

FUTURE URBAN TRANSPORT: BICYCLE VIADUCTS

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ABSTRACT

In the wake of the continuous acceleration of urbanization in China, the problems of traffic congestion, environmental pollution and inefficient travel caused by the high-mobility travel mode have gone from bad to worse. In the past few years, under the call of energy conservation and environmental protection and green commuting vigorously advocated by Chinese government, the bike-sharing in China is enjoying wide popularity among the public. However, there are still many issues due to the lack of perfect bicycle road network. This paper describes the construction of a new transportation network by building bicycle viaducts inside the city, to divert motor vehicles from bicycles, improve bicycle speed and ensure the safety and independence of bicycle travel. At the same time, in virtue of the construction of bike viaducts, we hope to achieve the cooperation in "PPP mode" between the government and the bicycle enterprises, mutually apply and manage bicycle elevated road, and provide a low-carbon, safe and fast new way of travel.

Key words: Urban traffic, bike-sharing, bicycle viaducts, PPP mode

1. BACKGROUND

As economy of China develops rapidly and people's living standards become higher, the pace of life is accelerating and the vehicle retention is rapidly increasing. Traffic congestion in urban areas is growingly serious which has become normalized. The speed is even below 10km per hour in the center of some cities. Meanwhile, a series of environmental problems such as municipal pollution, environmental degradation, energy crisis and global warming are looming along with the consumption of fossil fuels. It is imperative to change the traditional concept of development and develop a traffic mode dominated by the low-carbon transportation.

In 2008, Beijing pioneered the first urban public bicycle system after the Olympic Games. So far, all provinces and autonomous regions in China have established government-led urban public bicycle system. However, the piles of urban public bicycle system confined to the lack of its own hardware and software and did not really let the bicycle grow in its "second spring". Until the second half of 2016, as the capital feast shifted to bike-sharing, the no-pile shared bikes represented by ofo and mobike, began to thrive all over the country.

Currently, the road design system based on motor vehicles in China has determines that

the construction of bicycle lanes cannot squeeze the original motor vehicle lanes, while widening roads is also extremely difficult and unrealistic. Former Soviet Union transport experts once have proposed the construction of bicycle viaducts in the busy traffic area of the downtown area, so that the traffic capacity could achieve the excellent effect comparable to that of the subway. With the collapse of the Soviet Union, these plans came to an end.

Considering the current boom of bike-sharing in China, bicycles are diverted from the ground to the air. The author contends that it is feasible and effective to build bicycle viaducts in large and medium-sized cities in China.

2. SCOPES AND OBJECTIVES

Based on the requirements of developing bicycle traffic and the environment of bike-sharing, this paper puts forward the construction of urban bicycle viaducts to cope with the dilemma of urban traffic jams. The objectives mainly include:

1. The necessity of developing bicycle traffic;
2. The feasibility of building bicycle viaducts;
3. Construction form and technical standards of urban bicycle viaducts.

3. THE NECESSITY OF DEVELOPING BICYCLE TRAFFIC

3.1 Worsening urban traffic congestion

According to the relevant statistics, the number of motor vehicles in China has reached 310 million by the end of 2017, of which 217 million vehicles are motorcar, and it continues to maintain rapid growth. The growth rate of vehicles far exceeds the carrying capacity of the road, and the road traffic facilities are also relatively backward, which lead to frequent traffic jams in major cities across the country. According to statistics, 90% of the cities in China with a population of over one million are approaching the maximum traffic capacity, and about 80% of the road capacity is also near the limit. In the urban areas of many metropolis in our country, the average speed of motor vehicles is only 12km/h, even with 8-10km/h in the center of the city. Urban traffic congestion has become normalized, seriously affecting people's daily life, resulting in the waste of resources and environmental pollution.

3.2 Current situation of bicycle lane

In China's urban road design specifications and urban construction, although it spares space for slow-traffic lane, however, there are few construction and policies on bicycle lanes. The slow-traffic lane is gradually occupied by the motor vehicles or expanded to the path, or diverted to parking zone under the circumstance of increasing traffic congestion and difficult parking. The riders are forced to mix with pedestrians and vehicles, resulting in a sharp drop in traffic efficiency and dramatic increase in traffic conflict. Due to the flexibility of bicycles, it often interspersed in the motor vehicle lane, greatly increasing the probability of the traffic accidents and posing a great threat to the safety of the rider. Restoring the right of way and ensuring the travel safety is the premise for the revival of bicycle traffic, which is also the critical judgment for residents to choose the traffic mode. [1] However, it is unrealistic to regain the right of bicycle lanes in a short time. Therefore, it is inevitable to develop the bicycle viaducts.

3.3 The dilemma of bike-sharing parking

With the booming development of bike-sharing in 2017, bicycle is gradually gaining its popularity in China. However, the disordered parking of bike-sharing seriously affects the appearance and order of cities and brings a heavy burden on the management. The renter can park the bike at the place closest to destination after using it, which is one of the conveniences and advantages of bike-sharing. Actually, people will park bicycles everywhere, such as the side of the road, the greenery or even on the road when they arrive at their destinations, causing chaos and destruction of the green belts. This not only interferes with traffic but also damages the appearance of the city. Even if the bikes are parked properly, after all, they are parked on the sidewalk, which poses a problem for urban management department. Although these problems did not interrupt the development of bike-sharing, parking problems remain unresolved and ubiquitous in cities. It is not feasible for bicycle enterprises to put their hope on the consciousness and cooperation of the public instead of seeking effective solutions.

4. THE FEASIBILITY OF BUILDING BICYCLE VIADUCTS

4.1 Advantages of bicycle replacing private car

In recent years, the haze has seriously affected people's normal life and health, deteriorating the air quality of large and medium-sized city in China which is directly related to the rapid increase in vehicles. The pollution caused by vehicle emissions has played a great part in the source of urban air pollution. Therefore, it is one of the inevitable choices for the development of urban transport in China to build a low-carbon transportation system characterized by low-carbon, green, environmental-friendly, high-efficiency, low-consumption and safety.[2]

In terms of energy-consumption and the emissions of Carbon dioxide, motorcar is the most energy-consuming transport mode in different transportations, reaching 2795.1 KJ per hour, while the bicycle is the least. As shown in Table 1.

Transport modes	Bicycle	Walk	Motorcar	Bus	Subway
Energy consumption [KJ · (person · km) ⁻¹]	63.84	328.86	2795.1	714	322.4
Comparison of energy consumption	1	5.2	43.8	11.2	5.05
Emission of CO ₂ [g · (person · km) ⁻¹]	0	0	133.9	19.4	4.7

According to a study of Copenhagen government, 1 km of bicycles riding can generate net social benefits of 1.22 Krone (about 1.19 Yuan), while driving will produce 0.69 Krone. The construction of 1 km bike lane will bring about the net social benefit of 423,000 Krone (about 420,000 Yuan) in 20 years. Among various social benefits brought by bicycles, it contributes significantly to public health, urban marketing and tourism, air pollution and the reduction of

greenhouse gas. For example, Copenhagen was voted one of the most tourist-attractive cities in the world by *Time* in 2010, due to their successful marketing of bicycle brand image, and has been selected one of the most livable cities in the world by *Numero* for many years. The benefits of health and emission-reduction brought by bicycles for Copenhagen can't be underestimated, not only saving nearly 3.7 billion SEK in health-care expenditure, but also reducing 90000 tons CO₂ annually in Copenhagen.

Judging from the experience of urbanization in developed countries, it is an inevitable requirement for the future development of urban transport to return from motorcar to bicycle.

4.2 The foundation of constructing urban bicycle viaducts

4.2.1 The requirement of sustainable urban development

With the increasing complexity and diversity of modern urban spatial structure and function, the traditional urban form and planning method that have grown along a two-dimensional plane has been unable to meet the needs of social development and function. Urban space is increasingly becoming a systematic and three-dimensional trend. Under the background of highly comprehensive and three-dimensional development of urban functions, the urban bicycle viaduct in the air is one kind of facilities that solves the traffic problem, enhances the accessibility of commercial areas and improves the urban traffic system.

4.2.2 The popularity of bike-sharing

JiGuang Big Data (a mobile big data service provider in China) demonstrates that the MAU (monthly active users) of ofo and mobike in December has both exceeded 20 million, the former is 26.93 million, the later is 23.782 million. As related research reports show, in the first and second quarter of 2017, the users of ofo had accumulated a total of 1791 million kilometers in 20 cities of the country, which is equivalent to 44694 circles around the earth. After bike-sharing was thrown into market, nearly 80% of urban congestion has been relieved from the same period, among them, the congestion in 15 cities dropped more than 8%. In Beijing, over 60% of the congestion around the subway stations has been relieved, and the overall congestion has fallen by 4.1% over the same time. The prevalence of bike-sharing is an opportunity for development of urban bicycle viaducts in China.

4.2.3 Government policies

On February 6, 2016, the CPC Central Committee and the State Council promulgated the "Opinions on Further Strengthening the Management of Urban Planning and Construction", which explicitly put forward the requirements of "strengthening the construction of bicycle lanes and pedestrian lanes and promoting green travel". Guidance on encouraging and standardizing the development of Internet rental bicycles was enacted in August 2017. The document stipulates the operation, management and safety of the shared bikes, and also puts forward the requirements of "improving bicycle traffic network". It points out that a reasonable slow-traffic network and parking facilities for bicycles should be rationally laid out and integrated into the urban transportation system and connected with the urban public transport planning. At the same time, we should actively promote the construction of bicycle lanes and improve the network and accessibility of the bicycle lanes. It is wise to optimize bicycle traffic organization, improve road signs, correct illegal occupation of non-motor vehicle lanes, and guarantee the condition of bicycle traffic.

5. CONSTRUCTION FORM AND TECHNICAL STANDARDS OF URBAN BICYCLE VIADUCTS

5.1 Three categories of urban bicycle viaducts

There are three modes of urban bicycle viaducts: the first type is the tourist scenic bicycle viaduct. For the tourist city with certain view and landscape needs, the bicycle viaduct can be used to connect transportation hubs and urban areas, suburban hot spots or as a connecting route between scenic spots, avoiding tourists bringing pressure to the original traffic. At the same time, bicycle viaducts can also be used as scenic roads to attract tourists. The second type can be used to connect large-scale residential areas and work-gathering areas. Traffic between large and medium-sized cities, large-scale residential areas and work-gathering areas in our country is usually the "hardest hit" area of urban traffic congestion. The construction of urban air-bicycle routes between large-scale residential areas and work-gathering areas can alleviate traffic pressure, share commuters and even shorten commuting time. The third type can be built on the main arterial roads and secondary arterial roads in the cities to share the pressure on urban roads and ease congestion.

5.2 Construction form of urban bicycle viaducts

The main part of the bridge can be used in two forms of construction, one is the use of single-column structure, which is similar to the construction of the motor vehicle viaducts. The other is attached to the motor vehicle viaducts side. As the light weight of the bicycle viaducts and small traffic flow, selecting single-column structure can reduce investment and cost savings. Besides, the form is simple and beautiful, and the construction is convenient. The material is steel, because the steel structure has the advantages of light weight, convenient and rapid construction. The steel structure will make the bridge elegant in sight, reducing the building's own visual impact on people. We can supply shared bikes and urban public bicycles in the area next to the entrance and exit of the viaduct, making it convenient for riders to use.[3] Set a certain number of rider's rest platforms, bike parking platforms and bike lifts for the convenience of cyclists.

In addition, the bicycle viaducts does not simply separate the riders from the ground, but should integrate into the existing cityscape.

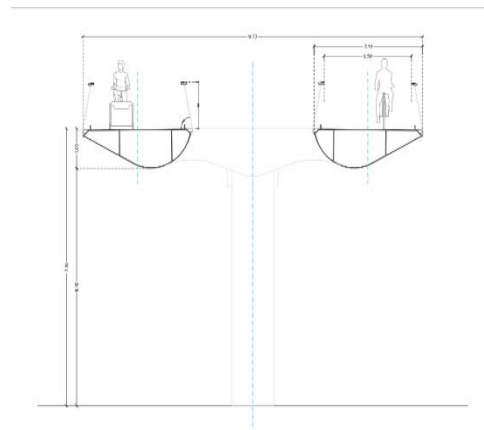


Figure.1 Rendering and cross-section[4]

6. CONCLUSION AND PERSPECTIVES

As cities continue to develop in a three-dimensional manner, the road structure system will inevitably change. The contradiction between the urgent need for low-carbon travel in recent years and the imperfection of the existing road network has also intensified. The construction of bicycle viaducts is the product of this background, which can meet people's current needs to some extent. At the same time, we should compile the special criterion, unify the standards of construction and improve the management system to cooperate with the related work.

This paper mainly discusses the bike viaducts in large and medium-sized cities of China. In addition, under the current dilemma caused by bike-sharing to urban managers and bicycle enterprises, enterprises can cooperate with government to construct and manage the bicycle viaducts with "PPP mode"(Public—Private—Partnership). The Chinese government and enterprises share their responsibilities reasonably and effectively for mutual benefits. With the constant construction and improvement of bicycle lanes, it will also be possible to build inter-city or even inter-provincial bicycle viaducts.

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