Research report on the Utility Tunnel Engineering based on BIM technology

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Abstract. The integrated pipe gallery centralizes various pipelines in the same tunnel space, which is the trend of urban infrastructure modernization. BIM technology is based on the emerging 3D model as the core design concept. BIM technology is a technological innovation in the field of engineering construction and is an effective way to realize the simulation, information, and wisdom of engineering projects. Considering the design and construction difficulty of Utility Tunnel, BIM technology is applied to the planning, design, construction, and operation management of underground integrated pipe corridor to overcome the shortcomings of traditional two-dimensional design in the performance of integrated underground pipe gallery design.

1. Introduction
1.1 Introduction of Utility Tunnel
Utility Tunnel is an infrastructure that more than two types of urban pipelines or all underground pipelines (water supply, drainage, electricity, heat, gas, communication, television, network, etc.) are centrally located in the same tunnel space, and special maintenance is set up. The port, the hoisting port, and the monitoring system implement a unified, planned, constructed, joint maintenance and centralized management, resulting in a modern, intensive urban infrastructure.

The underground integrated pipe gallery originated from Paris, and Japan is the most advanced country in the construction of underground integrated pipe corridors. The underground space was developed and utilized earlier in Europe. From the planned construction of the drainage pipe network to the Utility Tunnel that can be combined in a geologically-friendly area, it plays an important role in the underground space. In Northern Europe, even using the hard and stable advantages of bedrock, the development of underground integrated pipe corridors can be used to defend and protect the environment. There is no need to rely too much on supporting facilities after excavation and construction for the high hardness of the bedrock, thus the construction and maintenance cost is also saved. The underground integrated pipe corridor system in cities of United States, Japan, and Russia is also quite developed. The pipelines in the corridors are professionally complete, with a high degree of modernization, and the management system is scientific.

1.2 Advantages of Utility Tunnel
The advantages of Utility Tunnel are mainly reflected in the following aspects

(1) Comprehensive: Scientifically utilize underground space resources, and centrally arrange various types of municipal pipelines to form a new urban underground network management system.

(2) Long-term effect: It has good corrosion resistance because it is not directly in contact with the acid and alkali materials of soil, groundwater and road structure layer.

(3) Environmental protection: The municipal pipelines are laid in one time according to the planning requirements, which can create conditions for urban environmental protection, integrate the
overhead lines into the integrated pipe gallery, avoid the contradiction between greening and greening, improve the urban landscape, the safety of the city and environmental quality.

(4) Operational reliability: The layout and safety distance between the professional pipelines in the pipe gallery are in accordance with the relevant national regulations, and along the pipe corridor, combined with fire, explosion, pipeline use, maintenance, and other aspects.

(5) Earthquake disaster prevention: The structure of the integrated pipe gallery is good in ruggedness and can withstand a certain degree of the impact load. It has good disaster prevention and disaster resistance performance, it can guarantee water, electricity, gas, and the safety of their important lifelines such as communications, especially in wartime.

(6) High-tech: Modern and intelligent monitoring and management system is set up inside and outside the pipe gallery to ensure full monitoring in the pipe gallery, continuous feedback of operation information and low-cost, high-efficiency maintenance management effect.

(7) Promote the construction of sponge cities: the use of integrated pipe corridors to construct drainage and rainwater pipelines can provide early conditions for the solution of urban flooding and water reuse to alleviate water shortages.

1. 3 Application of BIM technology in Utility Tunnel
BIM is a building information model. It is a technical means integrating Building Information Model, Building Information Modeling and Building Information Management. It has been widely used in many buildings and engineering field.

At present, the application of BIM technology in the integrated pipe gallery is still in the preliminary exploration stage. Among them, BIM technology is used in the design stage to compare and select the project, collision check, etc.; BIM technology is used in the construction phase to mainly carry out construction simulation and schedule control; BIM technology in operation and maintenance phase mainly performs collaborative management and safe operation and maintenance.

2. Development status of BIM technology application in Utility Tunnel at home and abroad
2.1 Status of foreign research and development:
Szu-Min Kang, Yayu Tseng, etc. have studied BIM in the design, construction and operation stages of the integrated pipe gallery. Through the application of BIM technology, it proposes BIM-based facility management, integrates information about the pipe corridors and facilities, improves the reliability of pipe gallery and the management level of pipe corridors [1].

T. Park and T. Kang used BIM and GIS to study the preliminary feasibility of the integrated pipeline route. A feasibility study system for integrating BIM and GIS was developed to estimate the cost of the project to select the best route and further improve the project delivery method [2].

Harsha Vardhan Reddy Guduru Penusila conducted a BIM-based application study using the Texas project as an example. It is proposed how the pipeline construction will shift from the traditional two-dimensional model to the BIM process, affirming the value of BIM in the pipeline construction process [3].

Kang JA and Kim TH have studied the monitoring of integrated pipe corridors. It is proposed to use the monitoring and CCTV (closed-circuit television) images to implement real-time monitoring of the corridor to cope with the sudden situation of the corridor [4].

2.2 Status of domestic research and development:
Jiang Tianling and Li Fangfang rely on the ArchiCAD platform to explore the three-dimensional modeling, design and application of the pipe gallery through the project example of Haidong City, and to guide the construction of rationally arranged pipelines, make full use of the underground space, and perform collision detection on the BIM model [5].

Taking the underground passage construction of the Shanghai World Expo Park integrated pipe gallery as the background, Zhang Pengfei studied the visualization based on BIM in the design stage, evading the blind spots of design and demonstrating the optimal design. In the construction stage, the BIM software was used to simulate the construction support and excavation plan, which solved the difficulty of the underground passage of the open-cut large-section integrated pipe gallery and ensured the safety of the foundation pit and the pipe gallery [6].
Jiang Feng used BIM technology to simulate the construction process of difficult parts in the project, thus optimizing the construction plan and simultaneously implementing dynamic integrated management of all aspects of construction with BIM [7].

Li Fei studied the application of BIM in the stage of integrated pipe gallery construction. Through the application of BIM in the construction stage of Zhuhai Hengqin pipe gallery project, the demonstration application of BM in three-dimensional site layout, foundation pit support, steel bar calculation, hoisting simulation, field installation, etc., and the quality of BIM in integrated pipe gallery are listed. Control, cost control, and progress control [8].

Chen Yao proposed the quality control of applying BIM to the construction for the quality control problem in the process of integrated pipe construction. Demonstrate the feasibility of BIM quality control in the pipe corridor from the economic side as well as the technical aspect [9].

3. **BIM applied to the Utility Tunnel related practical cases**

BIM case of the Utility Tunnel of the Chinese University of Hong Kong (Shenzhen)

The integrated pipe gallery is located in the underground building corridor and is a dedicated pipe gallery for equipment pipes. The underground pipe gallery is 2500-4300mm wide and has a clearance height of 4600mm. There are nine buildings in the corridor, and there are eight types of equipment rooms for connected equipment.

3.1 **Construction Design Modeling**

According to the design drawings and modeling standards, through the Revit software, working set and link model, according to the division of architecture, structure and electromechanical, input the design drawing information into the building information model, integrate information, and integrate all the data into the proposed Construct a three-dimensional model of the Utility Tunnel. (Fig.1).

![Fig.1 Design model](image1)

![Fig. 2 complex pipeline nodes](image2)

3.2 **Design scenario simulation**

Based on the construction design model, the model is parameterized and real-time rendered, and the simulation design effect is visualized in advance. The BIM technology is used to simulate the initial design scheme, and the dynamic scheme discussion and dynamic adjustment demonstration are carried out through the scheme comparison demonstration to optimize the design scheme.

3.3 **Model review**

(1) Collision review: Based on the professional construction design models, Revit and Navisworks software is used for collision inspection to review the collision between structure and electromechanical, electromechanical and electromechanical, and generate a collision analysis report. According to this test report, the design adjustment, model optimization, and construction process optimization are targeted, which greatly improves the project efficiency.

(2) Clearance review: Use Revit software to carry out inspection and repair space in the integrated pipe gallery using auxiliary inspection such as dimensioning and splitting pipe gallery model. At the same time, the model is imported into Navisworks software, and the third person roaming mode is adopted. The internal structure of the pipe gallery and the spatial relationship of various pipelines are familiar, and the installation space and operation space of the pipe inside the pipe gallery are checked. Pipeline optimization based on test results and clearance requirements (see Figures 2)
3.4 Pipeline synthesis
Given the extremely complex pipelines, many design defects, and complex and diverse building structures. Based on the collision inspection report and the clearance analysis report, the pipeline adjustment arrangement scheme is formed by partial profile layout, local special arrangement and visual simulation. And then adjust the pipeline model according to the optimal layout scheme. Among them, the pipeline layout and the intersection of important nodes need to be comprehensively considered to determine the management plan (Figures 3).

![Fig.3 Partial node pipeline synthesis](image)

![Fig.4 Part of the node support hanger design](image)

3.5 Support hanger design
In view of the inability to pre-bury the bracket components and the extremely complicated pipelines, the project uses the Revit plug-in to design the three-dimensional support hangers to reduce the difficulty of on-site construction.

1) Preliminary design of three-dimensional support hanger: Based on the optimization model after the pipe harness, pipeline installation and national standard atlas, the layout distance of the support and hanger is initially set to 4m, and the three-dimensional support hanger style is created. At the same time, the bridge increases the screw hanger every 1.5 meters (Figure 4).

2) Calculate and evaluate the specifications of the hanger and hanger profiles.

3) Quantitative statistics of support and hanger: Based on the 3D model, the length and weight information of the associated profiles of Revit are used to calculate the amount of each profile through a detailed table.

3.6 Construction plan simulation
Based on the final optimization model, roaming video, 4D technology and other means are used to add construction order, mutual relationship, construction resources and measures to simulate the construction plan of the integrated pipe gallery area. The use of BIM technology mainly shows the foundation pit support, earth excavation, and construction structure construction, which makes the project dynamic display more intuitive and easy to understand the progress of the project at each stage.

4. Conclusion
At present, the development of BIM in China is still in its infancy, and there are still problems such as unsatisfactory related standards, unclear BIM implementation process, insufficient localization of related software, lack of professionalism, and weak interaction. However, with the gradual development and progress, these problems will be effectively solved, and BIM will usher in faster development and popularization.

The construction of foreign integrated pipe corridors is relatively early, and the application research of BIM-based pipe corridors is relatively mature. With the development of BIM in China and the government's strong support for the construction of integrated pipe corridors, BIM has achieved certain results in the application of integrated pipe corridors.

Domestic research on the design, construction, and operation and maintenance of BIM in the integrated pipe gallery has been involved, but it is not detailed. The construction simulation and
collision detection of BIM are mostly general, and there are no specific improvement measures. BIM's research in integrated pipe gallery design focuses on the design of complex nodes, the adjustment, and optimization of solutions, and how to combine terrain and roads.

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