

Evaluation of Systems and Technologies Of Underground Pipeline Gallery, Haikou

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Abstract. As the urban areas become denser, the built environment and land resources have limited the scope for further development of the urban areas. Haikou, as one of ten pilot cities to develop underground space, is chosen as the case in this study. Haikou Underground Pipe Gallery is a current underground building structure system that maximizes the utilization rate of land. This study investigates and analyzes the most useful and valuable technologies and systems of the Underground Pipe Gallery by survey and research. The result shows that U-shape construction technology is the most beneficial one and the electrical system is the largest and most widely used one. There are four high-tech applications in the electrical system: load power supply, construction of electrical distribution, power supply cable, and lighting facilities. In addition, a combination of green (sponge project), blue (water control) and gray (underground pipe network) infrastructure is utilized to create an optimal drainage system. It has made good use of the large area of urban green space and rainwater storage facilities.

Keywords: Electrical System, Drainage System, Underground Pipe Gallery, Haikou.

1. Introduction

Many densely developed urban areas are experiencing heavy pedestrian and traffic flows leading to a congested street environment. Besides, the densely built environment and limited land resources have limited the scope for further development of the urban areas to satisfy long-term community needs.

In 2013, Haikou was chosen as one of ten pilot cities to develop its underground space. It has six underground projects that will last 100 years [1]. For example, Haikou Underground Pipe Gallery (UPG) trial began in 2015. It relates to an underground comprehensive pipeline mode and an underground space comprehensive development and utilization system [2]. The invention relates to an underground comprehensive pipeline mode and an underground space comprehensive development and utilization system. Its characteristic is to realize the maximum utilization of underground space by digging up a small area. All pipes including power lines, telecommunication pipes, water pipes, gas pipes, and tunnel comprehensive underground pipelines, comprise the comprehensive underground pipeline. Its underground transportation network connected to the underground room together, forming a unified main body structure. Thus, an underground building structure system that maximizes the utilization rate of land is formed.

This study aims at the underground building structure system UPG in Haikou and analyses its systems and latest technologies.

2. Haikou pipeline distribution

Haikou underground pipeline system relates to an underground comprehensive pipeline mode and an underground space comprehensive development and utilization system. Its characteristic is putting the power line, telecommunication pipe, water pipe, gas pipe and other pipe laid in tunnel

comprehensive underground pipeline in a small area of dug up all the available underground soil. It makes the underground pipeline comprehensively, and its underground transportation network connected to the underground room together forming a unified main body structure. Thus, an underground building structure system UPG maximizes the utilization rate of land is formed [3].

The general principle of the distribution of water and electric pipelines is that small let big, pressure let no pressure, no slope requirements let slope requirements. The main air pipe, bridge, water pipe auxiliary, all kinds of pipelines priority horizontal and compact layout, unconditionally need to be arranged up and down, by the principle of wind power under water layout. The power supply and distribution system are mainly used for power supply and distribution of self-use and lighting load in an integrated pipe gallery, which is the basis of the operation of the pipe gallery. Generally, two 10kV power lines are introduced from the nearby substation to improve the reliability of the power supply, one main and one standby, respectively connected to 10 transformers [4].

The natural gas pipeline network is mainly distributed in Jiangdong, and is divided into two sections. The second phase of the natural gas pipeline network of Jiangdong Avenue in Jiangdong New Area has a total mileage of 30 kilometers, and has been completed about 15 kilometers at present. The natural gas pipeline network of Mei'an Industrial Park is planned to be nearly 70 kilometers, and about 62 kilometers have been completed so far, which is ready to supply gas to the park. At present, Haikou's gas pipe network covers 95.3% of the main urban area, and the gas penetration rate will reach 97% by 2020 [5].

The underground pipeline is intricate, including military light, water communications gas, electricity, and other pipelines [6]. These pipelines belong to different departments, most of the administrative, and capital are not local management, and coordination is more difficult. For example, Longkun South Road originally cross Haikou, and Qionghua two cities, and the underground pipe network data is incomplete which also caused a great influence on the construction unit.

For ease of management, Haikou's "underground city" electronic map is completed (Figure 1) including a data-sharing platform for urban construction b base construction and comprehensive pipeline census data The deep underground water pipe, gas pipe, and drainage pipe are closely related to the life. For example, the urban underground pipeline bears the more and onerous task and also is the basis for normal operation of the city. Pipeline planning, construction, and overall multi-management, low efficiency, the network cut constantly, and the complex relationship of chaos exposed the c chronic city management.



Figure 1 The distribution of the electronic pipeline (the red line illustrates the main pipeline and the blue line represents the branch pipeline)

Haikou urban construction basic data-sharing platform made comprehensive use of geophysical prospecting GPS, GIS, integrated digital mapping and other technologies, and completed pipeline detection in a total area of about 240 square kilometers, with nearly 500,000 pipeline points and a total length of 9,908 kilometers. According to the data, the electronic map of the "underground city" can not only see the distribution of the underground pipe network, but also see the 3D image of the ground, observe the objects in the scene from any angle and any distance, and the arrangement of underground pipelines is clear.

In addition, there is a new trenchless pipeline repair technology used in the Haikou underground pipeline system. In the past, it was necessary to cut open the road when repairing damaged pipes. However, the use of trenchless pipeline repair technology could avoid this damaging problem. The trenchless technology is using a new drainage pipe to replace the original pipe. The old pipe is split during the operation process, and then the new pipe is "squeezed" into the old pipe inside, to replace the old pipe. For example, during construction, a large rock fractured and deformed the old sewer pipe, preventing the new pipe from connecting, so we cut a small hole in the road to remove the rock. Through advanced technology and equipment, there is no need to excavate the road, pile support, etc. The traffic impact on the ground is small, people's travel is guaranteed, and this kind of construction method does not damage the surface road, through the small-caliber cut. It can effectively avoid many social impacts brought by general construction. At the same time, the application of trenchless technology does not damage the surface, and reduces the work of road excavation in the early stage, backfilling in the later stage, road restoration, and so on. It also shortens the construction period of the project, and reduces the labor cost of the auxiliary work in the early stage and later stage.

3. Methods and results

In order to evaluate the current technologies in the underground pipeline construction, this study designs questionnaires for different technological departments in Haikou. The questionnaire includes three questions: the department participating in the UPG project, the most beneficial technologies of UPG, and the systems comprising UPG.

3.1 The Departments Participating In UPG Project

Four departments are participating in the UPG project: government departments, higher learning institutions, investigation institutions, and production enterprises. From the perspective of organizational distribution, the production enterprises and government departments account for a large proportion of this project, indicating that it is a large project, indicating that it is a large project, which requires the production and construction of a lot of materials, and the government has intervened in this management (Figure 2).

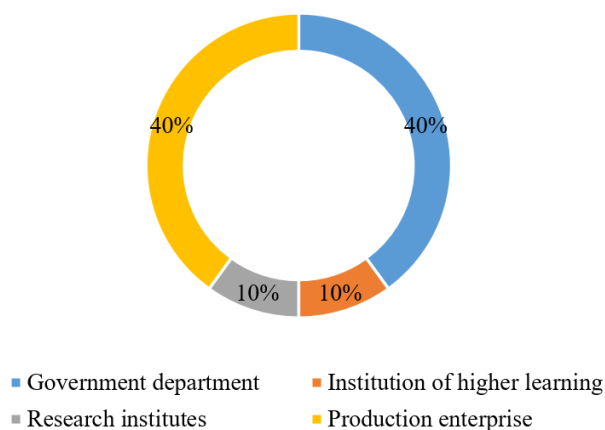


Figure 2 The percentage of each department participating in the UPG project

3.2 The Most Benefiting Technologies In UPG

As for the technologies benefiting UPG most, U-shape construction technology takes up more than half of the total (54%; Figure 3). Intelligent robot ranked second, with a percentage of 28%. By comparison, infrared sensor accounts for merely 15% of the whole while the new-lightning technology makes up only 3%.

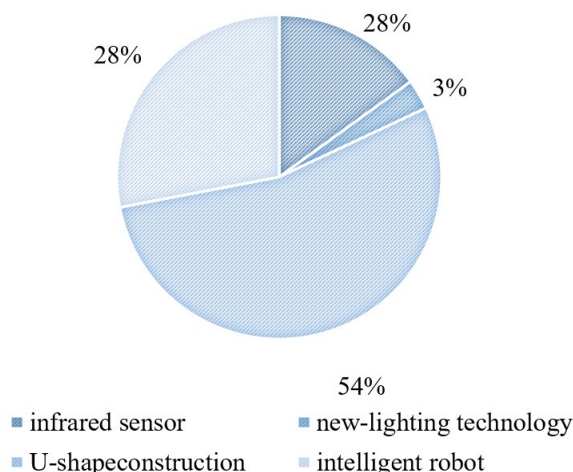


Figure 3 The percentage of each technology benefiting UPG

3.3 The Systems Comprising The UPG

It can be seen from the data that there are 4 types of systems that constitute the UPG (Figure 4). The electrical system is the largest (more than 50%). Next comes the gas system which makes up approximately 30% of the total, followed by the drainage system (less than 20%). Finally, it is the firefighting system that takes up the least of the total (less than 5%).

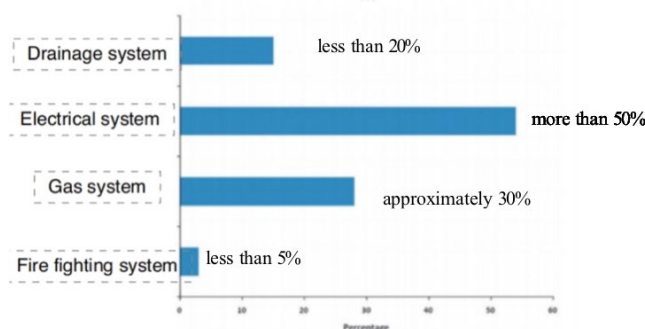


Figure 4 The percentage of each system comprising the UPG

4. Discussion

Based on the investigation results, this study focuses on the three most important systems of UPG including electrical, gas and drainage systems, and discusses the latest technologies used in these systems.

4.1 Electrical System

4.1.1 Power Supply And Distribution Equipment

Different levels of load power supply are applied in different types of equipment of the power system. Firstly, the secondary load power supply is adopted in the aspects of monitoring, emergency shut-off valve, accident fan and other equipment in the natural gas pipeline compartment. Two lines are used to supply power, and the corresponding emergency power supply is set up to ensure the effective transmission of electricity. Secondly, secondary load power supply is also adopted in the appurtenant equipment of the integrated pipeline corridor, such as fire-fighting, monitoring and emergency lighting equipment. Thirdly, the tertiary load power supply is applied in the rest of the appurtenant equipment [7].

The substation adopts two 10KV power supplies, and the power supply is taken from the local municipal power. The power supply mode is a ring-net power supply. At least two 10/0.4KV dry-type transformers are installed in the substation, and the operation mode is mutual standby or one

with one standby. This setup cannot cause big damage to the equipment even when the power supply fails. The low voltage side is wired in busbar sections, circuit breakers and automatic power switching switches are set at both busbars, and electrical and mechanical interlocking is set at the busbar switch and low voltage inlet switch. UPS uninterruptible power supply is provided for firefighting, monitoring, alarm, emergency lighting and other auxiliary equipment.

In addition, the installation of power supply and distribution equipment is suggested to be placed in a flat area as much as possible, which not only can improve the efficiency of maintenance later, but also can reduce the impact of environmental factors.

4.1.2. The Integrated Pipeline Corridor

In the construction of electrical distribution in the integrated pipeline corridor, the protection level of power supply and distribution equipment are reasonably controlled according to the installation environment of the area. In general, the protection level should be above IP65, and the corresponding anti-condensation device should be installed in the box to reduce the problem. The electrical equipment in the natural gas pipeline compartment should be installed with explosion-proof devices, and the explosion-proof level should be above ExdIIAT3.

There are three main forms of distribution stations in the integrated corridor: box-type substation, above-ground substation and distribution room, as well as underground substation and distribution room. Among them, the box-type substation is the most widely used, mainly because the laying of the integrated pipe corridor is mostly concentrated under the green belt. The use of a box-type substation can save land resources without affecting the landscape. In the design of the ventilation shaft of the integrated corridor, a series of devices including power lighting distribution cabinets, corridor lighting distribution boxes, emergency lighting distribution boxes, fan control boxes and monitoring distribution boxes are set up to ensure the power supply effect of exhaust fans, supply fans, lighting, maintenance and monitoring systems. In the choice of power supply method, the trunk distribution method is used from the box substation to the fire protection zone, while the gas cabin fan, emergency lighting and monitoring system are radial distribution with double power end switching.

4.1.3. Cable Selection And Laying

The power supply cable for non-fire protection equipment in the corridor is flame-retardant, and the power supply cable for fire protection equipment is fire-resistant. The length of the cable laying in the corridor is long. Besides the selection in strict accordance with the requirements of the code, the possible voltage changes in the event of a fire and the load capacity are accurately calculated, so as to strengthen the reasonableness of cable selection and ensure the normal operation of the equipment. In addition, if two cables are in the same cable trunking, they are separated by fire separation. The cable trunking is coated with fire paint on the outside, the connection between the bridges should be a good electrical cross-connection.

Power cable laying mainly uses two devices of cable bridges and galvanized steel pipe, and the cable is laid along the wall or ground laying track connecting to the designated equipment. When passing through the firewall, it is necessary to do a good job of blocking to avoid the spread of fire. Weak and strong cables are laid along both sides of the structure during the laying process. It is worth noting that the distribution cables for lighting, drainage pumps and maintenance power are laid in the cable bridges on the upper level of the support. The distribution cables for fire-fighting equipment and data monitoring and acquisition equipment are laid in a separate layer. Figure 5 is the cable laying diagram of the comprehensive pipe corridor supply and distribution system [8].

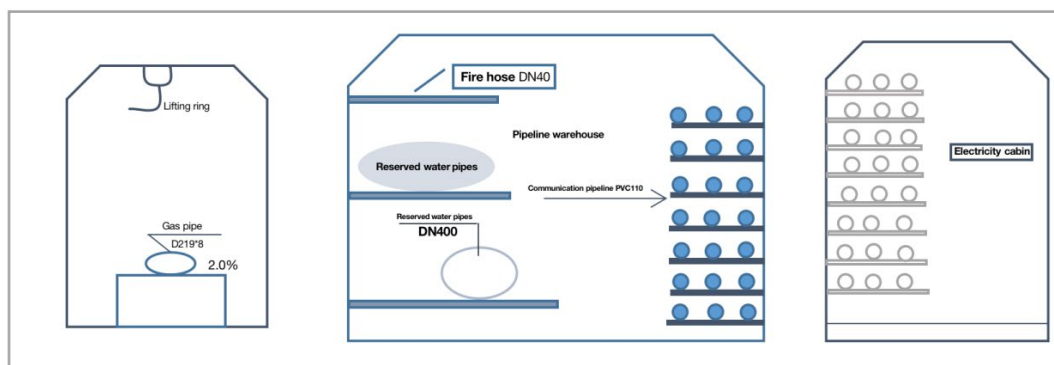


Figure 5 The cable laying diagram of the comprehensive pipe corridor supply and distribution system

4.1.4. Lighting And Alarm System

Lighting standards in different areas of the integrated corridor also have different requirements. For example, internal cabin lighting should be greater than 15lx, entrance and exit illumination should be greater than 100lx, and corridor emergency lighting should be greater than 5lx. In the choice of lighting fixtures, waterproof and moisture-proof fluorescent lamps and lanterns are considered. The lighting brightness is adjustable according to the lighting space. The use of emergency lighting equipment needs to refer to the normal lighting appliances, to ensure that its brightness is less than half of the normal lighting. In addition, the lighting fixtures need to be installed with protective facilities so that they can be used normally in an accident. Evacuation guide lights and safety exit lights are installed at the entrances and exits of the corridor and the fire doors, which are powered by emergency escape lighting. The lighting fixtures are manually/automatically controlled through the lighting distribution box, and manually controlled through the local buttons at the fire doors. Alternatively, the lighting equipment is controlled automatically and connected to the alarm system to ensure the effectiveness of lighting in disasters.

Furthermore, temperature detectors is installed on the surface of the power cables and the top of the compartment, and automatic alarm buttons and alarms are set in the area of the detector to achieve timely detection of fires and prevent casualties from occurring.

4.2 Gas Pipe System

As for the gas pipe system of UPG, the construction and renovation of natural gas pipe network facilities in major urban areas are conducted to improve the gas transmission and distribution systems.

One advantage of the gas pipe system is to ensure the purity of the gas. It meets the requirements of constant carrier gas flow and high purity of gas for analysis in the laboratory. Another advantage is the continuous gas supply. Therefore, more cylinder space is saved for the laboratory, and gas does not need to be cut off when replacing cylinders to improve experimental operation efficiency. Operators could manage fewer cylinders and pay less cylinder rent because all points of use come from the same gas source. In addition, gas outlets are placed at the right use point in the gas pipe system for providing a more reasonable workplace for staff.

This gas pipe system ensures the safety of personnel and gas storage, and protects analytical testers from toxic and harmful gases in the experiment.

4.3 Drainage System

The drainage system of UPG is of great importance to Haikou. It serves as a significant drainage tool, and is a combination of green (sponge project), blue (water control) and gray (underground pipe network) infrastructures.

Haikou follows the concept of Sponge City: allowing the city to breathe, building hard ground, and accelerating water flow downward. For example, in 2017, 16 sections of the road prone to water flooding were included in the reconstruction of the Haikou downtown area. The bridge culverts of

some sections were straightened. Some drainage pipe network systems were reconstructed in combination with the old city reconstruction system, and some new drainage pipes were built under the important underground passages that had not laid underground pipe networks in earlier years [9,10].

To protect and restore water ecological sensitive areas, white space is left at the early stage of planning, or occupied areas are given over to increase storage space. Due to the large building density and the difficulty of excavation in the old city, ecological and green building facilities are gradually developed in combination with the old renovation, and combined with gray facilities to control rainwater runoff. New urban areas are controlled from the planning level, so as to achieve emission reduction from the source.

As for water control, it is suggested to combine with the water system layout of Haikou, and increase the east-west drainage channels to intercept upstream water and relieve the drainage pressure of Longkun Ditch and Meishe River downstream [11]. In terms of the Sponge Project, the UPG has made good use of the large area of urban green space and rainwater storage facilities such as reservoirs to delay the peak flow of rainwater runoff and temporarily stored the peak flow in the storage facilities. After the flow drops, the water in the reservoir was discharged to reduce the peak flow, which improved the urban drainage and flood prevention capacity.

Recently, Haikou has adopted two types of rainwater regulation and storage. One is to utilize reservoirs, wetlands and low-lying areas for rainwater regulation and storage. The other is to use the existing green space to construct rainwater regulation and storage systems in urban areas by constructing regulation and storage pools. After the most of the underground pipe network in Haikou is completed, in addition to the pipe network transformation, it is necessary to set up drainage pump stations to increase the flood drainage capacity of gray areas, and at the same time use the green (sponge city) concept to systematically improve the local capacity of absorbing rainwater.

5. Conclusion

This study focuses on the underground building structure system UPG in Haikou, and investigates and analyses its systems and latest technologies by investigation and research. Survey results show that U-shape construction technology is the most beneficial technology for UPG. The electrical system is the largest among the 4 types of systems that constitute the UPG in Haikou.

There is four high-tech applied in the electrical system of UPG. Firstly, different levels of load power supply are applied in different types of equipment of the power system. The installation of power supply and distribution equipment is suggested to be placed in a flat area as much as possible. Secondly, in the construction of electrical distribution in the integrated pipeline corridor, the protection level of power supply and distribution equipment are reasonably controlled according to the installation environment of the area. Thirdly, the power supply cable for non-fire protection equipment in the corridor is flame-retardant, and the power supply cable for fire protection equipment is fire-resistant. Finally, lighting standards in different areas of the integrated corridor also have different requirements. Therefore, it is necessary to plan the power supply point reasonably, and strengthen the reasonableness of the power supply distance and the stability of the voltage to prolong the service life of the cable. For the equipment with high requirements of power supply level for secondary load, a reasonable power supply scheme should be set up to meet the requirements, reduce the cost investment and improve the overall quality of the integrated corridor construction.

The gas pipe system of UPG includes the construction and renovation of natural gas pipe network facilities. It not only ensures the purity of gas, but also supplies gas continuously. The drainage system of UPG in Haikou utilizes a combination of green (sponge project), blue (water control) and gray (underground pipe network) infrastructure to create an optimal drainage system. Haikou follows the concept of Sponge City, allowing the city to breathe. In addition, water ecological sensitive areas should be protected or restored. In terms of the Sponge Project, the UPG in Haikou made good use of the large area of urban green space and rainwater storage facilities such as reservoirs to delay the

peak flow of rainwater runoff and temporarily stored the peak flow in the storage facilities. After the flow drops, the water in the reservoir was discharged to reduce the peak flow, which improved the urban drainage and flood prevention capacity. Recently, Haikou has adopted two types of rainwater regulation and storage. One is rainwater regulation and storage mainly in reservoirs, wetlands and low-lying areas. The other is to use the existing green space to construct rainwater regulation and storage systems in urban areas.

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