Study on Traffic Organization Strategy for Occupying-road Construction of Qingkou Interchange on Shenhai Expressway

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Abstract. Expressway construction is an important foundation of regional economic development in China. In the process of expressway construction and maintenance, occupying-road construction is inevitable. Proper traffic organization during occupying-road construction can not only promote the vehicles to pass through the bottleneck section of the work zone safely, orderly and smoothly, but also is the necessary premise of the project. Taking the Qingkou interchange reconstruction project of the southeast section of the Fourth Ring Expressway in Fuzhou City as an example, this paper studies and discusses the traffic organization strategy during the occupying-road construction of the expressway. From the three levels: distal end, middle end and proximal end, the hierarchical control strategy of traffic organization is put forward, which can provide reference for traffic organization of occupying-road construction on expressway.

1. Introduction
The traffic organization in the process of expressway construction is not only a necessary part of the approval for the commencement of the project, but also an important prerequisite for the project to be carried out safely and orderly[1]. During the construction period, reasonable traffic organization can ensure the smooth progress of the project, and at the same time, minimize the adverse impact to the traffic, so that vehicles can pass through the work zone safely and efficiently[2].

At present, the traffic organization scheme for the work zone of expressway construction projects in China is mainly based on GB5768-2009 Road Traffic Signs and Markings, JTG H30-2015 Safety Operation Regulations for Highway Maintenance, and relevant management measures for traffic organization formulated by local departments[3,4]. These norms and management methods only provide general provisions for traffic organization and safety facilities layout in expressway work zone from a macro perspective, and lack of targeted traffic organization measures and solutions.

Taking the traffic organization of the work zone of Qingkou interchange reconstruction project of the Fourth Ring Expressway in Fuzhou City of Fujian Province as an example, this paper studies the traffic organization strategy of expressway occupying-road construction, and then provides certain theoretical basis and technical reference for similar projects.
2. Project overview

2.1. Project introduction
Qingkou interchange reconstruction project is located in Shenhai Expressway of Qingkou Town, Minhou County, Fujian Province, with mileage stake numbers from k2088 to k2091. Originally it was an important node connecting Shenhai expressway and Fuyin Expressway. In order to meet the needs of urban development, Fuzhou Fourth Ring Expressway is planned and constructed, which is formed by the existing Fuzhou Yinchuan Expressway, Fuzhou Ring Expressway from Qingkou to Bailong interchange, and the newly constructed southeast section of Fuzhou Fourth Ring Expressway from Yangmen interchange to Qingkou interchange, with a total length of about 153 km. The southeast section of the Fuzhou Fourth Ring Expressway crosses Shenhai Expressway at the Qingkou intersection and connects with the Fuyin Expressway. Because the Fuyin Expressway from Qingkou interchange to Bailong interchange is an important part of Fuzhou Fourth Ring Road, the reconstructed Qingkou interchange becomes an important node connecting Shenhai Expressway and Fuzhou Fourth Ring Expressway, as shown in Figure 1. Qingkou interchange has changed from a three-way intersection to a four-way interchange.

The reconstruction project includes the demolition of the old bridge and construction of the new bridge across the Shenhai Expressway. During the construction period, half of the expressway is occupied as the work zone, and only the other half can be used for vehicle traffic.

![Figure 1 Project location and road network distribution.](image)

2.2. Traffic conditions
Shenhai Expressway is a two-way four lane highway with a single width of 11.25m and a design speed of 120km/h. The 24-hour traffic volume in the north-south direction is 25000 pcu, the peak flow is 3585 pcu/h, and the service level is III. The 24-hour traffic volume from south to north is 23000 pcu, and the peak flow is 3250 pcu/h, and the service level is III.

Fuyin Expressway is a two-way four lane highway with a single width of 11.25m and a design speed of 120km/h. The one-way 24-hour traffic volume is 8000 pcu, and the peak hour traffic volume is 1073 pcu/h.

3. Principles and Strategies

3.1. Traffic organization principle

3.1.1. Safety principle: Ensure the safety of facilities, workers and vehicles in the work zone[5].
3.1.2. Principle of smooth traffic: It is necessary to ensure the smooth traffic of expressways and local roads during construction.

3.1.3. Principle of scientificity and operability: Scientific application of traffic engineering theory, striving for the scientificity of traffic organization scheme.

3.1.4. Principle of ensuring progress: The traffic organization shall be closely combined with the construction scheme and construction technology within the work zone to ensure that the traffic organization and construction process are consistent.

3.1.5. The principle of best benefit: Minimize the impact of the project to the social economic activities and the normal travel of residents in the surrounding area.

3.1.6. Principle of coordination and cooperation: Strengthen the contact with management departments at all levels, obtain assistance, and reduce the difficulty of traffic organization.

3.2. Traffic organization strategy
Because half of the Shenhai Expressway is occupied during the construction of Qingkou interchange reconstruction project, the traffic organization in the work zone needs to occupy the opposing lane. The cross section of the road in the work zone is changed from two-way four lanes to two-way two lanes, and the one-way road capacity is less than 3585pcu / h and 3250pcu / h, which can not meet the traffic demand of Shenhai Expressway. The key of traffic organization is to reduce the traffic flow through the work zone to avoid traffic congestion.

Considering the actual construction scheme, road network conditions, traffic conditions and traffic organization principles of the project, the traffic organization strategy can adopt the general idea of "distal-end diversion, middle end management, and proximal end control" for different types of vehicles to organize traffic at different levels, and cooperate with corresponding safeguard measures to ensure the implementation effect of traffic organization.

3.2.1. Distal-end diversion: The distal-end diversion is mainly for transit traffic which can be bypassed at the far end of the construction area by using the alternative expressway routes in the network of the region. By changing the guide signs on the expressway, the transit vehicles will be diverted from the
original optimal path to other alternative routes, reducing the number of vehicles passing through the work zone.

3.2.2. **Middle-end distributary:** The middle-end distributary strategy is to take split-flow measures at the exit of expressway in front of the construction area, in order to reduce the traffic through the construction area. By setting distributary signs, the traffic congestion in the construction area is informed, and some vehicles or certain specified types of vehicles (such as the vehicles unable to pass due to the work zone restrictions) are guided to get off the expressway from the adjacent expressway exit. On the diversion route, the corresponding guide signs shall be set along the route to guide the vehicles coming down from the expressway to the appropriate expressway entrance. The effect of middle-end distributary is to further reduce the traffic flow and the possibility of traffic congestion in the work zone.

3.2.3. **Proximal-end control:** The proximal-end control is to take the various control measures for traffic flow within the scope of construction area, such as speed limit, lane change, etc., to ensure that vehicles pass through the work zone safely, orderly and smoothly.

3.2.4. **Collaborative support:** The collaborative support means that the corresponding coordination management organization and mechanism of traffic organization in work zone shall be established to coordinate the cooperation of all units, so as to ensure that the hierarchical strategy and control measures can be well implemented and supervised.

4. **case analysis**

4.1. **Distal-end diversion**
The distal-end diversion strategy of traffic organization in Qingkou interchange reconstruction project is to replace the Shenhai Expressway (Lianfeng interchange to Yangmen interchange) with the lines composed of Fuzhou South connecting line expressway (Lianfeng interchange to Xiangqian Interchange), Fuyin Expressway (Xiangqian interchange to Bailong Interchange) and Fuzhou Ring Expressway (Bailong interchange to Yangmen Interchange), as shown in Figure 3. The transit traffic (such as the traffic flow to Fuqing, Putian, Quanzhou, Xiamen and to Luoyuan, Ningde and Wenzhou) is diverted from Shenhai Expressway (Lianfeng interchange to Yangmen Interchange) to the replacement line through Lianfeng interchange and Yangmen interchange, avoiding passing through the work zone.

![Figure 3 The route map of distal-end diversion.](image-url)
4.2. Middle-end distributary
The middle-end distributary strategy of traffic organization of Qingkou interchange reconstruction project is to set up a distributary route composed of Fuzhou South Link Expressway (Lianfeng interchange to Xiangqian Interchange), Luozhou bridge (Xiangqian interchange to Luozhou Interchange), Fuzhou Third Ring Expressway (Luozihuo interchange to Xiuzaizhai interchange) and Fuquan Expressway (Xiuzaizhai interchange to Huangshi interchange), as shown in Figure 4. Traffic diversion signs are set up along the Huangshi interchange, Qingkou interchange and distributary lines to guide some traffic vehicles that need to pass through the construction area to choose the diversion route, and enter and exit the expressway through Fuzhou toll station and Xiangqian toll station.

Figure.4 The route map of middle-end distributary.

4.3. Proximal-end control

4.3.1. Speed limit control: The design speed of Shenhai Expressway is 120 km/h, and the speed of many vehicles is fast. The traffic environment in the bottleneck section of Qingkou interchange work zone is complex. In order to ensure the traffic passing through the work zone safely and orderly, speed limit control should be adopted[6]. Considering that there are many vehicles in the bottleneck section which is as long as 3 km, in order to make the drivers have more sufficient reaction time to change the lane, the gradual deceleration scheme is adopted at the position 2 km ahead of the work zone, and the maximum speed of vehicles passing through the work zone is controlled at 40 km/h, with 20 km/h as a deceleration level every 300m.

4.3.2. Layout of operation area: The work zone must be controlled in accordance with GB5768-2009 Road Traffic Signs and Markings, JTG H30-2015 Safety Operation Regulations for Highway Maintenance. Warning area, upstream transition zone, buffer zone, working zone, downstream transition zone and termination zone shall be arranged in sequence. Signs, lines and safety facilities shall be set according to relevant regulations. In order to ensure the traffic safety at night and in bad weather, such as rainy days and foggy days, night lighting equipment and light warning facilities can be added.

4.3.3. Set duty point: In order to ensure the smooth traffic organization of the Qingkou interchange reconstruction project, according to the guidance of the Expressway Command Office of Fujian Province and Fuzhou City, and through full communication and coordination with expressway traffic police, local traffic police and road administration departments, eight fixed duty points and one mobile duty team are set up at the points where are easy to be congested. The staff are arranged to be on duty
24 hours a day, so as to deal with various emergencies in time. Engineering vehicles that can handle the fault vehicles should also be arranged at the key nodes. The specific positions of duty points and supporting facilities shall be determined at the construction site under the guidance of traffic police and road administration.

4.4. Collaborative support
The traffic organization of Qingkou interchange reconstruction project involves expressway traffic police, expressway administration, expressway management company, highway bureau, local traffic police and police station. It is difficult for multiple departments to coordinate with each other. In order to effectively and accurately implement the traffic organization strategies and measures, a special coordination group for traffic organization of Qingkou interchange reconstruction project was established. The team is led by the owner of the project, and all relevant department heads are members of the team. The name list and contact information of the leaders on duty and daily duty are clear. The responsibility of the team is to deal with the difficulties encountered in the traffic composition, coordinate the resources of various departments, and ensure the implementation of various traffic management measures.

4.5. Evaluation analysis
Through the hierarchical traffic organization strategy, the traffic in the work zone of Qingkou interchange has achieved good operation effect. The 24-hour traffic volume in the north-south direction through the work zone is reduced to 11000 pcu, and the peak hour traffic flow is 1465 pcu/h; the 24-hour traffic volume in the south-north direction is 10000 PCU, and the peak hour traffic flow is 1332 pcu/h, all within the traffic capacity of the road in the work zone. During the operation of the project, there is no serious traffic congestion and major traffic safety accidents, which ensures that the vehicles pass through the work zone safely and orderly.

5. Conclusion
Occupying-road construction is an inevitable phenomenon in the process of expressway construction and maintenance. The bottleneck section caused by occupying-road construction reduces the road traffic space, which is easy to cause traffic congestion and affect the safety of vehicle traffic. This paper constructs a hierarchical traffic organization strategy composed of distal-end diversion, middle-end distributary and proximal-end control, which can effectively reduce the traffic pressure in the work zone, ensure the safety, order and smooth traffic in the work zone, and provide feasible strategic ideas for the traffic organization of occupying-road construction projects.

Acknowledgement
Research foundation of Internet Innovation Research Center of Fujian University Humanities and Social Science Research Base(IIRC20200106)

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