

Improve the Urban Basic Construction of Facilities and Guarantee the Urban Traffic Flow

The Research of Traffic-Nodes After Completing the In-Plane Four-Palace Type Expressway Networks

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Abstract. This paper shows new-arisen traffic-nodes problems and the economic and social benefits brought from the Urumqi in-plane four-palace type expressway networks. It analyzes the present state of traffic-nodes, digs out the reasons for this. Furthermore, it brings up feasible solutions and scheme. It draws summary and reflection of the integrated traffic networks construction, and notes them down as valuable experience for the subsequent engineering. At last, I come up with thought and future planning of traffic management and organization.

Keywords: The in-plane four-palace type expressway networks · Traffic-nodes · Present traffic state · Solutions and planning

By rebuilding and enlarging the capacity of Urumqi's main road networks, 3-year lasting construction of the in-plane four-palace type expressway from 2012 to 2014 has realized the networking and three dimensional network system of expressway frame in central area. The in-plane four-palace type expressway networks has greatly improved the urban traffic environment, and perfected the road networks of Urumqi. In view of the reality, since this project was finished, it has obviously benefited Urumqi's traffic. Moreover, it has promoted the development of Urumqi's traffic and communication industry, this project has achieved immense economic and social benefits as well. By enlarging and remolding the routes, uplifting and rebuilding the ground expressway, building and transforming the intersections and ramps, not only have they improved the holistic traffic capacity and the service of the outer ring roads, removed the traffic bottlenecks and the jamming point, and enhanced the links and transformation of expressway and backbone road networks, but also it has strengthen the function of urban ring expressway. In the progress of building the in-plane four-palace type expressway, it was supported by the Government of Urumqi; it got consistent high raise and recognition in the industry; it was supported by all the citizens. During the period when it was gradually put into practice, it achieved successfully in the society. In all, in-plane four-palace type expressway networks has laid solid foundation for Urumqi's development and planning pattern in the future!

Meanwhile, because of the great change resulted from “Siphonic Effect”, which is caused by the transformation of the expressway backbone, and some influence which is caused by the limits of building overhead roads in the central area, traffic-nodes problems have arisen since the in-plane four-palace type was finished. The in-plane four-palace type roads project acts as the most significant municipal road engineering, so how to evaluate its benefits of improving urban traffic situation roundly, systematically, and accurately? How to master the reconstruction of urban traffic flow distribution after it was finished? How to diagnose and analyze the newly emerging traffic-nodes problems to improve the situation? How to build a far better integrated traffic network in order to provide basis, facts of traffic analysis for the subsequent road networks in the central areas such as “three-line crisscross”? How to provide useful experience and lessons for the subsequent construction of expressway network in the peripheral cities? These matters call for great attention. For this reason, although the engineering was completed, the traffic is in good condition; we still should dig into these matters and take actions to perfect it (Fig. 1).

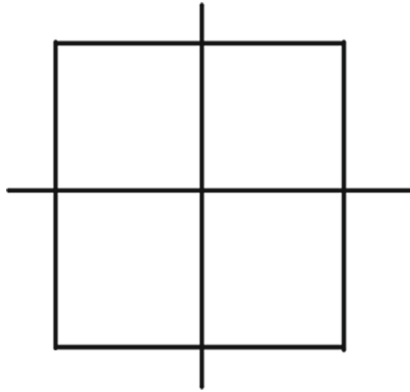


Fig. 1. The in-plane four-palace type expressway networks

1. Be serious about the investigation of the present situation, and evaluate the central road network traffic operation condition and effect reasonably.

The plan and construction of traffic system are supposed to be dynamic. For the reason that it must be advancing, though the reality may differs from the plan due to the changes in the development of social economy, we should take actions dynamic scrolling and always adjust measures.

The research of the in-plane four-palace type expressway networks analyzes its construction scale and adaptation to urban traffic demands, and the inner structure and function of the expressway networks in the aspect of level of construction and technical performance of road networks. It aims at revealing the use quality of the in-plane four-palace type expressway networks to optimize plans, offer information and gist for further decisions. With all sorts of quantitative index, we are able to analyze the urban traffic flow distribution and the differences from the previous traffic system. Also we can evaluate its effect that this engineering promotes traffic system running. The evaluation will

stands for “two combinations”: Combination of the efficiency evaluation of expressway system and the effect of traffic organization to other kinds of roads; Combination of improvement of go through in sections of highway or important roads and changes of new-formed urban traffic flow distribution. With quantitative analysis in different aspects and from different views, we can evaluate the function and main effects of the in-plane four-palace type engineering in urban traffic system systematically and accurately.

2. Research and diagnose of traffic matters after in-plane four-palace type expressway was built, and the following plans, measures to perfect it.

On the basis of first-stage evaluation, aiming at the coming up problems of traffic-nodes, we can carry out specific survey to accurately evaluate the extent, peculiarity, and factors of traffic jam. As a result, it's possible to think of comprehensive actions, including regional engineering, traffic management, and traffic organization as well.

- (1) According to the present situation after the first two phases were completed, we draw up conclusions about the main traffic-nodes.

- ① Liudaowan Overpass Ramps: south to the overpass is a north-to-south exit section where the traffic flow of north-to-south mainline of East Outer Ring Road, west-to-south turning ramp of Kenan Elevated Road and Liudaowan ground elevated ramp causes junction. Due to the seven up-down road streams change into three and the capacity of them differs vastly, it makes this point a prominent traffic-node in the whole road network.
- ② Back Street Off-ramp of East Outer Ring Road: It leads to serious jam because of the poor traffic capacity of the off-ramp roundabout and ground road junction.
- ③ Renmin Road Off-ramp: the traffic capacity of off-ramp entrance lane crossing is far from needs, which causes serious congestion.
- ④ Yuejing Street Overpass of East Outer Ring Road: As the planning and design for Yuejing Street Overpass haven't been put into practice, the old one being malformed overpass, huge traffic flow and complicated headings contribute to serious traffic jam.
- ⑤ West-to-north Off-ramp of Kenan Elevated Road: The fact that the traffic capacity of off-ramp entrance intersection is poor causes serious traffic jam and even influences the traffic stream in the artery.
- ⑥ Off-ramp of Kunming Road and ground road of Suzhou Road: the new-widen Suzhou elevated pier body has huge impact on ground traffic capacity and traffic flow capacity of transformation and organization. In this case, it's hard to satisfy vast ramps traffic demands of transforming on the ground. Different traffic flow directions disturb one another, which leads to frequent “Deadlock” phenomena and influences off-ramp traffic of Kunming Road evidently.
- ⑦ Off-ramp of Hetan Five Layers Overpass and Xinyi Road junction: The fact that the point of Hetan Five Layers Overpass off-ramp falling point is quite near Xinyi Road caused the result that the straight movement from Hetan relief road can't effectively interweave with right turn movement from off-road. Therefore, it results in a conflict point, and worse traffic jam.

(2) Through analysis and judgments, the factors of traffic-nodes are concluded as follows:

- ① Limited by the central land and other factors, several overpass ramps and up-down ramps don't reach the potential result. E.g. The impact of intersections.

The traffic capacity of intersection in much degree influences that of up-down ramps. In the crossing, vehicle is controlled by forbidden signal, so it is forced to slow down, stop, and then restart, accelerate. In addition, the outer ring road is located in the central area, the inner road networks running isn't that fluent. Traffic jam always happens during pick hours. The car waiting line being too long causes that traffic flow in the off-ramp is impossible to evacuate, which means ramp stream runs slowly, such as back street off-ramp of East Outer Ring Road, Yuejing street off-ramp of East Outer Ring Road, west-to-north off-ramp of Kennan Elevated Road and so on.

- ② in-plane four-palace type road engineering mainly widens the present elevated roads, so the new pier body inevitably will influence ground traffic capacity, especially in the ground roads' entry and exit:

Limited by elevated bridge pier body, new-built ramps take the place of separate belt or side pavement. Worse still, it has negative impact on some housing estates so that they must gather with new roads. Take Yuejing street off-ramp of East Outer Ring Road(two-lane road) for example, east to off-ramp, near News Building, traffic flow in the doorway collects and distributes through off-ramp, which leads to heavy jam in the right lane, also it influences the traffic capacity of ramps, slows the traffic stream and causes long waiting line.

- ③ After enlarging in-plane four-palace type roads' capacity and networking expressway, due to its apparent "Siphonic Effect", urban traffic flow distribution changes greatly, and it triggers new-arisen traffic jam matters.
- ④ Several traffic-nodes congestion also has something to do with other projects under construction that occupy land resource and the fact that the following engineering has not been operated.

At present, 1 line of Urumqi rail transit engineering is tense but orderly. It is principally underground construction of interval station, and it is completely closed. Occupying large construction field results in ground roads traffic organization changes so that it weakens present basic traffic capacity and then it intensifies partial road section's traffic pressure during peak hours.

- (3) In my opinion, taking those issues as point cut, on the basis of thoroughly, deeply investigating present traffic running problem, we should make plans in terms of regional engineering transformation, traffic management, adjustment and perfection of traffic organization. Here is the analysis of overall perfection thought:

Given that we should guarantee expressway running benefits, as congestion may influence the whole road networks, it's a reasonable choice to weaken the traffic function of expressway sub-flow (If necessary, adopt the way of temporarily closing ramps), and link expressway traffic to ground roads. By doing so, we can avoid that several jamming points leads to "Cask Theory" in the whole expressway system.

Elevated off-ramp and ground road intersection's perfection is supposed to be priority. Research includes how to widen the entrance road of off-ramp and ground intersection, how to perfect ground intersection organization, and how to coordinate, response and control ground intersection signals when congestion elevated line is spreading.

As for ground road beneath the extended elevated road, we'd better enforce our research into traffic organization perfection plan when it's in complicated road environment, perfect turning-around position, traffic signal control and traffic flow direction organization. In particular, avoid congestion spreading in Suzhou Road due to different traffic flow directions, which reciprocally overlay and disturb and then contributes to "Deadlock" phenomenon.

Based on this analysis thought, I come up with some advice for current main traffic-nodes problems in in-plane four-palace type roads as follows:

- ① Liudaowan Overpass Ramp: On the basis of feasibility study report, it's possible to close Liudaowan north-to-south ramp and carry out East Outer Ring Road (Nanhu East Road-Renmin Road) green wave traffic management during the peak hours or when at the "7-3" converging point exists heavy traffic jam. In terms of long-dated traffic organization planning, I suggest that we should put Kelamayi east second-phase project and Second East Ring Road elevated project as soon as possible. If the two projects could be in use immediately they're finished, numerous vehicles could distribute through the two elevated roads. As a consequence, it will obviously ease present traffic pressure from East Outer Ring Road, and remove current traffic-nodes.
- ② Back Street Off-ramp of East Outer Ring Road: A study report shows that it's useful to strengthen the traffic capacity of off-ramp roundabout and ground road intersection part and make measures to perfect traffic organization.
 - i. It's suggested that the exit at Back Street Off-ramp of East Outer Ring Road should cancel left-turn flow (to Dongfeng Road). This traffic flow could go through Dongfeng Road, Wuxing Road, turn right to Jianguo Road and turn left so that straight-left conflict points at the crossing of off-ramp exit and then increase off-ramp traffic flow speed;
 - ii. It's suggested that the exit at Back Street Off-ramp of East Outer Ring Road should cancel the crossing links Wuxing South Road. This traffic flow could turn right continuously to join Wuxing South Road or via Renmin Road off-ramp of East Outer Ring Road. At the same time, transform off-ramp exit into two-lane two-way road.
- ③ Renmin Road Off-ramp: Investigate and draw up actions to coordinate ground intersection with elevated off-ramp traffic organization and control plans at super saturation state.
- ④ Yuejing Street Overpass of East Outer Ring Road: Study partial-widen engineering measures to improve Yuejing Street bridgehead traffic capacity and traffic organization perfection plans.
- ⑤ West-to-north Off-ramp of Kenan Elevated Road: Study engineering measures to widen ground road at West-to-north off-ramp falling point and measures to organize, manage, coordinate and perfect ground intersection and off-ramp traffic.

The reason for peak-hour congestion in West-to-north Off-ramp of Kenan Elevated Road is that we cut down the numbers of lanes of ground system. It used to be one-way lane. During peak hours, traffic flow change into two lanes, plus a ground relief road to integrate traffic flow at ground crossing signal lamps. Since right-turn traffic flow is too much, which leads to long waiting line, it weakens traffic capacity.

It's suggested that we'd widen ground road for one lane to north at off-ramp falling point, levy a bungalow at Hepingqu bridgehead, and widen Aletai Road by adding one speed-change lane to increase right turn vehicle speed. It's suggested that construct pedestrian overpass at the gate of Xinjiang University, the museum's signal lamps. Meanwhile, remove present ones to decrease congestion resulted from traffic flow's waiting line. In this way, the overall traffic capacity in current section could be improved, and traffic pressure of these three ramps could be relieved.

Combined with long-dated traffic organization plans and thoughts, we can consider building elevated road at Xihong Road-Wooden Factory grade separation. Lessen ground road traffic pressure by connecting oriented interconnected ramp with Kenan Elevated Road, and congestion during peak hours could be removed fundamentally.

- ⑥ Off-ramp of Kunming Road and ground road of Suzhou Road: Study partial-construction engineering measures to improve ground road traffic transformation capacity of traffic flow from ramps and traffic organization and management plans. Especially perfect different direction traffic flow's turn around position.
- ⑦ Off-ramp of Hetan Five Layers Overpass and Xinyi Road junction: Study ideal plans to adjust Hetan Road broken section in Xinyi Road Overpass field. Setting two individual collector-distributor lanes to avoid conflict between right-turn traffic flows from five layers overpass off-ramp and straight-on traffic from Hetan relief road. At present, we can widen Hetan eastern relief road which links northeastern ramp. Besides, it is wise to widen the old one-way lane into one-way two-lane, remove, move back and build new high retaining wall, improve traffic capacity of relief road to Hetan mainline, and shorten vehicle waiting line on the relief road.

In addition, we should pay attention to connections between traffic-nodes and system improvement. Take these measures as point cut, we should think further and perfect plans on the basis of in-plane four-palace type expressway networks system analysis. To guarantee the effect and compare all sorts of plans, it is better to carry out systematical, deep, intuitive test, adjustment and perfection through field investigation.

3. Conclusion and suggestion of integrated in-plane four-palace type expressway traffic network engineering experience.

After the in-plane four-palace type expressway networks were completed, it serves as the most significant project to extent to peripheral area and to carry out arterial road networks transformation. From my point of view, it's quite necessary to analyze traffic function and arisen problems after in-plane four-palace type roads was completed from the aspect of integrated traffic networks. Make it clear the traffic function connection and link point between central area expressway system and arterial road system, between central area expressway system and peripheral expressway networks. Come up with

specific conclusions and propose for sub subsequent central arterial road networks and peripheral expressway networks construction as follows:

- (1) Construct peripheral through traffic to evacuate outer traffic, to distribute vehicle for foreign trade and freight vehicle.

Through traffic and freight transport has huge impact on urban traffic. Through traffic lacks peripheral main road, especially traffic flow in the east that it can't run smoothly. Most of it runs on north-southern roads such as Hetan Road, which occupies limited resources of north-southern roads. The future road networks should solve this problem firstly, perfect peripheral through and freight passageway, and reduce traffic pressure of central urban area road networks. Doing as follows:

- ① Enlarge eastern and western ring freeway construction in city peripheral field to shield regional traffic's interference to Urumqi's urban area;
- ② Tuwu huge freeway urban section is changed from Hetan Road far phase to eastern ring freeway, so it passes by urban massif. We can transform Wukui freeway into urban expressway (the Second Ring Road in the West), recover Midong-Ganquanbao section of Hetan Road to urban expressway, speed up to construct urban second ring expressway in the east to reduce in-plane four-palace type expressway system traffic pressure;
- (2) Plan well-connected urban road networks which gives priority to expressway and arterial road, and adds secondary trunk road and feeder highway.

Expressway system offers vehicle continuous traffic service that isn't disturbed by crossing signal delay, which means the speed is faster than ground roads. It even takes advantage in speed when traffic flow approaches designed traffic capacity over ground system. Although in-plane four-palace type expressway system set ramps linking ground roads in many places, passageways are much farther than ground crossings. What it mainly serves is middle-long distance vehicle. If too many short distance vehicles gather on expressway, it will certainly reduce the efficiency of expressway system.

Combining Urumqi's traffic development goal, construct efficient road traffic system, which construct expressway and arterial road as road networks skeleton, and take secondary trunk road, feeder highway as road networks basis. It is functional and has clear aspects. What's more, it can develop with other means of transportation in a balanced way.

- (3) Improve the traffic capacity of at-grade intersection, increase partial grade separation.

Traffic delay resulted from traffic saturation at crossings acts as the main reason for traffic jam. Improving the traffic capacity of at-grade intersection and increasing partial grade separation could improve the running state of elevated expressway. General crossings have poor traffic capacity because of straight-straight, straight-left and left-left conflict points. Traffic lamp control, channelization traffic and grade separation are able to decrease or remove the crossing conflict points.

In the central area where available land is limited, it's wise not to set huge overpass. When the traffic flow is not that huge, channelization, multi-phase signal control and

simple grade separation are ideal actions. Only when general measures can't solve the problem do we consider setting overpass. According to traffic demands forecast model, predict traffic flow in main road crossings and construct new overpass at the intersections of expressway's crossings or expressway-arterial road crossings.

(4) Strive to develop public transportation, and reduce the rate of personal transportation.

Faced with influence of urban traffic flow, doubled motor vehicle and "wasp waist" traffic bottleneck between new-old towns, depending on big-scale road construction will only put urban traffic problem into a vicious circle. To avoid urban traffic state worsening further, we must construct competitive urban public transportation system instead of personal cars. Give priority to recently constructed BRT in Urumqi's urban traffic planning and construction.

Public transportation could be ground, underground or overhead. Compared with cars, public transportation vehicle occupies less space but has bigger passenger traffic capacity. Complete integrated public transportation system which take rail transit as skeleton, including numerous means of transportation such as bus rapid transit, conventional public transit and taxis.

(5) Plan and construct external traffic hub facilities.

By setting traffic hub station, it improves urban transportation accessibility, and reduces the differences among stations so that it can balance popularity distribution. In this way, we can drive core cities' distribution, activate cities' peripheral land, induce new distribution of urban popularity and employment, and promote to perfect cities' space form. Setting traffic hub stations plays an important role in improving transportation (long-distance passenger traffic, conventional public transit, BRT, subway and so on) running efficiency, and is an significant aspect of improving urban transportation service level.

References

1. Dorigo M, Gambardella LM (1997) An ant system: a cooperative learning approach to the traveling salesman problem. *IEEE Trans Evol Cooperation (S1089-778X)* 1(1):53-66
2. 王川.车路协同环境下交通控制与诱导协同研究[D]. [硕士学位论文].兰州理工大学,2014
3. 王艳青.面向城市复杂道路的交通状态识别手段与算法研究[D].[硕士学位论文].同济大学,2015
4. 王奕曾,金立名,袁腾飞,城市道路交叉口车辆排队交通流状态理论研究,《城市建设理论研究》,第6卷第1期,72页,2016年1月

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