Land-based Transportation Infrastructure Connectivity under the Integration of the Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract. Transportation infrastructure connectivity is an important basic condition and driving force for the integrated development of the Guangdong-Hong Kong-Macao-Great Bay Area. The existing problems in transportation infrastructure connectivity of the Guangdong-Hong Kong-Macao Great Bay Area was pointed out. Then the impacts of transportation infrastructure connectivity on the integration of the Guangdong-Hong Kong-Macao Great Bay Area were discussed. On this basis, combined with the analysis of the characteristics of inter-city traffic demand in the Guangdong-Hong Kong-Macao Great Bay Area, the strategy for Transportation infrastructure connectivity in the Guangdong-Hong Kong-Macao Great Bay Area was proposed. This study provided a reference for the planning and construction of transportation infrastructure in the Great Bay Area.

Introduction

The Guangdong-Hong Kong-Macao Greater Bay Area is an important spatial carrier of our country for building a world-class urban agglomeration and participating in global competition. Recently, the Central Committee of the Communist Party of China, the State Council printed and issued Outline of the Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area, which proposed that the infrastructure interconnection should be accelerated and a modern comprehensive transportation system should be constructed[1]. The development of urban agglomerations can not be separated from the interconnection of regional transport infrastructure and the internal and external communication links based on transport infrastructure. The interconnection of transport infrastructure is an important basic condition and driving force for the integrated development of the Guangdong-Hong Kong-Macao Greater Bay Area, which is very important for optimizing the spatial structure and industrial layout of the urban agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area.

Domestic and Overseas Research Status

Regional integration and urban agglomeration integration in regional economic development is becoming more and more important at home and abroad, and more attention has been paid to its research (Qin Chenglin, 2017; Cheng Yuhong, 2016; Mao Yanhua, 2014, 2017)[2-5]. Studies have shown that there are many ways to promote the development of regional integration. Among them, transportation is an important way. The research by Liu Shenglong and Hu Angang (2011) shows that the improvement of transportation infrastructure has a significant positive impact on the inter-regional trade in China, and promotes the increase of inter-provincial trade[6]. The more developed the transport infrastructure, the lower the border effect. Xu Yang et al. (2013) thought that the integrated transportation system promotes the development of regional integration by enhancing regional accessibility, improving regional conditions, strengthening intra-regional exchanges and cooperation, and adjusting the proportion relations among regional industries[7]. According to Heni (2014), the transportation development makes the elements flow more
convenient in the region, the production and life boundary of the city extends along the traffic axis to reach the inter-city connection, and develops the multi-center network of urban spatial structure. Zhang Qi (2018) studied the impact of transport infrastructure on the convergence of economic growth, market integration and industrial integration in the Yangtze River Delta region. The results show that transport infrastructure can significantly promote regional market integration and the convergence of economic growth in the Yangtze River Delta. Jiang Che (2016) also studied the degree of coordination between transportation and regional economic development in Shenyang Economic Zone.

The Guangdong-Hong Kong-Macao Greater Bay Area is an urban agglomeration in the form of spatial organization, but it is not special in economic and social system with other urban agglomeration in the world. At present, the research literatures focused on the traffic of the Guangdong-Hong Kong-Macao Greater Bay Areas mainly focused on the Greater Pearl River Delta (PRD) or the Greater Pearl River Delta (PRD) urban agglomeration, which is mainly related to the integration of traffic. From the regional or urban composition, the Guangdong-Hong Kong-Macao Greater Bay Area is consistent with the Greater Pearl River Delta and the Greater Pearl River Delta urban agglomeration. Lin Geng and Xu Xueqiang (2005) pointed out that the incoordination of transportation infrastructure is one of the three problems that the development of regional integration in the Greater Pearl River Delta (PRD) is facing, and advocated that it should be based on the planning and construction of the transportation system in the Greater Pearl River Delta (PRD) to promote the development of regional integration. Mao Yanhua etc. (2014) also believed that the construction of excellent infrastructure network is an important way to enhance the international competitiveness of the Greater Pearl River Delta urban agglomeration. Qin et al. (2015) studied the impact of inter-city rail transit on the integrated development of urban agglomeration in the Pearl River Delta. It is pointed out that speeding up the construction of inter-city rail transit is an important way to promote the integrated development of urban agglomeration in the Pearl River Delta, and it is also necessary to optimize inter-city rail transit network. Chen Bin (2017) used enterprise data and cell phone signaling data to reveal the inter-city connection intensity, pointed out the problems existing in the track construction of the Pearl River Delta urban agglomeration, and put forward the structure model of the inter-city expressway and the dual metropolitan area of the Pearl River Delta.

There are also some scholars who studied transport infrastructure construction and the Guangdong-Hong Kong-Macao Greater Bay Area integration, which mainly focused on issues and policy research. Kong Weihong (2018) mainly studied the problems and countermeasures of the integration of land and road traffic in the Guangdong-Hong Kong-Macao Greater Bay Area's urban agglomeration, pointed out that the Guangdong-Hong Kong-Macao Greater Bay Area lacks the mechanism of co-construction and sharing of traffic. Traffic integration is an important guarantee for the Guangdong-Hong Kong-Macao Greater Bay Area to accelerate integration. He Liwu (2018) combed the causes and consequences of the lack of coordination of transportation projects in the Greater Bay area, and put forward forward suggestions according to the progressive logic of "Organization-Power-system-Project". Li Jun (2018), taking Zhuhai and Zhongshan as an example for traffic interworking of the Guangdong-Hong Kong-Macao Greater Bay Area, proposed traffic interconnection that two cities break the boundaries of administrative divisions, to make full use of each other's geographical advantages, gain from each other, strengthen connection and match between traffic planning and traffic facilities. Qin Chenglin (2018) selected the average path length, network density and other indicators to analyze the impact of traffic network construction on the Guangdong-Hong Kong-Macao Greater Bay Area integration, put forward the need to actively implement long-term traffic construction planning, and at the same time to innovate relevant supporting systems and so on, to vigorously promote the integrated development of the Guangdong-Hong Kong-Macao Greater Bay Area. Pang Biao(2017),Deng Huanbin (2017) and Zhao Hui (2018) put forward the existing problem and countermeasures about building an integrated traffic system for the Guangdong-Hong Kong-Macao Greater Bay Area and promoting the integration of the Guangdong-Hong Kong-Macao Greater Bay Area’s traffic logistics from...
hardware facilities, Software (institutional mechanism) and other aspects\textsuperscript{[18-20]}. Loo B P Y, Wang B. (2018) put forward the theoretical framework and field observation index of high railway stations and urban public traffic connection combined traffic theory and passenger transfer experience \textsuperscript{[21-22]}. 

At present, the Guangdong-Hong Kong-Macau Greater Bay Area's comprehensive transport infrastructure network looks at the internal traffic links, air transport is mainly responsible for outside area transport, while waterway transport is unable to adjust its routes because of the influence of natural rivers or coasts of the Pearl River. The waterway traffic, aviation and so on in the Bay area are relatively independent, and their inter-relatedness is slightly weaker. Therefore, this study does not investigate the impact of aviation and waterway transportation on the Guangdong-Hong Kong-Macao Greater Bay Area's integrated development. At the same time, due to the increasing sensitivity of trans-regional transportation to transport time, therefore the influence of rail transit (including high-speed rail and inter-city light rail) and expressway on the Guangdong-Hong Kong-Macao Greater Bay Area's integrated development was investigated. This paper points out the problems existing in the Guangdong-Hong Kong-Macao Greater Bay Area's traffic infrastructure interconnection, discusses the impact of traffic infrastructure interconnection on the Guangdong-Hong Kong-Macao Greater Bay Area's integration, and analyzes the characteristics of the Guangdong-Hong Kong-Macao Greater Bay Area's inter-city traffic travel demand. On this basis, put forward the strategy of the Guangdong-Hong Kong-Macao Greater Bay Area's urban agglomeration transportation infrastructure connectivity.

Analysis of the Demand Characteristics for Inter-city Traffic Traveling

People's socioeconomic activities are the origin of traffic, and inter-city travel has increasingly become one of the key factors that affecting the inner space and structure of the urban agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area. With the development of the Guangdong-Hong Kong-Macao Greater Bay Area's national strategy, grasping the demand characteristics of inter-city transportation in the Guangdong-Hong Kong-Macao Greater Bay Area is the basis of carrying out a new round of planning and construction of transportation infrastructure in the Guangdong-Hong Kong-Macao Greater Bay Area.

The Resident Population Distribution in the Guangdong-Hong Kong-Macao Greater Bay Area

The resident population distribution in the Guangdong-Hong Kong-Macao Greater Bay Area is mainly concentrated in the coastal areas of the harbour, taking Hong Kong, Shenzhen, Dongguan, Guangzhou, Foshan, Zhongshan, Zhuhai and Macao as the inner circle, Huizhou, Zhaoqing and Jiangmen as the outer circle of "double circle" structure. In 2017, the resident population of the Guangdong-Hong Kong-Macao Greater Bay Area was about 69.6 millions, of which the population in the inner circle was four times larger than that of the outer circle, with an average density of about 1200 people per square kilometer.

Daytime Population Distribution in the Guangdong-Hong Kong-Macao Greater Bay Area

The concentration of daytime population distribution in the Guangdong-Hong Kong-Macao Greater Bay Area is significantly higher than that in the nighttime area. During the day, the cities in the Greater Bay area are closely connected, and the two core cities, Shenzhen and Guangzhou, have super-strong radiation effects. At 10:00 a.m., the population of the Guangdong-Hong Kong-Macao Greater Bay Area is highly concentrated in the central urban areas of Shenzhen, Guangzhou and other neighboring cities such as Foshan and Dongguan. The total area of the agglomeration area is about 2900 square kilometers, accounting for 5% of the total area of the Guangdong-Hong Kong-Macao Greater Bay Area. With a population of 31 millions, about 46 percent of the total population of the Guangdong-Hong Kong-Macao Greater Bay Area, the population density is 1.5 times higher than at night.
Employment Distribution in the Guangdong-Hong Kong-Macao Greater Bay Area

The number of jobs in the Greater Bay area is about 43.9 millions in 2017, with the occupation-to-residence ratio of the permanent population is 0.63. The distribution of posts in the Guangdong-Hong Kong-Macao Greater Bay Area takes Shenzhen and Dongguan as the first level, Zhuhai, Zhongshan, Guangzhou, Foshan, Huizhou, Macao as the second level, Hong Kong, Jiangmen and Zhaoqing as the third level. The ratio of occupation to residence in the first level was more than 0.7, which indicated that the age structure of the population was relatively light, the proportion of young and adult population from external was relatively high, and the working population of the appropriate age was larger. The second-level occupation-residence ratio is between 0.6 and 0.7, indicating that the age structure of the population in these cities is moderate and the proportion of the population in all ages is more reasonable. The employment-residence ratio of the third level is between 0.5 and 0.6, indicating that the age structure of the population in these cities is relatively large and there is an aging trend.

The Distribution of Inter-city Traffic in the Guangdong-Hong Kong-Macao Greater Bay Area

The demand for inter-city traffic in the Guangdong-Hong Kong-Macao Greater Bay Area continues to grow. At present, the rate of inter-city traffic of the resident population in the Guangdong-Hong Kong-Macao Greater Bay Area is 0.14 person per day. The inter-city traffic between 11 cities has an average daily travel volume of about 9.8 millions people. The traffic links between Guangzhou and Foshan, Shenzhen and Dongguan are the most close, and the traffic volume between cities accounts for about 1/3 of the total inter-city traffic volume in the Guangdong-Hong Kong-Macao Greater Bay Area. In addition, Guangzhou and Dongguan, Shenzhen and Hong Kong, Shenzhen and Huizhou and other cities also have close traffic links.

The Inter-city Traffic Passageway in the Guangdong-Hong Kong-Macao Greater Bay Area

The inter-city traffic passageway in the Guangdong-Hong Kong-Macao Greater Bay Area can be divided into three levels according to the traffic volume. The first grade is the Shenzhen-Dongguan-Guangzhou-Foshan corridor, and the channel direction is L-shaped. Its transportation facilities are most developed, including a number of highways and Guangzhou-Shenzhen Intercity Railway, Guang-Foo Line, etc., with daily passenger volume of 1.5-2 million person on the cross-section of the passageway. It shows that the socioeconomic exchanges among the four cities are the closest. The second grade includes Hong Kong-Shenzhen, Shenzhen-Huizhou, Zhuhai-Zhongshan these three passageways, with daily passenger volume between 0.6 million and 1 million. Other channels for the third grade, channel cross-section daily passenger volume is relatively small.

The Problems Existing in the Transport Infrastructure Connectivity of the Guangdong-Hong Kong-Macao Greater Bay Area

The Lack of a Higher-level Coordination Mechanism in Transport Planning

Currently Hong Kong and Macao do not have access to the Guangdong Pearl River Delta rail transit network, for there is no direct highway connection between Hong Kong and the west coast of the Pearl River. The Guangdong-Hong Kong-Macao Greater Bay Area is involved in two special administrative regions and a large economic province. There are great differences in the mode of construction and supervision of transport infrastructure, and the Guangdong-Hong Kong-Macao Greater Bay Area's traffic planning lacks a higher-level coordination mechanism. Traffic planning is highly complex. The traffic planning between Guangdong, Hong Kong and Macao is rather fragmented, and it is not connected with the urban master plan, land use master plan and other special plans, which leads to the imperfect layout of transportation infrastructure and unreasonable structure.
Traffic Links Between the East-west Side of the Pearl River Estuary in the Guangdong-Hong Kong-Macao Greater Bay Area Are Not Smooth

The links between the Eastern coast of the Guangdong-Hong Kong-Macao Greater Bay Area (Hong Kong, Shenzhen, Dongguan) and the West Bank region (Macao, Zhuhai, Zhongshan) are currently blocked directly by the Pearl River Estuary. At present, it is necessary to connect rail transit and expressway through Guangzhou. The daily traffic volume in the East and West Bank is about 130000 person, accounting for only about 2% of the total inter-city traffic volume in the Guangdong-Hong Kong-Macao Greater Bay Area. The traffic links will not lead to effective complement between the development conditions and advantages between the East and the West. In particular, the momentum of innovation on the eastern coast of Shenzhen cannot effectively radiate to the West Bank and the financial services of Hong Kong. International trade services also do not effectively radiate cities in the West Bank.

The Gap in the Level of Traffic and Transport Management is Large

The Guangdong-Hong Kong-Macao Greater Bay Area’s transportation facilities are becoming more and more modern, but for the management methods and technical means of the relevant transport departments and units, the quality and ability of traffic management and practitioners, there is still a large gap between requirement of traffic modernization development, which may be a factor affecting the traffic development of the Guangdong-Hong Kong-Macao Greater Bay Area.

The Multi-modal Transport Integrated Hub is Less

It’s not closely connected and smooth enough among the various transportation modes, and the multi-modal transport integrated hub is less, transfer efficiency is not high and it has not reached the level of the modern transportation integrated hub. There is bad competition among different modes of transportation, so the comparative advantage of different modes of transportation can not be brought into play. For example, long-distance bulk rail, water transport is more appropriate, but because of the railway and waterway turnover links, long cycle, slow speed, people often choose to take the road, overloaded seriously, resulting in road overloading.

The Impact of Transport Infrastructure Connectivity on the Guangdong-Hong Kong-Macao Greater Bay Area’s Integration

The interconnection of transport infrastructure with expressway network and rail transit network as the main body will promote the integration of Hong Kong and Macao into the overall situation of the Guangdong-Hong Kong-Macao Greater Bay Area development and promote more effective interaction among urban agglomerations in Hong Kong, Macau and Pearl River Delta.

The Construction of Road Traffic Infrastructure Connectivity Will Significantly Enhance the Links Between the East and West Sides of the Pearl River Estuary of the Guangdong-Hong Kong-Macao Greater Bay Area.

Projects such as the Hong Kong-Zhuhai-Macao Bridge, the Deep-to-Middle Corridor and the Lingdingyang Highway Bridge will add important road access to the East and West sides of the Pearl River Estuary. The traffic vehicles of Deep-to-Middle Corridor and Lingdingyang Highway Bridge do not need to go through the border inspection formalities like the Hong Kong-Zhuhai-Macao Bridge. Therefore, after the opening of this project, the highway traffic between the East and West sides of the Pearl River in Guangdong Pearl River Delta region will be more convenient. Generally speaking, after the completion and operation of the Hong Kong-Zhuhai-Macao Bridge, the Shenzhen-Central Corridor and the Lingdingyang Highway Bridge, the highway links between the East and West sides of the Pearl River in the Guangdong-Hong Kong-Macao Greater Bay Area will be basically satisfied, and the highway network in the Greater Bay area will be more perfect.
The Construction of Rail Transit Infrastructure Connectivity Will Promote the Guangdong-Hong Kong-Macao Greater Bay Area's Internal Connection and Networking

Through Shenzhen-Hong Kong high-speed railway, Guangzhou-Pearl City Rail extension Line and other projects, Hong Kong and Macao will be connected to the rail transit network in the Pearl River Delta region of Guangdong Province, and the Guangdong-Hong Kong-Macao Greater Bay Area urban rail transit network will therefore cover all the cities in the region. This solves the problem that Hong Kong, Macao and Guangdong Pearl River Delta's rail transit network is not connected. In addition, the Lingdingyang Highway Railway Bridge project has also added a new rail transit channel, which makes up for the deficiency of the Hong Kong-Zhuhai-Macao Bridge and the deep-to-middle channel, thus making the Guangdong-Hong Kong-Macao Greater Bay Area's rail transit network form an important loop in the Pearl River Estuary.

Therefore, as far as the Guangdong-Hong Kong-Macao Greater Bay Area is concerned, it is impossible to eliminate the differences of economic and social systems in the short term, and under the circumstances where administrative divisions and inequalities are difficult to reconcile, it is an effective choice to promote their integrated development by realizing transport infrastructure connectivity and promoting the free flow of population and elements, and then to create a powerful endogenous motive force to remove the obstacles of system and administration.

The Strategies for the Traffic Infrastructure Connectivity in the Guangdong-Hong Kong-Macao Greater Bay Area's Urban Agglomeration

Making the Plan of Comprehensive Traffic for the Guangdong-Hong Kong-Macao Greater Bay Area Coordinated

The Guangdong-Hong Kong-Macao Greater Bay Area has become a national strategy and set up a coordination group for arranging the integrated traffic planning within the Guangdong-Hong Kong-Macao Greater Bay Area’s spatial scope, making use of big data's auxiliary traffic planning, under the forecast of the traffic demand of the regional integration, focusing on the connection of the main traffic lines in the region and the division and cooperation of the main traffic hubs. In the light of the actual development of traffic in the Guangdong-Hong Kong-Macao Greater Bay Area, they will re-examine the various types of traffic planning in the past, optimize and upgrade it, and draw up a new round of integrated transport system planning for the whole region. As a blueprint for coordinating and directing the Guangdong-Hong Kong-Macao Greater Bay Area's traffic construction and operation, the whole Greater Bay area is melted into an organic whole through the traffic artery, giving full play to the advantages of the Hong Kong and Macao regions and the Guangdong Free Trade area, and promoting the coordinated development of the whole Guangdong-Hong Kong-Macao Greater Bay Area.

Perfecting the Traffic Structure and Promoting the Linkage between the East and the West Coast

Perfecting the main network of highway and railway channels among the cities in the Guangdong-Hong Kong-Macao Greater Bay Area, speeding up the construction of the inter-city rail network in the Guangdong-Hong Kong-Macao Greater Bay Area, and strengthening the common highway docking among the cities. We will focus on strengthening the construction of transportation channels in the West Bank, deepen research on the Shenzhen-Hong Kong fast track in the western part through the construction of infrastructure such as inter-city railway and cross-river corridor, and do a good job in connecting the mainland and Hong Kong sections of the Guangzhou-Shenzhen-Hong Kong passenger dedicated line, the intercity railway of the Pearl River Delta and the light rail of Macao. So as to strengthen social, economic and cultural exchanges between the East and West banks, and promote further improvement of the spatial structure of the core regions of the Guangdong-Hong Kong-Macao Greater Bay Area from L-layout (Hong Kong-Shenzhen-Dongguan-Guangzhou-Foshan) to rectangular layout (Hong Kong-Shenzhen-Dongguan-Guangzhou-Foshan-Zhongshan-Zhuhai-Macau-Hong Kong).
Breaking the Industry Citadel of Different Transportation’s Way and Developing Multimodal Transport.

We will further speed up the construction of a comprehensive international transportation hub between Guangzhou and Shenzhen. According to the zero-distance transfer, seamless connection goal, improve the layout of major transport facilities, actively promote the introduction of trunk railway, inter-city railway, urban (suburban) railway, etc. to enhance airport gathering and distribution capacity. We will focus on developing river-sea transport, sea-rail transport, sea-to-public transport, public-rail transport, air-to-public transport and "one-unit" transport services, improve the conversion links of different modes of transport, improve the infrastructure and special equipment for multimodal transport, and strengthen technical standards. Information resources, service standards and other aspects of docking, give full play to the comparative advantages of different modes of transport, reduce transport costs, improve transport efficiency.

Promoting the Facilitation of International Customs Clearance

Relying on the platform of Guangdong e-port, promoting the construction of "single window" platform of the Guangdong-Hong Kong-Macao Greater Bay Area, and jointly improving the customs clearance environment of Guangdong port; We will speed up the implementation of the Guangdong-Hong Kong-Macao Greater Bay Area's Joint Inspection Unit to achieve "three mutual"-mutual assistance in law enforcement, mutual recognition of the results and mutual sharing of information; innovate the mode of customs clearance and inspection, so as to better play the role of the Guangzhou-Shenzhen-Hong Kong High-speed Railway and the Hong Kong-Zhuhai-Macao Bridge; We will promote the effective docking of urban rail transit and other transport modes, build a safe and convenient transfer and transfer system, and improve the customs clearance capacity and customs clearance facilitation level of Guangdong, Hong Kong and Macao ports. We will establish a joint mechanism for the facilitation of customs clearance at border crossings, improve the conditions of customs clearance facilities at border crossings, and actively promote the facilitation of multi-bilateral international customs clearance.

Realizing Seamless Connection between High-speed Railway Station and Urban Public Transport

The design of high-speed railway station and the services of software focus on the needs of ticket purchasing, transfer for vulnerable groups (people with disabilities, etc.) which highlight the humanistic care. The high-speed railway station and its public transport transfer service system should also enrich the language system and match the positioning of international first-class Bay area and world-class urban agglomeration. Using the abundant land reserve of the high-speed railway station, a shopping mall complex combining with public transport transfer service can be developed near the square of the high-speed railway station, which will optimize the transfer environment. In the design of ticket system, we should promote "The Greater Bay Area Bus Card" to reduce the transit transfer procedures of currency exchange and ticket purchasing, so as to better serve the more frequent cross-city trips within the "one-hour life circle".

Summary

The existing problems in transportation infrastructure connectivity of the Guangdong-Hong Kong-Macao Great Bay Area was pointed out. Then the impacts of transportation infrastructure connectivity on the integration of the Guangdong-Hong Kong-Macao Great Bay Area were discussed. On this basis, combined with the analysis of the characteristics of inter-city traffic demand in the Guangdong-Hong Kong-Macao Great Bay Area, the strategy for Transportation infrastructure connectivity in the Guangdong-Hong Kong-Macao Great Bay Area was proposed. This study provided a reference for the planning and construction of transportation infrastructure in the Great Bay Area to gain valuable policy enlightenment and further promote more effective interaction among urban agglomerations in Hong Kong, Macao and the Pearl River Delta.
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Reference


