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Cause Analysis and Countermeasures of Beijing city Congestion
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Abstract

The traffic congestion in Beijing intensified during the past few years and has seriously affected the lives of the residents. Till 2012, the total number of the registered vehicles in Beijing had exceeded five millions, which was far beyond the designed road capacity. This paper focuses on the sources and reasons about the traffic congestion in Beijing city and try to propose methods to relieve traffic congestion through analyses.

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key word: Congestion; Capacity; Road network

1. Instruction

Since 1990s, the economy of China had developed in a high speed, which made part of Chinese families became car customers, the private cars are becoming more and more popular. With the explosive increasing of private car number, the urban traffic congestion problem had become more and more serious. All the problems happened in western countries such as traffic congestion, environmental pollution, lacking of residential houses came to China. Apparently, only by building more roads can't catch up with the increasing speed of cars. Traffic congestion problem is becoming the most serious problem that holds city development.

As China's political, economic and cultural center and an international city, Beijing's urban road network infrastructure construction proceeded quickly in current years, more and more newly constructed or be about to build are laying cross Beijing. But these perfect looking road networks caused most serious traffic problem in the domestic. Capital city is called Most Congestion city by people. According to the data

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statistics, till 2012, the registered cars in Beijing has exceeded five millions which is far beyond the designed road tolerance. The traffic problem has become the livelihood issues and it has strongly influenced citizen livelihood, does harm to Beijing traffic development and holds back the internalization of Beijing city. As the leader of Chinese city development, if Beijing can handle the problems in a proper way, it will be a good model for other cities to follow.

2. The analysis of urban congestion causes

2.1. motor and non-motor vehicle mixed traffic (MNM) phenomenon

In our country, motor and non-motor vehicle mixed traffic (MNM) phenomenon is relatively typical characteristics of the traffic environment. In developed countries, due to the low number and small proportion of bicycles, road traffic is mainly to motor traffic, the MNM phenomenon is not outstanding. So these countries rarely involve MNM flow in the theory study of traffic engineering. However, our country exists a big bicycle power, the great difficulty in the urban traffic management is the hybrid passing of motor vehicles, bicycles and pedestrians in the intersection. In Beijing, for example, although it is hard to find the figure of bicycle in huge loop, but in some low level branch, particularly branch crossing section, it is normal that the motor vehicle, pedestrians and motor vehicle mix together. This not only disturbed the normal traffic order, also increased the probability of accident. It can be said that the mixed traffic is the root of the traffic problem, and it has become an urgent issue in urban traffic.

2.1.1 The basic characteristics of mixed traffic flow

(1) The factors of mixed traffic flow influence each other. Due to the different speed, driving track and target of motor vehicle, the non-motor vehicle and pedestrian in the mixed traffic flow, it can result in mutual influence and interference. Especially in the intersection, it is unable to take physical isolation, which make this kind of interaction more obvious. If this mutual interference is not properly processed or solved, it will greatly restrict the capacity of intersection of the mixed traffic flow, resulting in the whole road traffic congestion.

(2) Mixed traffic flow is generally with high density, high accident rate, and low speed characteristics. In some sections, as the vehicles run slowly, the non-motor vehicles and pedestrians will penetrate among them, and increase traffic flow density. In order to ensure traffic safety, motor vehicles have to run more slowly. Thus a vicious cycle has been created, seriously influence road capacity. Due to the intersection is a collection of roads toward multiple directions, compared to sections, traffic flow at intersection is heavier. And this is more prone to traffic jams, and easier to traffic accidents.

(3) Mixed traffic flow often will aggravate the pollution of the environment. Due to the influence of the bicycle and pedestrians, motor vehicle deceleration, parking waiting, restarting and acceleration has happened more
frequently. And these driving behaviors of the motor vehicle always lead to the most emission of pollution gas. Therefore compared with motor vehicle traffic flow, a mixed traffic flow will cause more noise pollution and air pollution.

2.1.2 The effect to the capacity of intersection caused by mixed traffic flow

When mixed traffic flows are moving on the intersection, if a non-motor vehicle flow interferes some a motor vehicle flow, the motor vehicle flow will transfer interference to the backward and around motor vehicles (when turning into motor vehicle flow), and rapidly transfer interference to other a stream of non-motor vehicle flow and pedestrians. And the influenced traffic flow and other strands of traffic flow affected by the interference will accordingly change its running state. In order to reduce or avoid the interference and collision by the mixed traffic flow, you must ensure that each traffic flow has an enough space for self mediation, protection. Specific conditions are shown in figure 2.

2.2. The negative effects on urban traffic brought by static navigation (represented by vehicle navigation)

The so-called "static navigation" means without the real-time dynamic traffic data, only using map data of the GPS satellite system database to positioning and realize the navigation. It just provides the driver with location information and static geographic information from the database like digital map. This kind of navigation is mainly based on vehicle navigation, mobile navigation, and domestic navigations are generally based on this principle. I will take the vehicle navigation as an example to illustrate the negative effects on urban traffic congestion brought by the static navigation.

According to different standards, the vehicle navigation system has different classification. In the hand of realizing the navigation function, there are basically two kinds: one is autonomous navigation system, the vehicle positioning and navigation functions are completed by the on-board terminal; the other is center-decided vehicle navigation system, the part of the navigation function need to be completed by the control information. However, the central-decided vehicle navigation related technology is not yet mature enough, the domestic market is mainly autonomous navigation terminal products [1]. The system principle as the figure 3 shows: if the vehicle
navigation system can open data interface and inject real-time dynamic traffic information into the database (as shown in the green diagram), then the static navigation will become a dynamic navigation system.

Because the research of vehicle navigation started late, the domestic construction of intelligent transportation system is still in the primary stage, and most navigation system are also in the static level, can provide the "map service", and cannot satisfy people requirements according to the real-time traffic information dynamic navigation needs. In Beijing, due to the enormous auto possession and large scale network, the navigation problem becomes obvious. This will lead to the following questions:

1. Because the upgrade of domestic navigation electronic map database is relatively slow. Today, the network construction is an on increasingly accelerating trend, but many vehicle navigation maps also based on the network data two or three years ago. As the Internet service becomes thorough popular, navigation is increasingly relied when people go to travel, and vehicle navigation undoubtedly bear the brunt. A lot of new traffic road are unable to get into the electronic map data base, causing a lot of vehicle navigation system induced to the original road. Invisibly it intensifies the original road traffic congestion, and also waste road resources in a certain degree.

2. Because the vehicle navigation system belongs to static navigation, the vehicle computer cannot deal with the actual traffic conditions. As for computer, it can only select one of the shortest paths according to the user's selection and settings. It happens that even if selected path has been in the serious traffic congestion, the computer will still take the driver there. This will deteriorate road congestion, "the shortest path" actually turned into "the most time-consuming path"

3. Electronic map database cannot display the traffic control situation. This makes choice made by the computer unenforceable, and greatly reduces the value in use.

2.3. Urban minor traffic accident can't get rapid processing

It has been long recognized that the traffic accident treatment is responsibility of traffic management department, handling the accident on their own has not been advocated. In fact, “Road Traffic Safety Law "has regulated the minor accident processing mechanism since it was issued and implemented in 2004. However, since China's current legal system and insurance system is imperfect, and the traffic participants are not familiar with traffic rules and insurance regulation, many people worry that a hasty decision will cause unnecessary trouble. Too many concerns make the accidental parties have to hand over the traffic police to process, and it makes
promotion of the traffic accident rapid processing very difficult. As shown in figure 4: If these minor accident is not processed efficiently and fast, directly it will aggravate urban congestion, increase the urban traffic load.

![Traffic accident processing mode](image)

**Fig.4 Traffic accident processing mode**

2.4. **Public transportation is under-developed**

Public transportation, the significant measure to alleviate the urban traffic congestion. In recent years our country has stressed that vigorously develop the public transportation. Figure 5 is the contrast of public traffic in Beijing and other developed urban in the world.

<table>
<thead>
<tr>
<th>Background</th>
<th>Seoul</th>
<th>Singapore</th>
<th>Hongkong</th>
<th>Beijing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (thousand)</td>
<td>10,580</td>
<td>5,080</td>
<td>7,020</td>
<td>20,180</td>
</tr>
<tr>
<td>Area (km²)</td>
<td>605</td>
<td>714</td>
<td>1095</td>
<td>16410</td>
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<tr>
<td>Per capita GDP (dollar)</td>
<td>34215</td>
<td>43117</td>
<td>31758</td>
<td>11307</td>
</tr>
<tr>
<td>Population density (thousand/km²)</td>
<td>17.4</td>
<td>7.1</td>
<td>6.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Track mileage (km)</td>
<td>290</td>
<td>178</td>
<td>214</td>
<td>442</td>
</tr>
<tr>
<td>Bus traffic (thousand/day)</td>
<td>8,700</td>
<td>5,070</td>
<td>10,980</td>
<td>13,390</td>
</tr>
<tr>
<td>Vehicle ownership (million veh)</td>
<td>2.13</td>
<td>0.97</td>
<td>0.65</td>
<td>5.12</td>
</tr>
<tr>
<td>Private car ownership (million veh)</td>
<td>2.10</td>
<td>0.50</td>
<td>0.44</td>
<td>4.00</td>
</tr>
<tr>
<td>Speed of central area in rush hour (km/h)</td>
<td>23</td>
<td>24</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>Bus number (veh)</td>
<td>10088</td>
<td>12951</td>
<td>19976</td>
<td>28343</td>
</tr>
<tr>
<td>Public Transport allocation rate (%)</td>
<td>70</td>
<td>65</td>
<td>89</td>
<td>44</td>
</tr>
</tbody>
</table>

**Fig.5 Beijing compared with developed cities’ public transportation in the world**

From these data, we can find some interesting phenomenon: such as, the city has the smallest per capita GDP also has the lowest traffic sharing rate; the city has the smallest population density also has the lowest speed of traffic flow in the central area during peak time. In addition, it is remarkable that average road area of Singapore's vehicle is 12 m², New York's is 43 m², Tokyo’s is for 26 m² [2], but Beijing’s is much higher than these data. Among these cities the traffic facilities is similar, but the road capacity of Beijing is lower than the international metropolis, in other words, Beijing has wider road, the group velocity of vehicle is actually slower. The huge bus
system does not give full play to the advantage, and the gap between Beijing and public traffic developed cities is evident. The reasons can be summed up as coming under three categories.

First of all, operation system of the public transportation is still not mature enough. In many places, lack of humanized processing, such as the facility is not perfect, not convenient to change the bus, traffic station congestion need to be solved. According to 2012 statistics, in Beijing, the rate of public transportation trip is 44%, and Brazilian Curitiba was 75%, Hong Kong was as high as 90% up to the first in the world [3]. Further, about the policy, bus priority policy has not been implemented well. In urban area the widespread bus lanes is not only for public transportation. The passengers have not experienced a higher right of way. Third, in operation scheduling, the arrangement of some line is not reasonable. The uneven distribution of vehicles caused the waste of vehicle resources, failed to the maximum use of public transport vehicles.

3. Research of Beijing urban congestion countermeasures

3.1. Establish and perfect bus priority policy

The public transport system is the system most able to support the sustainable development of cities. Compared with other modes of travel, the bus have a distinct advantage in many aspects. Such as environmental protection, energy conservation, urban land use and reduce traffic congestion etc. To solve traffic congestion in Beijing, we cannot only focus on controlling congestion, but also pay attention to increasing traffic capacity of road network from a macro-perspective. According to implementing the bus priority policy, Traffic Management Department should guide people using public transportation, which expand service capacity at the same time reduce the volume of traffic. This will become an effective means to solve the problem of traffic congestion.

The city with a sound public transport system has huge significance for urban governance congestion. Especially like Beijing who has large population and huge travel demand. Only being establish and perfect bus priority policies, and provide residents with a good public travel environment, in order to maximize the reduction of urban congestion problems.

3.2. Realizing dynamic navigation by dynamic traffic data

For the problems of current static navigation, I consider, now at this stage does not have a universal premise of vehicle dynamic navigation, we should focus on the development of traffic guidance systems which services to public. The system could timely pass real-time road conditions to the driver, providing drivers the basis for selecting the right path by data collection and variable message signs (VMS).

The traffic guidance system is a powerful manage tool. According to such wireless transmission vehicle traffic information display system, the traffic guidance system could realize traffic guidance, notice and warning for traveler. Through cooperating with the signal lights, variable speed identification and other transport facilities, it can reasonable control and balanced distribution of traffic flow and improve existing roads capacity and parking facilities usage. Meanwhile, it is also an effective resource integration system which provide a valid traffic analysis, manage and dredge congestion for traffic management department. It is more important that it can effectively solve the problem of traffic congestion, reduce traffic and prevent traffic pollution, improve traffic management level, to maximize the efficiency of the existing roads. The system principle as the figure 6 shows:

![Fig.6 The traffic guidance system schematic diagram](image-url)
3.3. Perfect the traffic accidents rapid processing mechanism

The traffic accident impact is quite large for traffic operating. Many traffic congestion is just caused by a little accident. Both from the legal system and the enforcement, Current rapid processing mechanisms are now difficult to alleviate traffic congestion. Reform is imperative. It is the inevitable way for develop of traffic accidents processing. Traffic management departments should communicate with insurance and other relevant departments to jointly cope with this change, in order to better serve the traffic management practices and adapt to the needs of economic development and harmonious society. Lead the traffic accidents processing to track a virtuous circle track of people-oriented.

4. Conclusions

Traffic is the city's "blood". It is the performance of the vitality and dynamism of the city, and also a measure of an important symbol of the modernization of the city. With the rapid growth of China's national economy and the accelerating process of urbanization, traffic congestion has become a major bottleneck, which restrict urban economic development and sustainable development. It is also seriously affect the normal operation of the urban life, plagued the work and life of the residents of the city.

As the developed city in the domestic, Beijing's contradiction between the rapid growth in demand for transport and urban transport supply lag increasingly prominent. In addition, deficiencies in the traffic management. These are the major reason of traffic congestion in Beijing. Alleviate the city's traffic congestion is a systematic project. Solving some single problem cannot alleviate the whole congestion. We should consider the solution from an overall perspective instead of focusing on some aspect. Only multi-party coordination, in order to solve the problem of traffic congestion.

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