The Present Situation and Design Implications of Traffic Connection in Beijing Railway Transportation Hub Station

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Abstract. Through the multi-period, multi-objective and multi-level investigation and analysis of the existing national railway hubs in Beijing, the main problems in the current operation is that the urban space connection and various types of traffic connections. The reason is that the railway hub transportation station should focus on development positioning, site selection layout, traffic matching and predictive design in the planning and site selection design process. The key points can be used as a useful reference in the design of the similar ones.

1. Overview
The railway hub station is a comprehensive transportation building that organizes various modes of transportation such as national railways, subways, conventional ground transportation, taxis, and social vehicles. It is important in terms of functions, functions and impacts on the city. Beijing South Railway Station, Beijing West Railway Station and Beijing Railway Station are the national railway hubs in Beijing. Through multi-period, multi-objective and multi-level research and analysis, it is found that during the operation of the existing railway hubs there are many impacts on the city such as urban space, and the smooth connection of various types of traffic. The research on the reasons for the formation of the alignment and the solution to the solution will provide clear focus for its better operation and transformation proposals, and also provide an important reference for the construction of similar types of railway hub transportations in the future.

2. Current situation of existing railway hub transportations

2.1. Beijing South Railway Station

2.1.1. Basic information. Beijing South Railway Station is located in Fengtai District, Beijing, China. It is the third largest railway station in Beijing and the largest railway station in Beijing with the largest number of trains. The building covers an area of 320,000 square meters, with 24 stock roads and 13 platform platforms. From north to south, there are 5 speed stations and 3 station platforms, 12 lines and 6 platforms in high speed field, and; 7 lines and 4 platforms in the intercity site.

2.1.2. Traffic Connection. There are three peak hours in the station every day: from 8:30 to 11:30 in the morning, from 12:00 to 17:00 in the afternoon, and after 23:00, for the night rush hour due to the
stop of the subway lines. For the bottlenecks in the process of path travel, the limitation of the number of road traffic connection nodes in the surrounding area, of the elevated platform used for social vehicles to send passengers, and of the number of roads, results in normal road congestion around the Station. Especially in the routine use, some of the vehicles who should leave as soon as dropping of the passengers immediately failed to operate according to the regulations. On the one hand, the management department based in the region lacks the power of law enforcement and cannot take punitive measures for these staying vehicles. On the other hand, the relevant supporting management measures have not been fully established.

The taxis currently serving the Station are all directed to the parking lot on the basement level of the South Station. However, during the path to the issuance, there are practical problems such as mixed with social vehicles and bottlenecks in the entrance, resulting in a large number of taxi drivers who are reluctant to travel to the South Station to pick up and drop off passengers. Consequently, a large accumulation of passengers in the Station are hard to take a taxi for a long time. The situation has been greatly improved through the joint efforts of various management measures and dredging measures of the station operators. However, the layout of the basement directly below the station building will inevitably interfere with passenger travel due to the mixed functions and unclear streamlines between the taxi and the social vehicles. The location of the Station, in the center of the city, results in the lack of sufficient future expansion space, is the most important reason for the inability to arrange the orderly layout of multi-functional vehicles.

2.2. Beijing West Railway Station

2.2.1. Basic information. Beijing West Railway Station is located in Fengtai District, Beijing, China, covering an area of 510,000 square meters, with a total construction area of about 700,000 square meters, of which station houses account for about 500,000 square meters, and the scale of the yard is 10 stations and 20 lines (excluding the main line), and the effective length is 650~880m.

2.2.2. Traffic connection. The Beijing West Railway Station is on the west of the West Third Ring Road, on the north of Lianhuachi Middle Road, on the south of the Guang'an Road, on the west of Fengw road, and adjacent to and the northwest side of Lotus Pond. The location of the site increased the traffic pressure of the surrounding area directly. The daily impact of the North Square congestion of the Station is very wide and quite frequently, covering the area from the west to the Jinjiacun Bridge, the south to the Lize Bridge, the north to the Hangtian bridge, and the east to the Baiyun Bridge. Sometimes could even affect the traffic in the Qianmen and Tiananmen areas.

The daily train design capacity is 60-70 pairs, and the average daily passenger flow is about 200,000 person-times. However, the actual train delivery volume during the peak season is as high as 90-100 pairs, and the maximum daily passenger flow is as high as 600,000. The contradiction between unlimited growth of passenger flow and limited space is increasing. Since the completion of the Station, the increase in the volume of the surrounding public transport has not been as fast as the increase in the volume of railway traffic, which has caused long-term traffic conditions in the vicinity. With the traffic volume increasing, the capacity of the ring-shaped elevated turntable is insufficient.

2.2.3. Base impact. In the expansibility and opening of Beijing West Railway Station, the south side is the No. 9 line to the west near the Lianhua Lake Lotus Pond Wetland. Due to the loose soil surface of the wetland, the base nonuniform settlement, including the main body of the Station and the construction of the rail transit line. Among them, the Beijing Metro Line 9, from the Military Museum Station in the north, to the Liuliqiao Station in the south, has reduced the running speed due to the problem, affecting the quality and experience of travel significantly.
2.3. Beijing Railway Station

2.3.1. Basic information. Beijing Railway Station located at No. 13 Jiawan Hutong, Dongcheng District, Beijing, China, covers an area of 250,000 square meters, with a total construction area of 80,000 square meters. The layout of the station is a tandem type, which is divided into the dispatching field, the handover site, and the shunting yard. There are 16 railway tracks and 8 platforms in the Station.

2.3.2. Overall layout. Beijing Railway Station is one of the top ten buildings in Beijing on the 10th anniversary of the founding of China. It is one of the links between the city's external transportation and public transportation within the city and other various modes of passenger transportation. In the context of the coordinated development of Beijing-Tianjin-Hebei, the functional positioning of the Station is mainly from high-speed and international passenger stations, or will be transformed to intercity and suburban areas (Beijing-Tangshan intercity railway). However, with the increasing number of the passengers, the functions of the transportation hub fail to meet the needs. The short comes of the station could be summarized as the lack of capacity for transportation and access facilities, the mismatch of rational layout and various communication methods, and the ineffectively utilization of the underground directly.

2.3.3. Urban space. The urban expressway around the Station has a hindrance to the traffic. The access roads around the site are not highly accessible and the traffic supply capacity is limited. At the same time, for the Mingcheng Site Park is a cultural relic protection area, the surrounding road network lacks room for further expansion. Therefore, the entrance and exit of the ground parking lot around the railway station is restricted by the surrounding roads and land use, and the access is inconvenient, resulting in strong dependence and interference to the external road network, reflecting the location restrictions of the project.

2.3.4. Traffic connection. The traffic conditions around the Station are limited. The bus stop signs are relatively scattered and far away from each other. According to the connection concept of railway hub transportsations, the order of connection between various types of traffic and railway hubs should be rail transit > bus > taxi > social vehicle. However, the current setting of Beijing Railway Station has not been rationally sorted. The transit connection out of the Station takes the off-station mode, being greatly affected by the passenger crossing point. For the complicated distribution of urban roads around the Station, the private car parking lots are mixed, and the fixed parking space for taxis is seldom, which greatly affects the passenger experience.

3. Inspiration from the design of existing railway hub transportations

By analyzing the problems of urban space connection and internal and external transportation connection in the operation process of Beijing's major railway hub transportsations, several key points should be paid attention to during the site selection and design of railway hubs, which are mainly reflected in development positioning, location layout, traffic matching and predictive design.

3.1. Development orientation

The railway hubs, especially large and extra-large railway ones, have important significance, status and role in urban space. The relationship of the railway hub to urban space is determined not only by its geographical location relation, but also by the inherent attributes of that in the overall operational service process. Therefore, whether the “city center” or the “city portal”, the railway hub should be well considered so as to help the growth and development in the subsequent construction and development process.

From the urban and rural planning theory, railway hubs can be placed in the middle of urban areas in small and medium-sized cities, while large cities can be set up in multiple cities, and should be
placed deeper into the urban center. This means that the railway hubs in large cities are generally located in relatively central locations. The “city center” function of the railway hub station should be reflected in its multi-functional composite property that integrates functions including politics, economy, commerce, entertainment, office and residence. Therefore, a clear development orientation and planning in the initial stage of the hub construction is of great importance. The realization of the composite function needs to coordinate the consideration of the location attribute, the characteristics of the surrounding urban space, the existing business functions of the surrounding, and the actual needs of the area, so as to achieve accurate positioning and reasonable integrated development, as while as fully realizing its "City Center" feature.

For the definition of the “city portal” of the hub, the function is more singular from the perspective of implementation, reflecting urban culture, economy and industry, which is the carrier that reflects a city's characteristics, individuality and connotation. Passengers arriving can recognize the city at a glance through the hub building in a short period, forming a completed “city impression”, understanding the difference between the city and other ones. Therefore, the building should be the city's business card and microcosm, a landmark building in the city. On the other hand, the “gateway”, as its name suggests, requires a smooth and convenient connection between the railway hub building and the entire urban space, helping the passengers to switch between the hub and the urban space through various modes of transportation quickly. Whether “city center” or “city portal” should be finalized based on the full and complete investigation, research and comprehensive considerations in the early stage of the hub planning.

3.2. Location layout
The railway hub transportation is an important transportation building. Especially the large-scale and extra-large ones carry hundreds of thousands of traffic per day. The construction of the hub has a huge impact on the surrounding urban, including space texture, environment, functional attributes and other aspects. During site selection, firstly, it is necessary to clearly assess the basic attributes of the area, including the surrounding historical and cultural resources, as well as the geological, hydrological, hydrogeological and other natural environmental conditions. The large-scale hubs are huge in volume, which reduced the surrounding areas connection convenience, resulting in the separation of the urban space texture. Therefore, it is necessary to consider how to minimize this impact in the planning and design process.

Meanwhile, the construction of the railway hub will inevitably lead to a surge in traffic, which will increase the use pressure and various needs for the local space, and will also bring new development to the built area. It can be seen that, various factors are fully evaluated to determine the significance of the scientific and rationality of project site selection. The impact of the railway hub on the urban traffic environment is reflected in the impact of various types of traffic. After the hub is completed and put into use, a large number of various road traffic flows pose great challenges to the traffic capacity of the surroundings. The quantity, grade, and parking space of the surrounding city roads are the most basic guarantees for ensuring the smooth operation of the railway hub and the undisturbed impact of urban traffic. During site selection, it is necessary to pay attention to the existing urban infrastructure conditions; on the other hand, it is necessary to consider the adjustment of the existing road functions for the hub construction and the actual matching of the newly planned roads.

3.3. Traffic matching

3.3.1. Road system. Various efforts should be made to solve the increasing pressure of space traffic surrounding cities, resulted by the construction of the hub. The road system around the site involves both inside and outside part. The external road system of the base needs to be built, expanded, or reconfigured for the use of existing functions. The internal roads need to be adjusted through orderly organization of passenger flow channels and different types of passages.
A large number of railway hubs in China are designed to connect the urban and the building, usually forming a multi-level multi-port connection, and setting up a special ramp for the railway hub station directly from the city. The ramp is only used by the railway hub station to send and receive passenger motor vehicles. Due to the exclusive nature of the ramp, the traffic flow changes dynamically with the arrival and departure of the station. The role of the dedicated ramp is mainly reflected in the traffic function that can realize the direct connection between different elevations and the railway hub station, as well as the momentum of the appearance through the additional ramp, highlighting the characteristics. However, it is rare to set up special ramps outside the hub station abroad, for the vertical transportation mode that can realize the connection has many different ways, including multiple levels such as underground space. In many foreign projects, the underground space mode is realized, which can also well meet the needs. However, the setting of the ramp is subject to economic factors and excessive caution, etc., when setting the redundant load capacity and reserved development margin is likely to cause a slight change in traffic flow to affect the normal use of the ramp. It can be seen that the design of dedicated ramp needs to be combined with the actual situation, and fully consider the factors such as passenger flow throughput, service nature, development positioning and other factors in the future long-term using period.

3.3.2. Transportation mode. Among different kinds of traffic mode, public transportation is the most reasonable and effective way in big cities. In addition, ground conventional traffic and rail transit play different roles in the passenger evacuation. The reasonable matching has become a key link to efficiently resolve railway-related passenger flows. The road network layout, line type selection and site positioning flexibility of the road bus are stronger, while the configuration of the rail transit needs to pass the in-depth investigation in the early stage, the reasonable selection of the site location, and the orderly connection design. Design and configuration based on factors such as passenger flow characteristics and demand, transfer convenience, etc., to ensure that the railway-related passenger flow can be in an orderly connection with the urban. Rail transit is the best form of urban traffic. Throughout the basic conditions for the construction of major railway hubs abroad, at least four rail transit routes are routed or adjacent to the vicinity of the railway hub to ensure that the huge passenger flow can be effectively resolved in a short period. This requires that in the site selection of the railway hub, it is necessary to comprehensively consider the planning and design of the urban rail transit network in the overall urban planning, and comprehensive adjustment design to ensure that there is sufficient rail transit capacity to match and avoid passenger accumulation in operation.

3.4. Predictive design
According to research statistics, the number of passengers on the largest daily passengers in Beijing South Railway Station, in the past three years, the maximum number of passengers sent has nearly doubled, the same condition happened in all the hubs being researched. This fully reflects the necessity of the building design for future use, renovation and expansion, with the characteristics of large volume, large investment, and long-term usage. Therefore, fully consider the development needs, predictive design, reserve space for expansion, etc., and reserve the possibility of building development and adjustment as much as possible within the foreseeable scope, are of great importance. Predictive design involves a wide range of aspects, including building site selection, land use planning, architectural function layout, space design, and form design, etc., and needs to be expanded to understand and forecast various development prospects in transportation related fields, to ensure that the new and more efficient large-capacity traffic mode could be realized when the conditions are met.

4. Conclusion
Through the investigation, the analysis, research and summary of the main problems and causes in the current operation, it is concluded that the railway hubs should be planned and designed from various aspects. The thinking and discussion carried out in the future can be used as a useful reference in the
construction and transformation of similar scale and grade railway hub transportations, so as to realize the planning from site selection to design and construction, and to fight for multi-network integration as a solid foundation.

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