

Research on Design and Construction Integration of Chongqing Rail Transit Line 9

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Abstract. The first phase of Chongqing Rail Transit Line 9 is the first urban rail transit PPP project in China. The General Contracting Headquarters conducts integrated design and construction research at Baoshenghu station on the 9th line. On the basis of the preliminary design documents, the deep drawing design of the super-large section underground excavation subway station was carried out and the application was supervised on the site, and good benefits were obtained in construction safety, quality and progress. The integration of design and construction of the subway station with large section of the No. 9 line was first implemented in the rail transit industry, laying the foundation for the further promotion and application of the design and construction integration under the PPP mode.

1. Introduction

On July 4, 2018, the General Office of the Ministry of Housing and Urban-Rural Development of the People's Republic of China, "Respond to the Approval of the Pilot Project for the Construction of Construction Drawing Design Documents by Shanghai and Shenzhen City, and agreed to carry out general contracting enterprises in Shanghai and Shenzhen." The pilot project of construction drawing design documents is compiled, which indicates that China's construction industry is developing towards the integration of design and construction.

At present, in the academic world, scholars have carried out a large number of integrated design and construction techniques for the construction and geotechnical engineering industry. For example, Lai Shouhong [1] studied the design and construction integration model and its working procedures. Li Dequan and Zheng Xiang [2] carried out research on the status quo of the integration of design and construction of China's construction industry, and analyzed the constraints of the slow integration of design and construction in China's construction industry. Duan Kaiyuan [3] conducted research on the integration of design and construction of prefabricated concrete houses. Wang Yu and Liu Chengjun [4-5] studied the management mode of rail transit construction under BT mode.

Scholars in the construction industry have conducted extensive research on the integration of design and construction, and there is little research on the integration of design and construction in the rail transit industry. This paper explores the integration of design and construction of the rail transit industry with the Baoshenghu station of the first phase of Chongqing Rail Transit Line 9.

The construction period of the first phase of Chongqing Rail Transit Line 9 is short. During the implementation of the project, the geological and environmental conditions around the line are

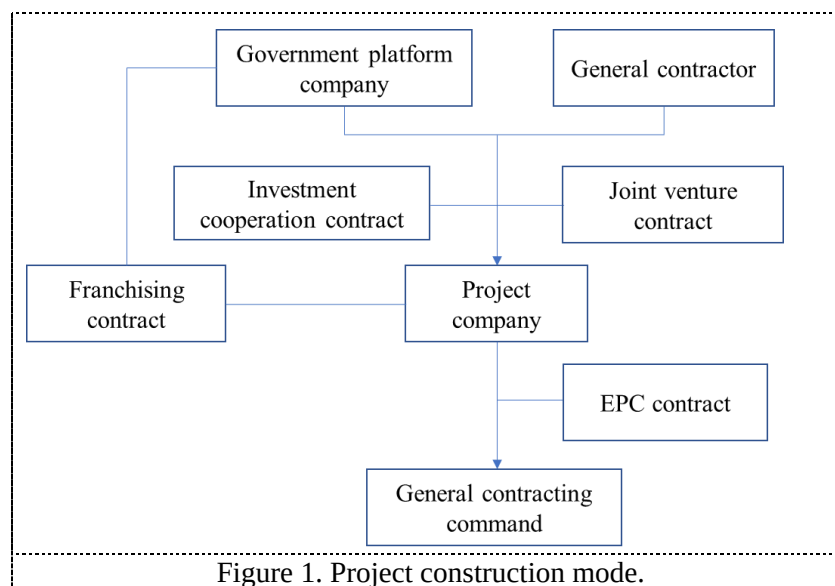


extremely complicated. The land acquisition and demolition of houses and buildings is difficult, and the transportation, such as power, gas, communication and drainage, is complicated. The task of guiding reform and traffic dissolving is arduous, the construction organization is difficult, and the safety, quality, progress, and output value tasks are difficult. In order to effectively solve these problems, Chongqing Investment and China Construction Co., Ltd. actively explored a new construction model and adopted the PPP operation mode of “investment and financing + design and construction general contracting + operation”. The General Contracting Headquarters of China State Construction Engineering Co., Ltd. has deepened the effective division of labor and cooperation in design and construction through construction drawings, and achieved good construction results.

2. Project profile

2.1. PPP model introduction

The first phase of Chongqing Rail Transit Line 9 is the first PPP model rail transit project in the country. The project adopts the EPC and land pocket model, and the government platform company and the general contractor sign the “Investment Cooperation Contract” and the “Joint Venture Contract”. The project company, the government grants the project company a franchise. The project company is the main unit of investment, construction and operation of the project, and the personnel of the project company are appointed by the shareholders of both parties. The project construction mode is shown in Figure 1. The preliminary price estimate approved by the competent government department is reduced by a certain percentage, but the adjustable price agreed in the contract is excluded.



2.2. Project introduction

The total length of the first phase of Chongqing Rail Transit Line 9 is about 32.276km, including 30.234km underground and 2.042km overhead. There are 24 stations in total, including 22 underground stations and 2 elevated stations. Baoshenghu station is the 23rd station of the first phase of Chongqing Rail Transit Line 9. It is located in the vicinity of Huixing Interchange in Yubei District, Chongqing. Baoshenghu station and the Baotong Road station on the 15th Line are the interchange stations. The structural type is a single arch double layer structure. The main tunnel of the station is a horseshoe-shaped section, which is compound lining. The tunnel excavation width is 22.24m, the excavation height is 21.23m, and the excavation area is 436.11m². Composite TBM interval is adopted at both ends of the station. According to the overall planning, composite TBM starts from the

front section of Baoshenghu station and passes through the station after the completion of the second lining construction.

2.3. Analysis of engineering difficulties

The preliminary design of Baoshenghu station is constructed by double-side guide pit method. The construction process is more complicated, and the risk of temporary vertical support is higher. In addition, the TBM station time requirement of Baoshenghu station is high, how to optimize design and improve Construction efficiency and construction risk reduction are one of the difficulties in this project.

After proposing an optimized design plan, how to ensure that the site is properly organized according to the optimized design plan and ensure the smooth progress of the project is another problem in the construction of the project.

Baoshenghu station is a large-scale underground excavation station. How to control the deformation of surrounding rock and ensure the safety of construction is the top priority of the construction of the project.

The general contracting headquarters not only manages the construction drawing design but also manages the construction marking section, gives full play to the advantages of the ppp project model, and carries out the optimization design and on-site construction supervision of the excavation mode of Baoshenghu station through the integration of design and construction.

3. Design optimization program research

The design has a great impact on the engineering cost, but the design institute is influenced by the traditional design concept, and will pay more attention to the specification and design safety, and the economic concern of the design scheme is not high. Therefore, in the PPP project, the design management team needs to be in a coordinated management role. Under the premise of ensuring the safety, quality and progress of the project, the construction drawing design optimization at each stage is organized. According to the contract, the project is the total estimated price. In order to ensure that the project cost does not break through the budgetary estimate, the general contracting headquarters is based on the preliminary design, using technology as the traction, hiring academicians and top experts to demonstrate support, and actively exploring the two sides under the premise of ensuring project safety, quality, environmental protection and construction period. The wall guiding method is optimized for the feasibility of the single-layer initial arch method. After being expertly demonstrated, the general contracting command will take the lead to further connect with the design institute.

3.1. Introduction to the original preliminary design

3.1.1. Original preliminary design and construction steps

In the original design document, the main structure of Baoshenghu station was constructed by double sidewall tunnel method, and the construction steps are shown in figure 2 below.

The construction sequence is as follows. In the first step, the upper part of the left side of the station is excavated and the initial support and temporary support are carried out in time. In the second step, the upper part of the right side of the station is excavated, and the initial support and temporary support are carried out in time. In the third step, the central pit on the left side of the station is excavated, and the initial support and temporary support are carried out in time. In the fourth step, the central pit on the right side of the station is excavated, and the initial support and temporary support are carried out in time. In the fifth step, the lower pit on the left side of the station is excavated, and the initial support and temporary support are carried out in time. In the sixth step, the lower pit on the right side of the station is excavated, and the initial support and temporary support are carried out in time. In the seventh step, the core soil in the upper part of the tunnel is excavated and the initial support is carried out in time. In the eighth step, the soil in the middle of the tunnel is excavated. In the ninth step, the soil in the lower part of the station is excavated. In the tenth step, the inverted arch

waterproof layer is laid and the inverted arch concrete is poured. Finally, a waterproof layer is laid, and the tunnel arch, the secondary lining of the wall and the internal structure are poured.

3.1.2. The original preliminary design problems

The original design has the following problems. The first one, the double-side guide pit method has many blocks, and the process transfer between the guide holes is cumbersome and the construction speed is slow. Article 2: The initial support of the vault during excavation by the double-walled guide pit method shall be closed until the intermediate core soil is removed, so that the initial support closure is not timely and the stress concentration is likely to occur. Article 3: The double-side guide pit method has a height of more than 20 meters when the central core pillar is removed in the later stage, and the fourth is the safety risk during the construction process. The temporary inverting arch and temporary coupling beam support measures during the excavation of each section More, the project cost is relatively high.

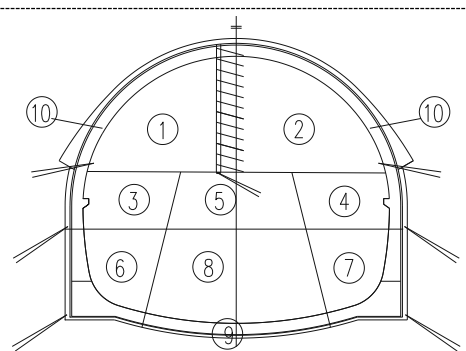
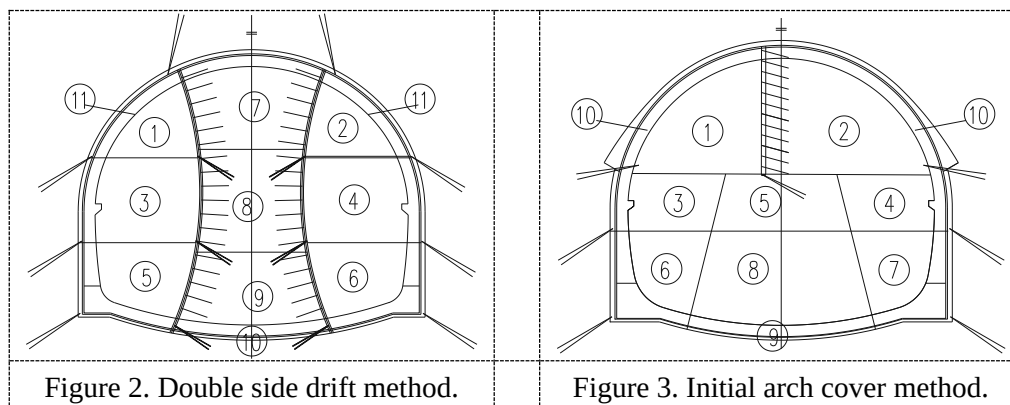
3.2. Introduction to deepening the design

Combined with the actual surrounding rock geological conditions of Baoshenghu station, considering the initial support strength of the original design and the safety reserve of the secondary lining structure without changing the original design, the initial support strength and construction procedure of Baoshenghu station are carried out. Optimization, combined with the advantages of the double-wall guide pit method and the CD method, the innovative proposal is to use the initial arch cover method to excavate. The sequence of construction steps is shown in figure 3 below.

3.2.1. Deepening the design and construction steps

The upper step of the initial arch cover method is excavated by the CD method; the step and the lower step of the station are first excavated in the order of the core soil method on both sides of the step, and the arch wall is integrally lining with a template trolley. See Figure 3 below for details.

The first step is to excavate the upper section of the upper step, the initial support and the temporary support. The second step is to excavate the right section of the step and the initial support. The third step is to excavate the left section of the step and the initial support. The fourth step is to excavate the right section of the step and the initial support. In the fifth step, the temporary middle wall is removed, and the core rock pillar in the middle section of the middle step is excavated. The sixth step is to excavate the lower section of the lower section and the initial support. The seventh step is to excavate the right section of the lower step and the initial support. In the eighth step, the core soil in the middle of the lower step is excavated. The ninth step is to apply the inverted arch waterproof layer and the inverted arch lining. The tenth step is to apply the waterproof layer of the arch wall and the second lining structure of the arch wall.



3.2.2. Advantages of deepening design

Compared with other shallow buried excavation methods, this method has the advantages of safe and reliable construction environment, less construction steps and high efficiency, and can reasonably utilize the characteristics of high integrity and stability of Chongqing stratum to achieve efficient construction, cost saving and shortening. The effect of the construction period.

From the safety point of view, the "first arch cover method" has the advantages of less process conversion, higher safety degree of removing the temporary intermediate partition wall, and less blasting disturbance than the "double side wall guide method".

From the perspective of construction progress, the "primary arch cover method" has the advantages of large construction space, convenient mechanized construction, simultaneous operation of multiple working faces, and relatively simple operation, compared with the "double side wall guide method".

4. Construction management

4.1. Construction management system

After the optimization design plan was proposed at Baoshenghu station, a complete management system was established from the general contracting headquarters to the project department to ensure that the site was properly organized according to the optimized design plan.

Establish a construction technology management system with the chief engineer of the headquarters as the core. Establish a three-level technical management network consisting of the chief engineer of the command department, the management department of the command department, and the production operation team of the project work area, and implement the system of on-site construction technicians, fixed posts and post responsibility systems, so that information sharing, hierarchical responsibility, and technical management work are implemented. Specific technical team and personnel.

4.2. Construction technology management measures

First, strictly control the management and control of construction technology. The technical team is divided according to professional technology, and each professional technical team leader is responsible for the system. The person in charge of the project technology department is responsible for technical management, planning and institutional operation, and reports to the headquarters for verification.

Second, strictly control the construction technical documents. Before the construction of each sub-division and sub-project, the person in charge of the project technical department organizes various professional and technical personnel to carefully study and check the construction technical documents, including technical documents such as construction drawings, design specifications and change notices, and deeply understand the design intent and technical requirements.

5. Construction achievements and experience summary

5.1. Construction effectiveness

Through the integration of design and construction, the General Contracting Command has carried out optimization design and on-site construction supervision for the excavation method of Baoshenghu station. The on-site construction quality and construction schedule have been applied well. The main body excavation support is 1.5 meters per day, the construction period is three months ahead of schedule and the cost saving is more than two million yuan. The work method has been promoted and applied to other large-section underground excavation stations on Chongqing Line 9. Through continuous practice and summary, the initial arch cover method is further optimized, in order to guide and guide the underground excavation projects of other subway stations in Chongqing. The comparison between the two construction methods is shown in table 1 below.

5.2. Summary of experience

The integration and design of the super-large section underground excavation metro station can be successfully applied and promoted in Chongqing Rail Transit Line 9, which is inseparable from the following factors.

First of all, the first phase of Chongqing Rail Transit Line 9 adopts the PPP mode, and the No. 9 line command is responsible for construction drawing management and civil construction, which provides a prerequisite for the design of the No. 9 line headquarters.

Secondly, the leadership of Chongqing Rail Transit Line 9 attaches great importance to design optimization and scientific and technological innovation work, and cooperates with the design management team of the technical center of the head office to jointly optimize the design scheme of the oversized section excavation station, and proposes the initial arch cover method. The design plan, and many times organized academicians, masters, experts inside and outside the group to review and guide the optimization program, which provides technical support for the optimization of design solutions.

Finally, a construction technology management system with the chief engineer of the headquarters as the core was established, and a three-level technical management network consisting of the chief engineer of the command department, the management departments of the headquarters, and the production team of the project work area was established to ensure the design of the site according to the initial arch cover method. Construction, which provides organizational guarantee for the field application of the initial arch cover method.

Table 1. Comparison of application effects.

Project	Double side drift method	Initial arch cover method
Method of characteristics	Block more, more procedures, multiple disturbances of land subsidence large	Less block, less process, less disturbance and less land subsidence
Subject range	Soft or earthy strata	Upper-soft lower-hard ground
Waterproofing quality	General	Well
Difficulty of construction	Complexity	Simplicity
Construction speed	Slow	Fast
Working security	High safety risk	Low safety risk
Amount of abandoned work	Large	Small
Construction costs	High	Medium

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