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Study on Green Transportation System of International Metropolises

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Abstract

With the acceleration of urbanization process, urban traffic congestion is becoming increasingly rigorous, and the contradiction among population, resource and environment is also becoming increasingly prominent. Green transportation is a low-carbon and environmental travelling mode. The active promotion of green transportation is not only good for intensive use of road resources, the ease of traffic congestion, the decrease of energy consumption and the improvement of air quality, but also, as a return to healthy and leisure lifestyles, good for the improvement of citizen health. By systematically analyzing the green transportation development experience of international metropolises during the process of transportation development, this paper identifies the problems that green transportation of Beijing is facing, and proposes countermeasures and suggestions on improving the green transportation system of Beijing and advocating green travelling.

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1. Overview of Green Transportation System

Canadian Chris Bradshaw proposed the Green Transportation Hierarchy in 1994, with the priority order of green transportation as walking, bicycle, public transport, shared vehicle, and single-driving vehicle as the last [2].

From the perspective of means of transportation, green transportation system includes walking, bicycle, regular public transport and rail transport. From the perspective of vehicle of transportation, green transportation vehicles include various low-pollution vehicles, such as dual-energy vehicle, natural gas vehicle, electric vehicle, hydrogen

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power vehicle and solar energy vehicle. Green transportation also includes different kinds of electrified transportation vehicles such as trolley bus, tram car, light rail and subway. Green transportation is a new concept and a practice goal, specifically referring to the convenient, safe, efficient, low-pollution, humanized and diversified urban transportation system. It adapts to the habitat environment development trends, is led by public transport, and coordinates with ecological environment and urban development. The concept of green transportation is proposed together with the concept of sustainable development, which is the transition from "vehicle-oriented" to "people-oriented" [6]. Green transportation advocates the decreased use of private motor cars, the increased use of walking, bicycle and public transport, and the use of clean energies and vehicles. It is a low-cost, pollution-free, land resource and space saving transportation system suitable for all kinds of travelers.

Green transportation is not only a low-carbon and environmental travelling mode, but also a return to healthy and leisure lifestyle. The construction of green transportation system is good for the intensive use of road resources for ease of traffic congestion, the decrease of energy consumption for energy conservation, the reduction of exhaust emission for improvement of air quality, the reduction of carbon emission for decrease of greenhouse effect, and the construction of livable cities for improvement of citizen health. Green travelling, featuring flexibility and high punctuality, has good development foundation in China. It is an ideal means of transportation for short-distance travelling and transfer as well as an indispensable part of urban comprehensive transportation. Meanwhile, the development of urban green transportation is an important measure for saving energy, reducing carbon and PM2.5 emission and improving environment [1].

2. Analysis of Experience of International Metropolises on Green Transportation System

Green transportation is an important means for easing traffic congestion and solving urban pollution and environmental problems of major international cities, which actively promote green travelling and public transport, and shift from being vehicle-oriented to being human-oriented.

2.1. Copenhagen

2.1.1 Basic Information

Copenhagen was once a car-oriented city and had already formed a partial bicycle road network in 1960s and 1970s. Copenhagen keeps the tradition of bicycle for a long time, becoming a well-known "city of bicycle" with over 40% of residents going to work by bicycle. In 1962, Copenhagen constructed the first pedestrian street called Strøget, which has now become a paradise of pedestrians after 40 years of walking system consummation and reformation. In Copenhagen, the number of bicycles exceeds the urban population, with 36% of citizens relying on bicycle for daily commuting, resulting in CO2 emission reduction by 90,000 tons annually. For the city, the goal is to reach 50% of citizens relying on bicycle for commuting by 2015 [4].



Fig. 1. Average Travelling Share Ratio for Work and School in 2008-2010

2.1.2 Analysis of Major Experience

• Reasonable urban planning

In 1947, Copenhagen proposed the famous "Five-Finger Plan". The plan specified to carry out urban expansion through five radial corridors from downtown to the surrounding, and the space between these corridors would serve as city green wedge for development restriction [9]. Developed rail transportation systems are distributed along the corridors and closely integrated with the land development project along the lines. The majority of public buildings and high-density residential areas are distributed around rail satiations, which not only shortens the travelling distances, but also brings convenience for citizens to choose the bicycle-rail combined travelling mode. So far, "Five-Finger Plan" is still strictly implemented by Copenhagen, the government of which arranges the majority of lands for future development in the high-density built-up areas, and stipulates that newly-built office buildings must be within 600m walking distance from public transportation stations.



Fig. 2. Copenhagen "Five-Finger Plan" (left) and 2007 version "Fingers Plan" (right)

• Consummated bicycle system planning

In 1980, Copenhagen government approved the first bicycle network plan, which was proposed by Danish Federation of Cyclists in 1974. In 1997, the government issued the Traffic and Environmental Planning, specifying the general goal of restricting car growth and actively developing bicycle and public transport. In 2000, the government issued the Urban Traffic Consummation Plan, detailing the bicycle development goal of Copenhagen, and laying a foundation for the approval of specific implementation of Bicycle Lane Priority Plan and Bicycle Green Lane Plan in the same year. In 2001, the government issued the Copenhagen Traffic Safety Plan, proposing the reduction of bicycle accident mortality rate by 40% during 2001-2012. Currently, bicycle has been integrated into different levels of Copenhagen urban planning management work. In 2002, Copenhagen government issued the Bicycle Policies 2002-2012. In 2011-2015, Copenhagen proposes the Good, Better and Best Copenhagen Bicycle Development Strategies 2011-2025, setting for the second time the goal of building the best country of bicycle in the world. Detailed implementation plans are listed in the urban budget report.



Fig. 3. Copenhagen Bicycle Policies 2002-2012 (left) and Copenhagen Bicycle Strategies 2011-2025 (right)

• Friendly walking system planning

Since 1968 when Copenhagen began to transform Strøget, a trunk road, into the first pedestrian street, Copenhagen has intentionally been promoting the pedestrianization in downtown area steadily. Copenhagen government releases a new five-year plan about every five years, not only reporting the current walking characteristics, but also proposing the goals for key indicators such as walking share ratio and average travelling time and specifying the key improvement directions for the subsequent work.

2.2. Tokyo

2.2.1 Basic Information

Tokyo is the core area of Metropolitan Area, governing 23 special areas, 26 cities, 5 towns and 8 villages, covering an area of 2187km2 and having a population of 12,790,000. Tokyo is a typical rail-dominated city. The share ratio within the entire metropolitan area was 30% for rail, 14% for bicycle and 22% for walking in 2008.



Fig. 4. 2008 Traffic Mode Share Ratio of Tokyo Metropolitan Area

2.2.2 Analysis of Major Experience

• Coordinated development of city and transportation: Highly intensive development along rails

Tokyo is a typical rail-dominated metropolis in the world, with built-up areas along rail traffic from central three areas to district area and then to Tokyo traffic ring, showing an axial concentrated extension. In Tokyo Metropolitan Area, the population increased by 1.88 million within 1.5km from metro stations and by 80,000 outside 1.5km from metro stations in the decade from 1995 to 2005, which is a significant increase.



Fig. 5. Tokyo Metropolitan Area Development Trend

The 5th traffic survey on Tokyo Metropolitan Area (2008) indicated that the main means of transportation was urban rail traffic, the share ratio of which increased from 23% in 1978 to 30% in 2008, becoming the means of transportation with the largest increase [10].

• Taking parking management as the means for strict control over vehicle ownership and use

Japan has developed a series of laws and regulations on different kinds of parking management, including Road Traffic Law, Urban Planning Law, Parking Lot Law, Vehicle Custody Space Law and Tokyo Parking Regulations, and has made constant modifications and consummations, forming a comprehensive and consummated parking lot law system and enabling the legal compliance of parking construction and management. In order to effectively solve the parking chaos at night, Japan formulated the Vehicle Custody Space Law in 1962. It is clearly stipulated that car owners must obtain night parking permits when registering cars, or otherwise cars could not be purchased; where there are changes to motor vehicle owner address or parking address, registration at the public security authorities is also required. This effectively solve the night parking problem for residents. High and differentiated parking charge is one of the major features of parking in Tokyo. For the central business districts with the highest land value, the parking charge is the highest, as parking price respects market rules and reflects the real cost. The monthly income of Tokyo residents is JPY 300,000, and about one third of the monthly basic income will be used for paying parking charge if they drive cars.

• Re-planning of bicycle road space

In Japanese traffic regulations, bicycle is positioned as light vehicle, which could take the motor vehicle lane in principle. However, due to the sharp increase of traffic accident death toll (15,000) in 1970, traffic administration authority issued the emergency refuge ordinance for the purpose of reducing death toll: Allowing bicycles to take the sidewalks. This temporary ordinance was executed for a long period, resulting in no special riding lanes for bicycles but sharing the space of sidewalks with pedestrians. It could be said that bicycle in Tokyo has never been provided with a good riding environment. In 2007, in order to improve walking and bicycling environment, Japanese government modified the Road Traffic Law, proposing the separation of bicycling from walking, after which bicycles need not share the sidewalks. In 2010, Tokyo issued the Adjustment Policies on Cycling Space in Tokyo, adopting the measures including designating a special bicycling lane in roadways, and separating cycling lane from sidewalk through visual and physical isolation areas. It was planned to have a total road mileage of 221km by 2020.

• Strengthening of public promotion and communication

On the promotion of bicycle, Tokyo also stresses the public promotion and communication. As shown in the picture, the public promotion activity "environmental traffic campaign" will be held annually, covering lectures, learning experience, riding, bicycling safety learning, etc.



Fig. 6. Tokyo Bicycling Campaign

2.3. New York

2.3.1 Basic Information

New York, the biggest city in the US and the world, is located in the northeast of American Atlantic coast and the southeast of New York state. Motor lanes in many streets in Manhattan are changed to bicycling lanes and sidewalks, livening the former urban roads, enhancing the communication between human beings, and promoting city prosperity.

2.3.2 Analysis of Major Experience

• Transportation and land use: Highly intensive development along rail traffic

There's good interaction between the urban land exploitation strength of New York and large capacity of public transport (see the following figure). Highly intensive land development concentrates along the metro lines. This enables the walking range of metro station to cover more population and attract more potential groups to take Consummate bicycle lane network

Roads in New York were not provided with special lanes for bicycles basically at the beginning of construction. Only some biketrails were provided, but the bicycles must share the motor vehicle lanes in urban roads. So the travelling by bicycle was of poor conditions. Since 1970s and 1980s, New York had gradually set bicycling lanes in municipal motor lanes; particularly after 2007, the special bicycling lane in New York embraced rapid development. The planning report entitled New York Urban Planning: Greener and Better New York specifies to promote the use of bicycle, including encouraging bicycle growth strategies and completing the general planning of 1800 mile in 2030, so that the travelling by bicycle becomes more convenient [5].

- Create high-quality pilot walking projects
- New York Broadway Avenue reconstruction project

New York Broadway Avenue reconstruction project refers to that New York City transforms Broadway Avenue in downtown core area Times Square into a special pedestrian lane. Although this reduces the space for cars, it provides more space for pedestrian activities and guides more people to use walking and public transport instead of cars. This measure not only improves car flow in New York core area, but also promotes the development of surrounding retail industry and service



Fig. 7. New York Metro and FAR Distribution



Fig. 8. Broadway Avenue: before and after Reconstruction

• 9th Avenue reconstruction project

New York has redesigned trunk roads such as the 9th Avenue, so as to further balance different kinds of means of transportation and improve the walking and bicycling environment. A series of measures are adopted for the reconstruction of the 9th Avenue: Increase the number of traffic islands and marks good for walking across streets to enable safer and more comfortable walking; re-design road sections to provide road rights for full range of traffic users and increase highly praised parking protection bicycle lanes; and increase central isolation greening belts. 9 months after the completion of the 9th Avenue reconstruction project, bicycling frequency increases by 40%, the number of bicyclists riding for 12 hours on business days increases from 780 prior to implementation to 1100 after implementation, and the bicycling on sidewalks also decreases.

3. Existing Problems of Beijing Green Transportation System and Reasons

Currently, green travelling has become an important means for easing traffic congestion and solving urban pollution and environmental problems of major international cities, which actively promote green travelling and public transport, and shift from being vehicle-oriented to being human-oriented. Though Beijing has made great achievement in public transport, the proportion of travelling by bicycle decreases by 16.6% within five years, even exceeding the increase amplitude of public transport. Within 3km distance most suitable for bicycling, the proportion of travelling by bicycle is just 56%. It could be said that green travelling system composed of public transportation and bicycle still could not effectively compete the increasingly severe problem of "high growth rate, high use intensity and high density aggregation" of cars. Specifically:

3.1. Existing Problems

• The awareness of green travelling has not yet been formed

Currently, the car use intensity in Beijing is too high, with annual mileage of private cars of 15,000 km, which is 1.5 times of London and over 2 times of Tokyo, and the use proportion in core areas is much higher than that in other international cities [11]. According to surveys, travelling by car within 5 km accounts for 40%, which is completely suitable for travelling by bicycle, so the awareness of green travelling needs to be further raised.

• The speed of travelling by public transport is still low, restricting the further improvement of public attraction.

The most prominent problem existing in public transport service level is slow operation with poor reliability, which is also the biggest weakness compared with cars. Currently, the operation speed of ground traffic, rail traffic and cars in Beijing is 0.4:0.6:1, with obvious difference. Ground public transportation is featured by low speed, mainly due to the lack of powerful support of bus lanes. Beijing lags behind in the speed of designating special public transport lanes, and the special public transport lanes are still not connected into a network, particularly the congestion roads in central area lack special lanes, which affects the further improvement of public transportation attraction.

• The quantity of pedestrian and bicycle infrastructures is insufficient, and the travelling environment is deteriorating.

The improvement of green travelling infrastructure is the improvement of green travelling conditions and the increase of travelling flexibility and attraction. However, the bicycle lanes at both sides of the auxiliary roads of fast road are often occupied by high-speed electric motorcycle, motorcycle, motorcycle taxi or even motor vehicle; some secondary trunk roads do not have designated special bicycle lanes, while many special lane marks are damaged and could not be identified; the width of many walking lanes is less than one meter, so the spatial demand for pedestrians in single direction could not be met.

• Disorderly parking of cars takes up large "green travelling"

The guarantee of "road right" is one of the most effective ways to encourage residents to choose green travelling mode. However, disorderly parking of cars in Beijing takes up a large proportion of formerly insufficient "green travelling" space. The occupation of bicycle lanes and walking lanes is a common practice rather than a single case. The bicycle lanes in the auxiliary roads of fast roads (especially the second ring road) are more often than not occupied, so bicycle users (many are parents with children) could just ride forwards between the parking cars and the fast-running cars, without any guaranteed travelling safety.

3.2. Root of Problems

The reasons of the above problems could be summarized as the following:

The construction of green travelling system lacks legal guarantee.

In foreign countries, bus priority is often under legal protection. France issued the new Urban Traffic Law in 1982, America issued the newly revised Ground Traffic Law in 1991, and Switzerland issued the Public Transportation Law in 1995, all giving priority to the development of public transportation. However, China hasn't issued any laws and regulations on public transportation, and there is insufficient legal encouragement and support to weak travelling means such as walking and bicycling.

• The investment construction and management system of green travelling system is not consummated.

The construction of green travelling system should have a normalized and long-term institutional mechanism in a series of aspects such as planning (including organic connection with urban land utilization planning and infrastructure planning), investment arrangement, implementation plan and operation management of urban comprehensive transportation system. Currently, the situation of "each department acting on its own" still exists. Although Beijing has reached a consensus on the strategic level of giving priority to public transportation, but different departments still fail to reach consensus on the implementation of specific priority measures, and has not formed effective joint force in specific actions.

• Different aspects of green travelling system have different degrees of lags in standards

For example, public station construction standards, public lane designation standards, rail traffic station supporting transfer facility standard, walking and bicycling planning and design standards, car parking transfer system construction standards, etc. need upgrading and consummation.

• Highly intensive use of cars reflects the high dependence of users on cars, and the awareness of green travelling is weak

Effective encouragement and guidance measures need to be provided on how to actively guide citizens to consciously choose green travelling mode, reduce the over dependence on cars and advocate low-carbon living modes.

3.3. Relevant Suggestions on the Construction of Green Travelling System

· Straighten out the mechanism of green travelling system, and strengthen the general coordination

Establish a coordination team led by municipal governmental leaders and participated by relevant departments, strengthen the general coordination, set a working mechanism for planning, investment, construction and management linkage, periodically organize joint conference, study to solve key difficulties, study to formulate local regulations and relevant policies on green travelling, guarantee the priority of public transportation, and guarantee the priority of bicycle travelling and walking. Upgrade and consummate relevant planning, design and construction standards and regulations, and considerate the municipal transportation infrastructure and urban building planning and construction, so as to create good prerequisites for green travelling [3].

· Strengthen green travelling awareness, and actively advocate green travelling

Actively promote the concept of "green travelling", create good social environment, carry out in-depth and constant promotion activities themed with green travelling, give full play to the functions of enterprises, schools and communities, and encourage the active participation of civil groups and environmental protection organizations, and travelling promotion education base and volunteer teams for green travelling. Meanwhile, adopt comprehensive means such as administration, economy and technology, further guide the scientific, reasonable and civilized use of cars; advocate the use of modern technological means such as video and telephone conference and on-line office to reduce personnel flow and ease traffic pressure.

• Increase the service level of public transportation, and enhance the attraction of public transportation

Implement the priority of public station and road right, and increase the service level of ground public transportation. First, competent governmental departments formulate opinions on public station priority, implement them in the sections such as planning, investment, land acquisition and relocation, construction and operation management, and speed up the construction of public stations; second, for the non-implementation of supporting public stations in residential communities, carry out cleaning work for the public stations in existing residential communities and return the stations to public operation, and competent traffic departments participate in the completion and acceptance of newly-built residential communities; third, move the public bus parking out of the downtown, and change the bus stations in central areas into transfer centers; fourth, public security, planning and traffic departments enhance the designation of bus lanes, particularly fast bus lanes in congested sections.

Strengthen scientific application, and increase the information and intelligence level of green travelling

Study to establish long-term mechanisms for bus information construction investment, consummate bus intelligent information management systems, scientifically optimize bus networks, reasonably configure buses, optimize vehicle structures, and actively promote the construction of energy conservation and environmental

protection buses and supporting facilities; integrate taxi reservation service and intelligent dispatch systems throughout the city, and reduce the unloaded ratio of taxi; adopt encouragement measures, and extend the popularization scope of expressway Electronic Toll Collection (ETC); increase the traffic information service level and the integration with digital TV, mobile TV, 3G and other new media, and provide real-time, convenient and humane traffic information service.

4. Conclusion

Green travelling is a kind of intensive, effective and environmental travelling mode with low emission, low energy consumption and low pollution [7]. Green travelling system refers to the travelling system giving full play to the advantages of rail traffic, ground public traffic, bicycle and walking, and featuring reasonable labor division based on distance, adaptation to different groups and orderly connection. Currently, the study and practice of green transportation system in China is just at the starting stage, and calls for in-depth study and identification of green transportation system construction of international cities to reasonably promote the construction of green transportation system according to the development characteristics and stages of the city.

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