Interchange		
			Xijiangjie (Interchange)-Xijiang Street-Western Chongshan Road-Tawan Street-Northern Baogong Street-Western Jianshe Road- Shenda Road-Beiliguan		
		Intersecting Road Diversion	Divert from Danfu Freeway		
			Zaohuaxi Toll Gate- Shenbeikaifa Road-Shenyu Highway-Xijiang Street-Western Chongshan Road-Tawan Street- Northern Baogong Street- Western Jianshe Road-Shenda Road-Beiliguan		
Evacuation Routes (Arranged in descending order according to priority)	Emergency event occurs in sub unit [1A-1]	/	①Hongqitai-[1A-1]-(1-1)-[1B-1]-Hongqitai		
	Emergency event occurs in sub unit [1A-2]	①	②Hongqitai -[1A-1]-[1A-2]-(1-2)-[1B-2]-[1B-1]- Hongqitai		
	Emergency event occurs in sub unit [1A-3]	②, ①	③Hongqitai -[1A-1]-[1A-2]-[1A-3]-(1-3)-[1B-3]-[1B-2]-[1B-1]- Hongqitai		
	Emergency event occurs in sub unit [1A-4]	③, ②, ①			
Rescue Routes	Emergency event occurs in sub unit [1A-1]	①Hongqitai-[1A-1] ②Beiliguan-[1B-4]-[1B-3]-[1B-2]-(1-1)-[1A-1]			
	Emergency event occurs in sub unit [1A-2]	①Hongqitai -[1A-1]-[1A-2] ②Beiliguan -[1B-4]-[1B-3]-(1-2)- [1A-2]			
	Emergency event occurs in sub unit [1A-3]	①Hongqitai -[1A-1]-[1A-2]-[1A-3] ②Beiliguan -[1B-4]-(1-3)-[1A-3]			
	Emergency event occurs in sub unit [1A-4]	①Hongqitai -[1A-1]-[1A-2]-[1A-3] -[1A-4] ②Beiliguan -[1A-4] (driving reversely)			



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5 CONCLUSION

In this research, an approach to generate emergency traffic organizations, e.g. diversion routes, evacuation routes and rescue routes, for ring road expressways was proposed. Findings from the research could be summarized as follows:

(1) Two types of diversion method, which are First-level diversion and second-level diversion, were proposed. The former method is commonly used, and the latter one could be applied when the queue is too long.

(2) Evacuation vehicles were classified into two types: Type-A evacuation vehicles and Type-B evacuation vehicles. The suitable evacuation route of each type of evacuation vehicle was proposed respectively.

(3) Two alternative rescue routes were given. One rescue route should use the emergency lane of blocked road section, while another rescue route needs to use the opposite lane and the closest median opening.

The proposed approach was applied in generation of emergency traffic organization routes of the 3rd ring road expressway, Shenyang. All diversion routes, evacuation routes and rescue routes were given based on the proposed approach, when the emergency event occurs on the different sub-units of outer ring road section and the road section blocked, which validates the efficiency of the proposed approach.

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