Compilation Standard of Specification for Construction and Quality Acceptance for Urban Utility Tunnel of Shaanxi Province

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Abstract. In order to standardize the related procedures and quality control requirements for the construction and quality acceptance of utility tunnel in Shaanxi province. The relevant departments of Shaanxi province have compiled Specification for Construction and Quality Acceptance for Urban Utility Tunnel of Shaanxi Province (The following is referred as Specification). This paper first systematically summarizes the history and present situation of the construction of utility tunnel at home and abroad. Then it is pointed that the main problems in the construction of the utility tunnel in China are the lack of the basis for the construction. Introduced the establishment background, guidelines, framework, for 3 issues were discussed. These 3 problems are that processing and construction method of foundation is still using the housing construction is reasonable or not, whether the configuration of steel bar of top and bottom panels of utility tunnel can be optimized and it is possible for the waterproof of the structure to replace the outsourced.

1. Introduction
With the development of urbanization, the "urban syndrome" characterized by over saturated population, crowded building space, traffic jams and backward infrastructure has been formed in Chinese cities[1]. In order to solve the development dilemma of this city, it is necessary to pursue the sustainable development of the city. The efficient use of urban underground space and modern infrastructure is an important feature of the future city. As the direction of new urban development, the development and utilization of underground space is attracting more and more attention. The construction climax of underground structures such as subway, Underground Street, underground parking lot and underground storage facilities is rising in the world. Europe, Japan, France, the United States and other countries with high economic level are at the forefront of urbanization. The development of underground space has been transformed from a single underground structure to a comprehensive utilization of underground space[2]. The development and construction of underground space in China started late, but its development speed was fast and its results were remarkable. It has changed from the original underground commercial street and subway to the utility tunnel that marks the smart city.

2. Compilation background

2.1 The construction history and present situation of the utility tunnel
2.1.1. **Foreign country.** The construction history of the utility tunnel can be divided into the initial stage, the embryonic stage and the modern stage. Utility tunnel originated in the sewers of Paris, in early 19th century, in order to improve the water distribution in Paris city, the design and construction of underground drainage system, which can be considered as the initial stage of utility tunnel construction, this phase of the utility tunnel stage is only included in the water supply and drainage network in the municipal pipeline. At present, the first utility tunnel, which is generally recognized by the international community is born in France. In 1832, a utility tunnel containing municipal pipelines, such as tap water, compressed air, communication and power was built in Paris. This utility tunnel brings multiple municipal pipelines into it, which is the rudiment of modern utility tunnel. In a long period of time, a number of utility tunnel were built in Britain, Germany and Japan with reference to this model. The details of the construction are shown in Table 1 [3]. After 21st century, with the economic development of all countries in the world and the acceleration of cooperation and exchange, a consensus has been reached on the concept of modern utility tunnel in the world. Modern utility tunnel is to lay all kinds of municipal pipelines in accordance with demand and nature.

| Time | Country      | Section Form | Accommodating Pipeline          | Remarks                  |
|------|--------------|--------------|---------------------------------|--------------------------|
| 1861 | London England | semicircle   | gas, sewer                      | width: 3.66m, height: 2.29m |
| 1893 | Hamburg Germany | rectangle    | supply                          | width: 0.39m, height: 1.9m, length: 455m |
|      | Osaka Japan   | rectangle    | power cable, telecom, sewage    | width: 3m, height: 2m, length: 270m |
| 1926 | Tokyo Japan   | rectangle    | telecom                         | width: 1m, height: 0.6m |
|      | Tokyo Japan   | rectangle    | gas                             | width: 1.5m, height: 1m  |

2.1.2. **Domestic.** The development of China's utility tunnel started late. The first utility tunnel is a rectangular reinforced concrete utility tunnel built in the Tiananmen Square on 1958, which has a width of 4m and a height of 3m. After 1990, many cities in China have carried out utility tunnel construction in succession. The construction of some cities is listed in Table 2 [4-6]. Since 2013, China has introduced a number of policy documents related to the construction of utility tunnel. Since 2015, the ministry of housing and finance ministry, to carry out the pilot work of utility tunnel, the first selected are: Baotou, Shenyang, Harbin, Suzhou, Xiamen, Shiyan, Haikou, Liupanshui, Baiyin, a total of 10 pilot city, the second batch of selected are: Zhengzhou, Guangzhou, Shijiazhuang, Qingdao, Weihai, Siping, Hangzhou, Baoshan, Nanning, Yinchuan, Pingtan, Jingdezhen, Chengdu, Hefei, Haidong, a total of 15 pilot city.

| Time | City        | Scale of Construction                  |
|------|-------------|----------------------------------------|
| 1994 | Shanghai    | Zhang yanglu utility tunnel, 11.5 km  |
| 1999 | Hangzhou    | City station square utility tunnel, 1.1 km |
| 2002 | Beijing     | West zone of zhongguancun utility tunnel, 1.9 km |
| 2004 | Guangzhou   | Guangzhou university city utility tunnel, 17.4 km |
| 2006 | Kunming     | Chenggong new city utility tunnel, 38.4 km |
| 2009 | Shanghai    | Shanghai world expo site utility tunnel, 6 km |
2010  Shenzhen  Guangming new distric utility tunnel, 22 km
2012  Nanjing  Jiangbei new area utility tunnel, 58 km
2016  Beijing  Southern hexi utility tunnel, 8.9 km
2016  Guangzhou  Cao yuan nan street utility tunnel, 3.8 km
        Central area utility tunnel, 48 km

2.2 Status quo of construction standardization
At present, there is only one national standard *Technical code for urban utility tunnel engineering*[^7] for the construction of utility tunnel in China. The ninth chapter is the specification for construction and acceptance, although the breakdown of the foundation engineering, the cast-in-place reinforced concrete structure, precast reinforced concrete structure, but the section of each section is only 5, 6 provisions, the ninth chapter altogether only have 46 articles. The construction of utility tunnel is a complex engineering system involving many disciplines, such as structure, geotechnical, water supply and drainage. Regardless of construction or quality acceptance, these 46 provisions are far from enough to meet the requirements of quality control. There is an urgent need for a detailed specification of construction and quality acceptance in the field of utility tunnel construction.

3. Principles for the compilation of Specification
Stick to the existing laws and regulations, national standards and industrial standards, on the basis of regional geological characteristics, combined with the construction experience of utility tunnel, optimize the construction process and relevant measures to ensure the safety of the premise, put forward more detailed construction and quality acceptance articles.

4. Framework and content

4.1. Framework
Specification includes 14 chapters, such as general, terms, basic rules, excavation engineering, foundation treatment, etc. The framework is illustrated in Figure 1.

4.2. Key contents

4.2.1. Regulation of sub-divisional works. In the compilation of Specification, referred to the principles of divisional works and sub-divisional works in Unified standard for constructional quality
acceptance of building engineering [8], combined with the actual construction organization of utility tunnel, the utility tunnel project is divided into divisional works, sub-divisional works and items. The specific division is shown in Table 3.

Table 3. The divisional works and sub-divisional works of utility tunnel

| Project | Utility Tunnel |
|---------|---------------|
| Divisional Works | Foundation | Main Body Structure | Wat er- pr of | Ancillary Facilities | Pipeline Engineering |
| | | | | | |
| | | | | | |
| Sub-divisional Works | Earthwork | Foundation support | Foundation control | Foundation treatment | Waterpr-oof Engi neering |
| | | | | | |
| | | | | | |

4.2.2. Quality control of construction process. Compared with Technical code for urban utility tunnel engineering [7], Specification increased the two chapters of excavation and waterproofing works. During the compilation of this regulation, we not only focused on the quality acceptance after the completion of all stages of the utility tunnel construction, but also put forward strict requirements for the quality of construction process.

4.2.3. Relevant regulations of steel utility tunnel. With the continuous improvement of the research and construction level of steel structure in China, the steel utility tunnel has been applied more and more in construction because of its advantages such as convenient production of factory prefabricated parts and fast assembling on-site.

5. Discussion

5.1. Whether the foundation treatment method of building construction is still apply for utility tunnel

The methods for foundation treatment and construction in Specification refer to the relevant regulations in structural engineering. As a shallow underground structure, the utility tunnel is built by excavating part of the soil in the soil layer and then constructing the utility tunnel structure in it. The building is built directly on the ground floor, and its construction is the loading of the lower soil layer. The weight of the utility tunnel is much smaller than that of the original excavation. Therefore, the construction of the utility tunnel is the unloading of the soil under the foundation of the utility tunnel. At the same time, the soil layer that under the foundation of the tunnel under the gravity of the upper soil has basically completed the consolidation with high density and bearing capacity. Therefore, in
theory, it can be considered that no foundation treatment is needed for the construction of the foundation soil during the construction of the utility tunnel. In order to ensure the stability of the foundation and control the settlement, we only need to simply treat it. However, in the actual construction process, almost all the units for the construction of the utility tunnel foundation according to the requirements of the housing construction, use replacement foundation, composite foundation and dynamic compaction foundation to deal. This kind of construction has the behavior of excessive waste of foundation, and the relevant regulations on the foundation treatment of the utility tunnel need to be optimized.

5.2. Whether the configuration of steel bar of top and bottom panels of utility tunnel can be optimized
The common rectangular utility tunnel is cast or prefabricated, the reinforcement of top and bottom panels are almost the same form. After the completion of the utility tunnel, the top soil will be backfilled. When the top soil is stabilized, a circular arch similar to the original soil excavation chamber will be formed, so that the earth pressure and other loads on the top of the utility tunnel will be greatly reduced. Therefore, the top and bottom panels with the same form of reinforcement is not reasonable\(^{[9-11]}\), the configuration of steel bar should be optimized.

5.3. Whether the structural waterproof can completely replace the outsourced waterproof
It is stipulated in Specification that the waterproof of the utility tunnel should include the self-waterproof of the structure, the waterproof of the rolled material and the waterproof of the film. In the actual construction, the waterproof is also the way of combining the structure self-waterproof with the outsourced waterproof. However, there are many problems such as complex construction, difficult quality control and difficult inspection of waterproof effect in outsourced waterproof. Based on this, we should focus on whether some measures can make the concrete structure self-waterproof meet the requirements and cancel the outsourced waterproof structure, such as proportion optimization of concrete and additives.

6. Conclusion
This paper makes a detailed summary of the construction of utility tunnel, and gives a brief description of the main details of Specification. At the same time, some contents in Specification are discussed. The compilation process of Specification refers to the relevant specifications and research results both at home and abroad. Combined with the construction experience, detailed sets for the construction and quality acceptance of the utility tunnel are provided. The chapters are divided into reasonable sections and perfect contents, which provide guidance for the construction and quality control of the utility tunnel in Shaanxi province. At the same time, it can be used for the construction of utility tunnel in other cities. Further research and optimization are needed for the problems existing in the Specification, such as the foundation treatment method, configuration of steel bar of top and bottom panels of utility tunnel and waterproof.

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