

# Research on the Management Mode of Utility Tunnel Maintenance and Operation in High-Tech Zone Based on Bim Model

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**Keywords:** Bim Model, Maintenance of Utility Tunnel, Operational Management, Information Technology, Three - Dimensional

**Abstract:** In the traditional two-dimensional information transmission and communication mode such as drawings and characters, there are many problems, such as multi-disciplinary design objects are easy to conflict, complex nodes are difficult to express, and engineering information is difficult to obtain in real time. Utility tunnel building information model (bim) data, bim information data of corridor pipelines, monitoring information data and information around the corridor are integrated into a whole, and a collaborative management platform with bim as the core is built by using internet of things technology, thus solving the problems existing in utility tunnel's later operation and management. This paper uses bim technology to analyze the advantages of bim in operation and maintenance management in utility tunnel. Combined with the operation and maintenance management project of utility tunnel project in high-tech zone, this paper introduces the construction of bim-based intelligent operation and maintenance management system in utility tunnel, which provides a relatively perfect integrated solution for operation and maintenance management in utility tunnel.

## 1. Introduction

With the rapid progress of urbanization in our country, meeting the residents' demand for water, electricity, gas and other energy sources, ensuring the normal realization of urban communication and other functions, and avoiding the occurrence of "road zipper" and "spider web in the air" problems have become urgent problems for major cities. Developing utility tunnel is an important solution [1]. The construction and operation management of utility tunnel is a complex system engineering. Due to the diversity of its storage pipelines, the planning of utility tunnel needs to comprehensively consider the layout of various comprehensive ports such as route outlet and evacuation exit along the route as well as the organic connection of other utility tunnel areas to be built in the future [2]. Rapid urbanization has led to a large increase in the urban population. With the continuous expansion of the city scale, the demand for public infrastructure such as power supply, water supply and drainage, heat supply, gas supply, communication and so on, which are the basis of urban development, has also increased greatly. The traditional management mode mainly relies on human patrol inspection, which has been unable to meet the needs of safe operation and management in utility tunnel. With the large-scale construction in utility tunnel, an efficient and safe operation and management mode in utility tunnel is an important issue that we should pay attention to.

At present, bim for design and construction is mostly applied separately in the traditional pipe gallery working mode, and their respective modeling is inconsistent and difficult to exchange information [3]. Utility tunnel's construction mode makes the pipeline laying more scientific and orderly, and it is very convenient to expand and maintain the pipeline in the pipeline corridor to avoid repeated excavation of the road [4]. The research object of this paper is the collaborative management platform of urban underground utility tunnel project based on bim technology. The introduction of bim technology into the whole life cycle of planning, design, construction, operation and maintenance management in urban utility tunnel will significantly improve the integration of project information in utility tunnel. At present, the platform-based method of pipe gallery project collaborative management based on bim technology is still in its initial stage, which is also a new

way of pipe gallery project collaborative management in the future.

## **2. Bim Concept**

Parameterized and visual bim drives design in a parameterized way, displaying engineering objects in the form of three-dimensional physical graphics. Bim-based visualization model includes not only all information of digitized components, but also rule information among components. The design-construction collaborative management platform based on bim technology can well connect the engineering bim models in the design phase and the construction phase, ensuring the unity of data and information among all participants. Three-dimensional visualization transforms the traditional line-type abstract expression in engineering projects into three-dimensional physical graphics that are easier to communicate. It is not only used for simple applications such as effect drawing display, but also can realize visual management of the whole process of engineering projects [5]. Therefore, bim technology is a data-based tool to simulate real engineering behavior by integrating various related information of construction projects. As all component and element information is concentrated in a unified model, all participants communicate and cooperate based on a unified bim model, and can timely, accurately and efficiently deal with problems occurring in various stages and systems. The pipeline in the pipe gallery, physical parameters, position parameters and functional parameters of the foundation matching implementation are coded and stored in a unified model, so as to realize the integration of design, construction and management and meet the requirements of visual monitoring and management of the pipe gallery by a third-party manager in a three-dimensional environment [6]. Although china's bim software cannot meet the requirement of fully planning the project cost at present, with the application of new means such as software secondary development, the goal of controlling the cost through bim technology will soon be realized.

## **3. Advantages of Bim in Utility Tunnel Operation and Maintenance Management**

### **3.1 Data Integration and Sharing**

BIM technology integrates all kinds of relevant information from design, construction, operation and maintenance to the end of the life cycle. It has five characteristics of visualization, coordination, simulation, optimization and plotting [7]. With the application of BIM technology in the design stage and construction stage of utility tunnel, the vertical and horizontal complex corridor pipelines are presented to managers in three-dimensional visual stereoscopic images. BIM-related software can be used to simulate various phases of the project, such as energy efficiency simulation in the design phase, progress and cost simulation in the construction phase, disaster evacuation route simulation in the operation and maintenance phase, etc. The same model is used in the design, construction, operation and maintenance phases, and different information is added to the model in different phases, thus ensuring the correct circulation of engineering information [8]. It is convenient for the installation, maintenance and daily management of various pipelines, and can also reduce the later maintenance cost of engineering pipelines. If problems are found in the construction process, the designer can upload the latest model to the platform in time according to the feedback, then the builder downloads the updated model, and after the modification is completed, the design change file can also be generated by means of one-key export, etc. It can make the design, construction, operation and maintenance management form a unified BIM information model as a whole, and infrastructure data such as early design and construction will provide strong support for later operation and maintenance work. All of them are concentrated in BIM database to provide information data for operation and maintenance management system, so that each system with independent information can achieve resource sharing and business collaboration.

### **3.2 Visualization of Operation and Maintenance Management**

During debugging, prevention and troubleshooting, operation and maintenance management

personnel often need to locate the location of building components (including equipment, materials, decorations, etc.) in the space, and at the same time query the relevant information needed for their maintenance. With the introduction of BIM technology, the latest operation and management information of all relevant units can be timely input and loaded into the operation and management system. To achieve dynamic management, each unit can also view and preview the pipe network information of the surrounding corridor units at any time. In general, on-site operation and maintenance managers rely on blueprints or practical experience, intuition and discrimination to determine the location of building equipment such as air conditioning systems, electricity, gas and water pipes [9]. These devices are usually installed on the top plate, inside the wall or under the floor, etc. where they cannot be seen. If the three-dimensional model of the project is established at the initial stage of design, and the model is handed over to the construction personnel for reference during construction, three-dimensional internal and external browsing can be carried out for relevant complex nodes during the structural construction stage. In the design phase, BIM modeling software is applied to complete the construction of relevant models and complete the integration and sharing of information on the BIM platform, providing a basis for the smooth implementation of the project in the subsequent construction and operation phases. Reduce the secondary or multiple pollution caused by repeated ground excavation, reduce the impact of pipeline construction on urban traffic, improve road use efficiency, save traffic costs, and make urban ecology more optimized.

### 3.3 Decision-Making and Simulation of Emergency Management

The data needed for emergency management are of spatial nature, stored in BIM and can be searched [10]. By providing real-time data access through BIM, emergency response decisions can also be made without obtaining sufficient information. At the same time, monitoring equipment, fire prevention equipment, lighting equipment, drainage facilities, ventilation equipment and other equipment in the pipe gallery are identified with professional marks, and BIM models of internal equipment and facilities are established according to actual information such as equipment size and pipe gallery location. Before the preliminary planning of the urban underground utility tunnel, topographic survey data and road design drawings of relevant areas are obtained from the road specialty, and through a series of processing of the original data.

Emergency management system (Figure 1): the system realizes early warning, disposal guidelines, knowledge base management and emergency simulation drills under different emergency situations. it covers the whole process of case rehearsal from information collection, and provides many application examples for emergency management and emergency training of the pipe gallery.

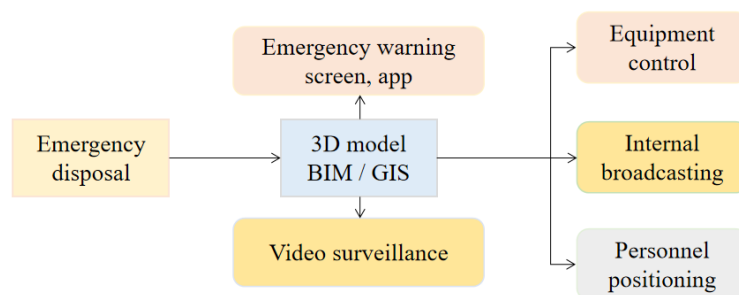


Fig.1 Schematic Diagram of Emergency Linkage Disposal

According to the application of BIM technology in operation and maintenance management, BIM can provide detailed information to emergency personnel before they arrive. Through the establishment of BIM information database, the management data, safety data and function data of each pipeline are loaded into the management system. According to monitoring and collection, the operation indexes of each pipeline will be continuously transferred into the management system. Even the construction personnel at the grass-roots level of the project can well understand the specific forms of complex structures and improve the construction accuracy. The optimized BIM

model can generate construction drawings that meet the construction requirements through processing, as well as three-dimensional drawings, roaming animation, etc., and provide accurate electronic information for the construction phase and operation and maintenance phase of utility tunnel, thus realizing lossless transmission and efficient utilization of information.

## 4. Bim-Based Operation and Maintenance Management and Application

### 4.1 Application Target

BIM technology is applied to the operation and maintenance management project of utility tunnel Project in High-tech Zone. The BIM model is used to provide auxiliary support for the comprehensive operation and maintenance management of utility tunnel in the visual mode, reduce the management operation and maintenance costs, and effectively improve the operation and daily maintenance costs of the pipe gallery. Mainly includes utility tunnel building model, structural model, internal equipment model, corridor pipeline model, etc.

The operation and maintenance of utility tunnel not only involves the supervision of government departments, but also requires the participation of ownership units such as water supply companies and communication companies, and even the assistance of designers and constructors in case of special circumstances. BIM-based operation and maintenance of utility tunnel adopts B/S operation mode to provide a unified communication platform for the participants of the pipe gallery, as shown in Figure 2.

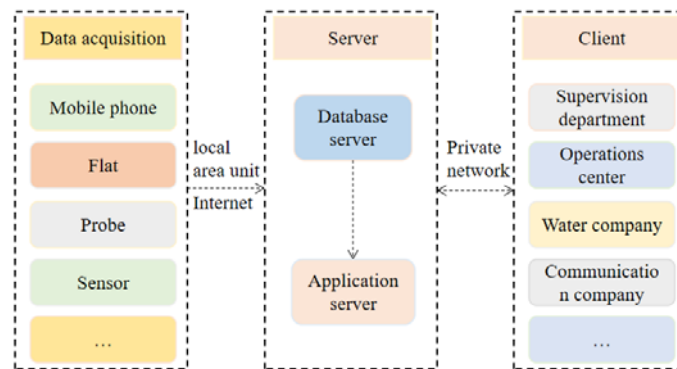


Fig.2 Operation and Maintenance Mode of Integrated Pipe Gallery Based on Bim

Information such as the specific size and material of each structure is designed by designers. Through platform-based collaborative management, designers can give component information to the model in time. Using BIM technology and combining with new information technologies such as Internet of Things, mobile applications, big data and cloud computing, the three-dimensional visualization management of utility tunnel is realized, providing a relatively perfect integrated solution for the operation and maintenance management of utility tunnel. The combination of BIM and VR technology can simulate entering the accident site, so as to formulate a reasonable rescue and emergency repair plan, improve the accuracy and safety of accident disposal, and shorten the time of accident disposal. To provide unified data services to the outside world, to realize the storage, management, analysis and sharing of all kinds of data and information in utility tunnel, and to provide complete and effective data support for all kinds of intelligent applications. Utility tunnel has adopted more advanced automatic control system and detection technology to discover hidden dangers in time, greatly improving the operation stability of various professional pipelines in the trench.

### 4.2 Bim-Based Functions of Utility Tunnel Intelligent Operation and Maintenance Management Platform

#### 4.2.1 Operation Monitoring Function

The platform integrates three-dimensional geographic information, equipment operation information, environmental information, safety prevention information, video images, early

warning and alarm signals, inspection information and other contents, and unifies centralized display on a three-dimensional visualization platform to realize integrated three-dimensional monitoring and scheduling of utility tunnel. Using Internet, Internet of Things and other technologies, integrated into a unified management platform to integrate BIM information existing in the early design-construction phase with later operation and maintenance information. This not only has curved surface as the design basis, but also has detailed electronic topographic map to provide design reference. Social subjects (enterprises) will assume part of the government's responsibilities and obtain the franchise. The government and social subjects will establish a community relationship of “full cooperation, benefit sharing and risk sharing”. The government's financial burden will be reduced and the investment risks of social subjects will be reduced [4]. Through the three-dimensional visualization platform, the map, image and terrain data of the area where the pipe gallery is located are integrated, and the three-dimensional model data of the pipe gallery, pipelines and equipment and instruments in each geographical area are loaded to customize the observation angle of each system. Using the advantages of BIM visualization, the overall operation status of the pipe gallery can be viewed intuitively. At the same time, valuable reference information can be provided for pipeline units, design units and construction units planning to enter the gallery so as to formulate reasonable design and construction schemes.

#### **4.2.2 Entrance Management Function**

According to the principle of “one platform, one network”, the functional design of the platform integrates the production equipment, production information and service information related to the high-tech zone and the management corridor into one platform, and combines the thematic information of the intelligent management corridor with the geographic information of the administrative division of the high-tech zone in the form of GIS map. According to the size of water flow, pressure-bearing value and safety factor of water supply and drainage pipelines, the number of pipelines to be used in the water supply and drainage pipeline network is further optimized, and management personnel are prompted to open and close the corresponding pipelines. Second, the road cross-section assembly is created, and the terrain profile is generated, and then the road longitudinal break is reasonably designed according to the terrain profile. The pipeline entrance management function obtains the monitoring data provided by the professional monitoring system of the corresponding entrance pipeline in the form of a data interface, graphically displays the operation status of the entrance pipeline and provides a report analysis function, which is convenient for the operating unit to master the real-time operation status of the entrance pipeline. And through the platform for information sharing, then the construction personnel can obtain the progress information of the project at any time during the construction phase and view it, supplemented by interactive functions. Finally, three-dimensional road models are created by assembling design routes, road profiles and road cross sections, and road curved surfaces are generated. Even if the design information is suddenly modified for some reason, construction personnel can obtain the latest information from the platform in time. Ensure that the structure of the construction stage and the design stage are completely consistent.

#### **4.2.3 Asset Management Function**

There are many kinds of internal facilities and equipment in the pipe gallery with huge data, including power supply system, lighting system, water supply and drainage system, ventilation system, communication system, fire fighting system, etc. Information technology is essential for orderly management and maintenance of these equipment. Utility tunnel Big Data Analysis comprehensively analyzes the Internet of Things data, operational asset management data and emergency file data accumulated during the long-term operation and maintenance of the system. The unified power grid pipelines entering the corridor can be reasonably classified by the comprehensive operation and maintenance management system, which can be divided into industrial power grid, urban power grid, agricultural power grid and other categories according to the power grid usage, and can also be classified according to the division of urban administrative regions. The project template sets parameter information and application functions such as project

unit, linear pattern, dimension, etc. The use of appropriate project templates can help designers to minimize repetitive workload and improve design efficiency and drawing output. The graphic part is mainly responsible for wrapping the controller and positioning and judging the characters through it. The main camera is bound to the graphics and is responsible for acquiring the images of the parts that the characters browse. It is roughly equivalent to the role of our eyes. The information of facilities and equipment comes from analyzing BIM data to obtain structured information data and spatial model data. Combined with Internet of Things, the status monitoring of equipment can be realized.

#### **4.2.4 Operational Management Function**

The platform operation and management function is an important part of the core application system in utility tunnel. This function realizes the daily work and management for the operation organization of the pipe gallery, including daily inspection, regular maintenance, equipment maintenance, etc. By installing monitoring equipment at the corresponding position of the natural gas pipeline network, the physical parameters, safety factor and operation status of natural gas in the pipeline can be obtained in time. Adjust and optimize in a three-dimensional visual environment to solve the problems of collision between pipelines, collision between pipelines and structures, and insufficient space for installation and maintenance. At the same time, a model clearing button is established to clear the project after clicking the button, i.e. all components disappear. The staff responsible for patrol inspection will bring mobile equipment to the site according to the planned route to patrol the pipelines, cables and equipment in utility tunnel according to the patrol inspection plan, and fill in patrol inspection records through the mobile client to report the abnormal situation.

#### **4.2.5 Early Warning Plan Function**

The function of early warning plan includes triggering alarm and plan disposal. There are two mechanisms for triggering alarms: one is to configure the alarm triggering mechanism, which will automatically trigger the alarm when the incoming data from the Internet of Things reaches the threshold; The second is that the personnel on duty in the central control room know the event according to video monitoring or other methods and give special alarm in the system. For some important equipment and components, such as fire fighting facilities, monitoring facilities and important pipelines, regular inspections shall be set up, and the inspection contents, inspection requirements, inspectors and inspection results shall be entered in a timely manner, so as to timely generate failure repair reminders for the failed components and potential safety hazards during the inspection. At the same time, the system pushes the event status and disposal progress to relevant users including field staff and management personnel, and sends short message reminders. The maintenance details will be entered into the corresponding BIM model database, including relevant information such as maintenance reason, maintenance time, maintenance personnel, maintenance process, etc., and electronic documents will be formed so that the responsibility will be transferred to the person. BIM-based collision inspection can avoid design defects caused by designers' space imagination ability in the past. Application of relevant BIM software can realize intelligent inspection of collision points, intuitively display collision of outgoing lines in design, and significantly improve design quality and design efficiency.

### **4.3 Bim Application Implementation Technology Highlights**

The BIM-based utility tunnel operation and maintenance management platform is implemented in combination with the operation and maintenance management requirements of utility tunnel. The application of BIM technology in the operation and maintenance management of underground city utility tunnel will greatly reduce the frequency of accidents, save the time for handling accidents and reduce energy consumption. The platform is connected with monitoring systems for various professional pipelines, and is effectively integrated. When there is a problem with professional pipelines, the ventilation, lighting, drainage, fire fighting and other systems in utility tunnel shall be jointly controlled to ensure the safe operation of utility tunnel and various professional pipelines.

The platform can save and apply the operation and maintenance data during the construction period, so that the operation and maintenance management company can quickly take over the project and carry out the operation and maintenance management business, greatly saving the handover time of the whole project and improving the operation and maintenance management level.

## 5. Conclusion

This paper puts forward the basic mode of utility tunnel intelligent management platform based on BIM, and designs three-dimensional visualization, real-time monitoring, asset management, plan management, operation management, early warning plan management and other comprehensive functions for the utility tunnel comprehensive management platform according to the specific needs of actual business. Through the application of the platform, it is expected to reduce the error and leakage problems caused by collision and misalignment during the design phase. Let the government and social capital participate in the construction, management and operation of the whole life cycle of the project. The cooperation period between the two sides will be longer, the information will be more symmetrical and the risk sharing will be more reasonable. The application of BIM technology in operation and maintenance management in utility tunnel will provide effective solutions to the difficult problems of cost audit, pipeline entrance fee collection, management fee sharing mode, construction financing mode, etc. in utility tunnel, thus realizing visualization, integration, scientific and intelligent construction management of urban underground utility tunnel.

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