Brief Analysis on the Control and Management Measures of Urban Road Congestion

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Abstract. With the rapid development of cities, traffic congestion appears more or less in large and small cities. With the continuous increase of motor vehicles, problems such as traffic congestion, energy shortage and environmental pollution have also appeared one after another. Urban traffic problems are getting worse, and urban congestion needs to be solved urgently. This article focuses on the optimization of urban land layout, expansion of urban transportation infrastructure construction, strict control of the total number of vehicles, priority development of public transportation, and vigorous development of intelligent transportation systems. Countermeasures and solutions are proposed in this paper to alleviate traffic congestion and to make effective suggestions.

1. INTRODUCTION

As a part of daily life, transportation is closely related to people's lives. Due to the unscientific development model in the early years, traffic congestion has become a problem that cannot be ignored in people's lives, and has become one of the important indicators that affect people's happiness. In order to effectively alleviate this phenomenon, scholars from all over the world are actively exploring feasible mitigation measures and solutions. This article introduces the content of traffic congestion, including the definition of traffic congestion from different perspectives, the judgment methods of traffic congestion in different countries and cities, the analysis of the causes of traffic congestion and the specific measures to alleviate traffic congestion. It has a certain reference effect on alleviating urban traffic congestion. Based on the advanced nature of the transportation discipline, it is necessary to consider the situation in the next ten or twenty years when taking measures and determining development policies. With the continuous development of the transportation system and the city, new problems will also appear. In order to facilitate future sustainable development, these problems must be prevented and dealt with in advance before they become serious.

2. The concept of traffic congestion

With the progress of society and economy and the improvement of people’s living standards, private cars have become a common way for people to travel. The number of private cars in our country is also increasing year by year, followed by frequent traffic jams, which has brought great trouble to people's
lives. Nowadays, traffic congestion is not only common in large cities, but also in some small and medium-sized cities and even towns. Traffic congestion has become an urgent problem to be solved.

At present, scholars from various countries do not have a unified definition of traffic congestion. Traffic congestion is a traffic state, which can be defined according to the flow, speed, and density in traffic flow parameters, or according to the relationship between traffic supply and demand. Early scholars who studied traffic flow defined the phenomenon of time loss caused by slow driving of vehicles on the road as traffic jam based on the relationship between traffic volume and speed. Some scholars pointed out that the essence of urban traffic congestion during peak hours is an imbalance of traffic supply and demand. When traffic demand exceeds the amount of traffic that the road can supply, vehicles are stranded on the road, which leads to traffic congestion [1]. Guo Dan, Li Yan and Jiang Zhu [2] believe that although traffic congestion is a phenomenon of vehicle detention caused by the imbalance of traffic supply and demand, it has both spatial and temporal characteristics, objective phenomena and subjective feelings. It needs to be measured from multiple dimensions such as transportation resource supply, demand satisfaction, and management science. The research contents of other scholars are shown in Table 1.

| Year | Scholar(s) | Comment Content(s) |
|------|------------|-------------------|
| 2016 | Ji Jing [3] | Based on the Traffic State Index (TSI), it analyzes from the three aspects of congestion degree, congestion distribution and congestion trend, and builds a quantitative evaluation system for urban road traffic congestion. |
| 2017 | Zhou Nanjin [4] | On the basis of the comprehensive evaluation method of the status quo, a "state before trend" analysis method is proposed. |
| 2018 | Li Fuzhong [5] | Based on information entropy weighting method and grey system theory, the framework of grey relational evaluation model is constructed. |
| 2018 | Xiong Li [6] | Constructed a theoretical model of urban congestion based on the elements of traffic 5S (Streams, Structures, Spaces, Scenarios, Societies). |
| 2018 | Zhu Yun [7] | Fuzzy neural network evaluation model is constructed by using fuzzy analytic hierarchy process and neural network theory to evaluate urban road traffic congestion. |
| 2019 | Fan Xinyue [8] | A traffic congestion evaluation method based on road segment dissipation index is proposed, which can be applied to road network traffic congestion situation prediction. |
| 2020 | Hou Liping [9] | According to the lane occupancy, speed jumping probability, traffic flow characteristics and the time-varying characteristics of its parameters, an urban traffic travel time index model for evaluating the severity of traffic congestion is obtained. |

Localities are also exploring their own methods of determining congestion status. Chicago Transit Authority defines traffic congestion from the perspective of lane space occupancy and time occupancy rate, that is, "the traffic state corresponding to a 5min lane occupancy rate of 30% or greater." Highway Capacity Manual 2000 calls the unstable traffic flow below 22km/h the congested traffic flow. Traffic congestion on urban roads by the Japan Road Corporation is defined as a traffic state where vehicles running at a low speed below 40km/h for more than 15 minutes or repeatedly starting and stopping are queued for more than 1km. The Ministry of Public Security of People’s Republic of China defines traffic congestion from two aspects: the waiting time for vehicles at intersections and the average speed of urban arterial road vehicles [1]. Based on the research of the floating car collection and analysis system, Beijing has established a "five-dimensional" road network dynamic evaluation index system [10], which consists of congestion intensity, congestion range, congestion time, congestion frequency and operation reliability, as is shown in Figure 1. The dynamic evaluation index system is used to describe the multi-dimensional dynamic change characteristics of traffic congestion, and based on this, a road network traffic congestion index classification standard is proposed to quantify the degree of congestion of the road network in a specific area and specific time period, so as to realize the scientific definition of traffic congestion.
Figure 1 "Five Dimensions" Congestion Evaluation System

To sum up, there is no clear definition of traffic congestion. It is a traffic state, which has different definitions from different perspectives. It can be considered comprehensively according to a certain aspect or several aspects such as speed, time, density, supply and demand. Therefore, for a certain road in a specific state, different evaluation criteria will produce different evaluation results. The more factors considered, the more reliable the conclusions obtained.

3. The causes of traffic congestion

The causes of traffic congestion are complex. It may be internal or external factors in the transportation system; it may be a local reason or the whole reason. Therefore, when analyzing the causes of traffic congestion, we should consider the whole and a multi-disciplinary aspects.

3.1. External factors of the transportation system

There are many external factors that cause traffic congestion, the most important of which is the incoordination between urban development and the development of the internal transportation system. The development of urban modernization has made the transportation system more comprehensive, systematic and social, which is mainly reflected in the scale of urban population, the layout of urban functions and the number of motor vehicles. The process of urbanization is accelerating, and the urban population is growing by leaps and bounds. The imbalance in the layout of urban functions has led to the distortion of the temporal and spatial distribution of traffic demand, and the relationship between traffic supply and demand has become more complicated. The motorization process has exceeded expectations, and the excessive use of cars cannot be effectively controlled.

3.2. Internal factors of the transportation system

The problems of the transportation system itself are mainly attributed to transportation supply and demand, transportation structure, and transportation control. Scholars such as Lu Huapu [11] believe that the root cause of traffic congestion is the imbalance between traffic supply and demand. Ding Hongxiang [12] believes that the development of our country's urban transportation and urban transportation facilities are lagging behind the development of the automobile industry and the number of national cars. The contradiction between the automobile age and the traffic environment is an important cause of traffic congestion. In terms of urban traffic management, various traffic resources lack effective integration. Bus and subway, as the most important means of passenger flow, are not unified and supplemented. Instead, they operate separately, causing a waste of public transportation resources. The intelligent development and coordination of public transportation is weak. At present, our country's traffic management methods are relatively scarce. Compared with the traditional management methods based on experience and traffic police on-site supervision, the new equipment of electronic eyes, electronic display boards and other equipment have enriched the continuity, system and comprehensiveness of traffic management. However, these have not played a more effective role in tackling traffic congestion. They focus more on the supervisory role such as illegal photography.
4. Specific measures to optimize urban congestion
The practice and research countermeasures to relieve urban traffic congestion can be divided into developmental measures, management measures, and restrictive measures. The problem of urban traffic congestion is a systemic problem, and comprehensive measures need to be adopted to control it. Priority is given to the use of developmental measures to improve urban traffic supply capacity. Strive to enhance the level of urban traffic management, and actively implement management measures. Taking into account the historical basis, development level and fairness of our country's urban development, restrictive measures should be carefully considered.

4.1. Optimize the layout of urban land and make it develop in coordination with transportation
The most fundamental problem of urban transportation is that the transportation system cannot keep up with the pace of urban development. To fundamentally solve the problem of traffic congestion, it must be managed from the source. When planning the future of the city, it is necessary to consider the transportation system that matches it. This requires us to pay attention to the overall structure of the city, reduce the unlimited expansion of the city, and establish a "multi-center" urban pattern. Each "urban center" is a relatively independent development space, which will build compound functions to ensure its own job-living balance. Shanghai is developing multiple urban centers such as the Bund and Wujiaochang. Around megacities, develop medium-sized cities as soon as possible, establish a cascade structure of urban agglomerations, disperse the population in the central city as soon as possible, and control the excessive concentration of the central area. Beijing, Tianjin and Hebei are building the integration of Beijing-Tianjin-Hebei in order to relieve Beijing’s population and traffic pressure and promote the development of Tianjin and Hebei.

4.2. Speed up the construction of transportation infrastructure and build a large-volume transportation system
Our country’s infrastructure construction has already ranked first in the world, but the transportation infrastructure of some cities is not very complete, especially in terms of mass transportation. The public transportation system of a considerable part of the city is not perfect, the covering area of bus is small and the line network density is low. And some large cities have too few rail transit lines to meet the increasing transportation demand in the next ten years. In addition, the roads of ringing the city and parking facilities are also issues that need to be considered. For such situations, the following measures should be taken. Speed up the construction of public transportation network and rail transit to give full play to its large-capacity backbone transportation role as soon as possible. In order to cooperate with the construction of the public transportation network, it is necessary to build a road network system with reasonable gradation. The construction of expressways, primary and secondary branches needs to be in a reasonable proportion. We should continue to accelerate the construction of parking garages to alleviate "difficult parking", and more facilities with larger capacity such as parking buildings and underground parking can be used lots.

4.3. Optimize the urban traffic structure and promote the development of mass traffic modes
Judging from the experience of the construction of large cities in the world, the subway system is the most effective means of transportation in megacities. As an important symbol of urban public transportation, the subway has many advantages such as large capacity, high efficiency, low energy consumption, intensiveness, convenient ride, punctuality, safety, comfort and etc. It is an important way to solve the problem of urban traffic congestion, to realize the adjustment of urban spatial layout and to balance the development of the city. There is a high density for the people’s density in the urban centers of our country and the urban structure has been formed, it is difficult to reconstruct old district with a low cost for the construction of more urban roads which involve a large number of demolition and relocation. Therefore, the construction of subway is the only way for the transportation of big cities. Another symbol of urban public transportation is public transportation, which is an important supplement to the subway and makes up for the shortcomings of the subway that is not suitable for short-
distance travel. The urban bus passenger transport system and the subway network form the "the aorta of urban traffic", provide urban residents with a low-cost, safe and friendly environment for traveling. It plays an irreplaceable role in medium and short-distance travel services and it is an important measure for traffic congestion and pollution in large cities.

We should vigorously develop passenger public transportation, establish a relatively complete public transportation system, give full play to the flexible and convenient characteristics of the public transportation system in the city, make full use of the traffic function of urban roads, and solve the needs of medium and short distance passenger transportation. At the same time, as a supplement to the subway system, a seamless connection with the subway system should be built to solve the problem of urban population gathering in the subway, and effectively exert the subway’s efficiency.

4.4. Control the total number of motor vehicles and slow down the growth rate of motor vehicles
Due to the rapid growth of motor vehicles, urban roads are difficult to meet the traffic demand. Some major cities have adopted more or less measures to strictly control the number of motor vehicles, which mainly include of implementing motor vehicle restrictions, restricting the entry of motor vehicles from other provinces and cities and implementing new motor vehicle license plate lottery and bidding. In order to solve the problem of motor vehicle congestion and air pollution, market and administrative measures to control the total number of motor vehicles are taken by the local government. It can be seen from Figure 2 that from 2014 to 2018, the number of newly registered motor vehicles in Beijing and Shanghai showed a trend of first increasing and then decreasing, which shows that the government’s measures have played a role in restraining the surge of motor vehicles.

![Figure 2 Newly registered civilian vehicle ownership in Beijing and Shanghai from 2014 to 2018](image_url)

However, it is not a long-term solution. Before a suitable solution is found, we have no choice, and they can alleviate traffic pressure and bring certain effects to traffic congestion management to a certain extent.

4.5. Vigorously develop intelligent transportation systems to promote sustainable urban development
In addition to the development of the subway system, an intelligent transportation system is also an effective way to relieve traffic pressure. For the first-tier and super-first-tier cities in our country, the urban framework has been basically formed, and it is difficult to change the traffic mode. Under the condition of limited road resources, increasing road operation efficiency can maximize resource utilization and reduce traffic congestion. Intelligent transportation can improve the existing transportation services, maximize the utilization of resources such as roads, vehicles and parking facilities, achieve a comprehensive balance of transportation operations and greatly improve the overall
efficiency of the transportation system. It is not only the direction of the development of urban transportation’s future but also an important means to ensure the sustainable development of the city.

4.6. Enhance the concept of transportation and adhere to people-oriented

As one of the four elements of transportation, people are the most important factor. The ultimate action point of traffic congestion control measures is people, those measures aim to provide residents with a safe, efficient, fast and comfortable travel environment. When carrying out traffic jam managements, we must fully consider people’s subjective feelings, and we should not blindly pursue performance while ignoring the residents' feelings. Many small cities have such a phenomenon. In order to alleviate the impact of pedestrian crossing on the traffic flow on the road, pedestrian overpasses are set up not far from the pedestrian crossing. Due to the lack of consideration of human subjective factors, the utilization rate of pedestrian overpasses is extremely low, which does not have the expected effect and results in waste of resources and incomprehension of urban residents. Recently, a newly built overpass in a city has received strong dissatisfaction from the residents because of the pedestrian ramp. The slope of the ramp is too steep and the width is too narrow, which brings great difficulties to the driving of non-motorized vehicles. People can only come down to push it, causing a large number of non-motor vehicles waiting to pass at the entrance to be blocked. In case of rainy day and snow day, this place will become a frequent accident and congestion source.

The effectiveness of traffic congestion managements largely depend on the public’s feelings after travel, which is the most intuitive for travelers, and public participation is also related to the effectiveness of governance. Civilized travel awareness and good travel habits are also key measures to alleviate congestion. It is crucial for relevant departments to strengthen publicity and guidance to increase public participation. In order to build and share a civilized travel environment for all people, we should call for civilized, green, law-abiding and enthusiastic participation of residents. It also helps the government to formulate long-term transportation policies through political channels.

5. Summary

For many cities, it has reached a critical period of urban and urban transportation development. Whether it is a large city or a small and medium-sized city, under the dual constraints of resources and environment, traffic congestion has become a social problem. The government needs to guide the governance work, re-examine it from different angles, adhere to the development idea of “on-demand management and control”, formulate corresponding norms or systems and strictly implement them, create an urban spatial form of coordinated development of transportation and use of the land, and improve the traffic structure to make it to more use of large-scale transportation. In addition, people’s feelings are one of the most intuitive manifestations of whether traffic jam measures are effective. When carrying out traffic managements, we must pay more attention to human’s factors. Comfort, as one of the goals pursued by traffic management, it cannot be ignored when we pursue efficiency. We must adhere to the people-oriented concept and manage traffic congestion under this concept.

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