

Reflections on the Construction of Water Supply and Drainage in Integrated Pipe Corridor of Sponge City

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Abstract: With the continuous development of economy and society and the continuous improvement of peoples' living environment requirements, the concept of sponge city construction has been recognized and understood by more and more people. The country has also recognized the significance of planning and construction of sponge cities. In the process of planning and constructing a sponge city, it is necessary to combine the reality of urban development with the construction of urban water supply and drainage systems and underground pipe corridors to promote the process of urban modernization. Based on this, this paper analyzes the water supply and drainage construction of the integrated pipe corridor in the sponge city.

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0 Overview of sponge city concept

Sponge city is also known as a hydroelastic city. It divides cities into different regions according to their needs. Building materials with better water absorption properties are used as sponges. They are mainly used in living areas and recreational areas where residents are more populated and the regional use performance is stronger. Effectively exerting the performance of building water storage materials, it will absorb as much rain as possible when there is a large amount of rainfall, which will help prevent flooding caused by the accumulation of rainwater^[1-4]. After a large amount of rainwater has been absorbed by building water storage materials, the total rainwater on the urban road

surface will be reduced to a great extent. In addition, the absorbed rainwater can also be recycled, which not only solves the problem of accumulation of rainwater but also meets the development strategy of recycling water resources in China. Sponge city concept, mainly through the use of water storage materials, is a cycle for better absorption, purification, and reuse of rainwater, which fully controls rainwater flow, prevents floods, and reuses resources. It is not only helpful to solve the hidden problems in the design of municipal drainage engineering but also conducive to the sustainable development of China's water resources.

1 The significance of water supply and drainage construction for integrated pipe corridor of sponge city

1.1 Improve environmental adaptability

The complex terrain in China has caused precipitation to be less concentrated. In regions with uneven rainfall distribution, there may be drought and flood disasters, which will be the focus of urban drainage construction. Sponge city drainage can spread water on the one hand and, according to the characteristics of sponge adsorption, optimize and improve drainage system construction, increase the use of water capital, and use scientific and effective methods to reduce the occurrence of drought and flood. The establishment of a good urban drainage system can effectively improve water resources, deal with local droughts and floods, and avoid problems such as rivers pollute the city and alleviate the pressure of urban floods.

1.2 Restoring damaged water body

Build a sponge city and optimize drainage system construction. Strengthen the construction of science

and technology for urban drainage system planning drainage, so that the characteristics of natural capital can be stored in front of the urban construction period and maintain the original urban ecological environment system. Eco environmental systems are used to optimize the environment of major cities so that contaminated water can be cleaned and reused, and maintaining the normal development of buildings will not damage the natural water environment. Building drainage should pay attention to the systematic nature of urban water resources and study the internal water recycling of the city^[5-7]. The urban drainage system and the use of land capital of the buildings are summarized and analyzed to improve the city's water capital utilization and to rationally allocate the urban underground water network.

1.3 Increase the utilization rate of urban water resources

With the rapid development and progress of economic construction in various cities, the pace of urbanization has entered the stage of improving urbanization quality as the main development goal. The constructors of all walks of life in our country must not only adhere to the scientific and new concept of urbanization development as their guiding direction but also effectively integrate the city's resource protection and construction work to carry out sustainable development, establish a new type of urban water resources system, and to improve the utilization of urban water resources. The construction of urban water resources system supported by the concept of Sponge City has become an inevitable development path. It can alleviate the problem of water shortage in the city. In the construction of the city, it can also carry out systematic construction of overall planning for rainwater and strengthen the management and treatment of rainwater^[8-10]. It can effectively use and discharge rainwater and thereby infiltrate, store, purify, and manage rainwater. This not only effectively collects and utilizes rainwater resources but also reduces the pressure on the city's water supply and effectively solves the city's flood control and disaster reduction emergency response.

2 Water supply and drainage construction application status

2.1 Insufficient use of rainwater

The increasing use of industrial materials has led to a continuous increase in the hardening ratio of urban roads. At present, most of the urban roads are asphalt

and concrete roads. The road of this kind of material accelerated the degree of runoff of rainwater and adversely affected the runoff environment of the overall water cycle, thereby aggravating the crisis of the lack of groundwater resources within the city. The construction of China's rainwater utilization project started relatively late, and related technologies are not advanced enough. In addition, the overall structure of the internal pipelines in our cities is not perfect, and even rainwater and sewage pipelines share the situation, leading to the obstruction of rainwater recycling.

2.2 Insufficient ability to withstand heavy rainfall during short durations

The greenhouse effect caused the temperature to fluctuate significantly, resulting in the frequent occurrence of short-duration and heavy rainfall^[11]. The characteristics of the excessive intensity and time instability of strong rainfall in short durations also increase the extent of surface runoff in local formations. In the past, the structure of the urban drainage system was not stable enough to result in insufficient capacity for short-duration heavy rainfall, and it was unable to guarantee effective drainage of rainwater during short-duration heavy rainfall events, leading to the occurrence of internal flooding in cities and flooding also aggravated urban water resource pollution, which had adversely affected the personal safety of urban residents.

2.3 Facility maintenance efficiency is not high

In the process of urbanization, with the continued expansion of urban construction areas, higher requirements have been put forward for water supply and drainage systems. In the past, urban water supply and drainage pipelines could not meet the needs of urban water use at the present stage in terms of structure, quality, and overall length. At the same time, the continuous increase of the urban population base has also aggravated the demand for urban water resources in social life. The relevant departments in the urban construction phase have not paid sufficient attention to the underground and water supply system construction and have also led to the imbalance of underground facilities and ground facilities in the process of urban construction^[12]. In addition, due to the neglect of the management of urban water supply and drainage systems by some people in the process of urbanization, the maintenance and management of the urban water

supply and drainage system were not standardized enough, which restricted the stable development of urban water supply and drainage systems.

2.4 Poor weather resistance

In recent years, the occurrence of extreme weather has brought even more severe challenges to the construction of the city. These extreme weathers are characterized by abruptness and intensity, such as continuous stormy snowstorms and typhoons which can easily lead to water supply pollution and flooding and can also cause great damage to the city's infrastructure and road congestion, etc. Severe extreme weather may even affect people's lives and property safety. However, the current urban infrastructure construction in China has weaker resistance to extreme weather, resulting in even greater damage and losses. The later repair work is difficult and affects the further development of the city.

3 Key points for water supply and drainage construction in integrated urban pipe corridor

The sponge city concept has important guiding significance for the future development of the city. At the current stage of development, we must recognize the practical problems faced by urban development, combine the characteristics of the city's own development and, under the guidance of the concept of scientific development, attach importance to the protection and development of the environment and optimize urban water supply and drainage systems and underground pipeline construction to create a better urban environment for people.

3.1 The application of sponge city concept

3.1.1 The infiltration concept of sponge city

In the urban construction, the main objects of the paving design are the landscapes of the municipal public area and the residential area. In the traditional paving process, not only does the applied material have poor water permeability but it also seriously affects the quality of the rainwater that is used for permeation and recycling. Efforts have been made to improve rainwater infiltration through the effective use of paving designs or to use rainwater ditches in the streets around the city for rainwater storage. Second, the paving design of urban pervious roads has caused poor rainwater

penetration on the ground due to the continuous expansion of pavement construction area in traditional urban construction. To improve this situation, permeable concrete can be paved on the roads and parking lots of the communities. This not only enhances the penetration of rainwater but also effectively reduces surface runoff and facilitates the underground drainage and storage of rainwater. At the same time, it can also replenish rivers and groundwater through effective decontamination and discharge, effectively controlling the loss and pollution of water resources.

3.1.2 The concept of storage in sponge city

First, design the storage module. The design of the rainwater storage module belongs to a high-tech product. It not only has a large bearing pressure but also can achieve a good water storage effect in an effective space and can also be combined with a waterproof cloth or a geotextile for water storage and discharge. Through the reasonable settings of the inlet and outlet pipes and the water pump, the stored water resources can be used for toilet flushing, road surface cleaning and irrigation of lawns, and other water facilities. It can even be used for cooling water circulation and firefighting water. Second, design underground reservoir. The collection process of rainwater mainly includes eight components: Pool, sand-draining wells, high ventilation caps, low ventilation caps, inlet pipes, outlet pipes, ventilation systems, and overflow pipes. In the selection of large green plants such as shrubs and trees, light porous aggregates are generally used to match them. The particle size is >25 mm, and the depth of the aquifer should be >60 mm. In the selection of hedgerows and vines, ceramsites with particle size of 15–20 mm are generally used to match them and the depth of the aquifer reaches 80 mm.

3.1.3 The concept of stagnation in sponge city

First of all, the design of the rain garden will generally set the grass in the marginal area so that the stormwater runoff can be trapped in this area before entering the buffer zone. The setting of the buffer zone not only needs to put some fine stones to buffer the runoff velocity and filter impurities but also has the plants with strong moisture resistance as the dividing line to effectively prevent the loss of plants after rainwater wash out. Second, the design of ecological detention areas can be carried out in two ways. One is the grass groove design. This design is mainly used in residential areas, industrial

areas, commercial areas, parks, and other areas. It not only has strong input capability but also has strong ability to cut pollution and purify, which can effectively replace the roadside rainwater pipe and rainwater ditches system; the other is the design of a rainwater pond, which is also known as a seepage pond, which not only achieves good rainwater permeability but also makes full use of natural and artificially constructed ponds and depressions to supplement groundwater, effectively reducing the peak runoff.

3.1.4 Concept of purification, use, and discharge in spongy city

In view of the current status of urban development, the cost of urban green space construction will be higher than the road surface design, but urban green space construction still use the stone to isolate the green belt from the road, which is unfavorable for the absorption and utilization of rainwater.

To enhance the water absorption of the city and enable the city to have a high water absorption capacity like a sponge, the use of sunken green space is a more effective technology application. It not only brings a different style to the city's landscaping but also the application effect is also significant. The effective way of sunken green space not only enhances the city's water storage and purification capacity but also increases the city's storage capacity. The main construction modes include wet ponds and wetlands.

3.2 Focus on planning and leading

Under the background of the sponge city, it is necessary for the city to continuously develop the concept of the sponge city in the construction of the water supply and drainage system facilities and truly build the city into a place with good "elasticity" and better environmental adaptability. Therefore, it is necessary to pay attention to planning and leading. In the process of urban planning, it is necessary to conduct a comprehensive plan for the overall development of the city. At the same time, special planning strategies and constructive planning strategies must also be established. Integrate specific planning behaviors into the overall planning goals. In addition, it is also necessary to reduce the impact of planning on cities as much as possible. By focusing on the management of stormwater runoff and the construction of urban stormwater systems, we can effectively improve the urban water supply and drainage status from the source. Effectively relieving

urban floods has also enabled the full use of rainwater resources. This has a significant significance for the construction of a sponge city and the formation of a complete water circulation system within the city.

3.3 Scientific construction of integrated pipe corridor

In urban planning and construction, it is necessary to comprehensively consider various factors that affect urban development, make overall plans for all types of construction, and integrate the overall planning with the specific plans for each construction. In the specific planning process, it is necessary to minimize the impact, specify the specific development goals, take into account the city's natural environment, geographical environment, and humanistic environment, in particular, have a full understanding of the city's precipitation, water reserves, and other conditions, strictly control urban stormwater runoff, eliminate water pollution from the source, make full use of rainwater resources, and establish a complete internal water circulation system.

From the perspective of the construction of the sponge city itself, the construction workload of the sponge city is relatively large, the structure is complex, and the construction workload of the underground pipe corridor is huge. It also involves the construction of other pipelines. Therefore, it is necessary to link a series of links such as water supply, flood control, drainage, and water cycle protection, make overall planning, and finally scientifically promote urban water supply and drainage construction and the design of underground pipe corridor.

3.4 Coordinate the construction of underground pipe corridor

Sponge city construction is a huge engineering system. In addition to the water supply and drainage system construction in the process of urban construction, it will also involve other aspects such as communications, electricity, gas, and monitoring. Therefore, in the process of construction, it is necessary to strengthen the communication with other departments, reduce construction resistance, strengthen communication, reduce redundant construction and useless construction, and regard the construction of different pipelines in the city as a unified whole, paying attention to its coordination.

3.5 Doing relevant pilot work

The pilot study is conducive to enrich the sponge city construction theory and address all kinds of practical

problems. We should increase the pilot strength on the existing basis, use existing sponge cities as the foundation, and conduct scientific research on the basis of ensuring the safe operation. In the construction practice, it is necessary to actively introduce the advanced experience of building a sponge city, especially the technology of using rainwater and water resources, so as to make this work standard, and further promote the promotion of the sponge city. Take the successful experience in Bristol, the UK, as an example. The difference between the city and most of the sponge cities in China is mainly because the city has a small population. Therefore, the city can carry out large-scale ground facility construction. For large cities in China, large-scale ground facilities do not seem feasible to ensure land use efficiency. In the follow-up work, the three-dimensional application of urban space can be considered, such as the use of the residential area roof and green space in the community. Greening the roofs of residential buildings and making them work together with the green belts on the ground to store rainwater, allow them to directly infiltrate into the ground and use them in a centralized manner, such as irrigation of green land, and improve the utilization of natural precipitation. The three-dimensional application model of urban space is shown in Figure 1.

3.6 Optimizing the top-floor design

The top-floor design can be seen as the basic guarantee for the development prospects of the sponge city in China. Overall, the experience of building a sponge city in China is scarce, the practice time is short, and there is a lack of processing experience in facing some common problems, which is also one of the reasons for the various problems that exist in the current water supply and drainage system of the integrated pipe corridor

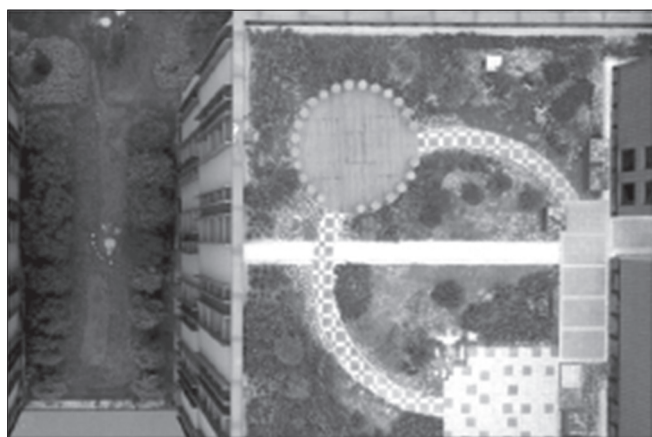


Figure 1. The three-dimensional application model of urban space

of sponge city. In the follow-up work, optimization of the top-floor design can start with two aspects: (1) Summarize the experience of domestic sponge city construction and carry out summary analysis and promotion and (2) learn from the experience of foreign sponge city construction, analyze the similarity between the object and our country's city, and summarize the experience and generalize^[2]. Taking the experience of foreign sponge city construction as an example, Bristol, the UK, is a typical sponge city and its drainage system is well designed. When rainfall occurs, rainfall is directed through the equipment to the surface for concentration. The concentrated water resources are used for agricultural irrigation and planting through a series of natural streams, pipes, channels, etc. The water resources with low use value and high impurities are used for irrigation in urban green lands to maintain a livable and green urban environment. China can learn from related experience to optimize the top-floor design of domestic sponge cities.

3.7 Realizing the connection of pipeline and big data

With the development of smart cities, the application of big data technology can provide assistance for urban construction and improve the efficiency of urban system operation. In the construction of water supply and drainage in the underground integrated pipe corridor, the construction of intelligent monitoring facilities is part of it. If we can realize the interconnection of drainage pipelines and big data, it will be of great help to enhance the construction and maintenance of water supply and drainage in integrated pipe corridors. Based on this, to meet the needs of urban intelligence and technological development, it is necessary to rationally design ancillary facilities and realize real-time monitoring of integrated pipelines during construction. The personnel of the control center can track the running dynamics of the pipeline all the way. With a click of the mouse, they can grasp the actual situation of the underground pipelines, improve the safety, stability, and standardization of the pipeline operation, and lay a solid guarantee for the operation and maintenance management in the later period.

3.8 Vertical treatment of pipelines and drainage pipe networks

First of all, we must rationally plan and optimize the layout of the integrated pipe corridors and drainage

networks. In general, urban drainage networks are mostly collected and discharged by districts and are located in different districts. They are located at the junctions and are connected at local locations. If the rainwater pipe network zone and the sewer network zone are appropriately merged, the zone boundary lines will be overlapped, and an integrated pipe corridor will be set up using this boundary line to relocate the trunk pipe that can be integrated into the pipe corridor to the line position, so as to reasonably avoid intersection of the drainage networks. Second, priority is given to the drainage line. Integrated pipe corridors should avoid the drainage pipelines. It is unrealistic to separate the drainage pipeline network from the overall layout of the pipe corridors. In particular, some areas are first to develop specialized pipeline network planning and then to develop integrated pipe corridor planning. In the construction process, the uncoordinated elevation of pipe corridors and drainage pipelines can easily occur. Based on this, to carry out the construction of integrated pipe corridors, we must adhere to the principle of giving priority to the construction of drainage pipelines. Finally, the drain line passes through the gallery and can be set in inverted siphonage. When there are problems such as large construction difficulty or high construction risk, such as when the soil thickness on the top of the pipe gallery is >6 m, the drainage pipeline can be used to avoid the plan of the corridor. When there is a vertical elevation conflict between the two, the elevation of the integrated pipe corridor remains unchanged, and the drainage pipeline passes through the pipe corridor in an inverted siphon manner.

3.9 Formulate a systematic development plan

The construction of the “sponge city” is a long-term and complex construction process. It is necessary to integrate the manual management with the ecological environment and effectively maintain the internal ecological environment of the city through urban planning, flood discharge, and ecological environment maintenance. Improving the environmental benefits of the construction of water supply and drainage systems will provide a guarantee for the stable operation of urban society. Therefore, in the process of urbanization, relevant management personnel should make a preliminary assessment based on the actual situation, combined with the current urban water supply and drainage system operation and the scale of urban development, comprehensively consider

the current topography, cultural characteristics, and other factors, and formulate a systematic water supply and drainage system development program for “sponge city.” In the process of the construction of the sponge city, the overall planning of the city should be formulated with the principle of scientific overall planning, combined with construction standards and control schemes. During the operation of the system development plan, the construction standards for the various stages of the drainage system can be formulated in accordance with relevant laws and regulations, and measures for the construction of green water supply and drainage systems can be carried out according to the development of the times, that is, to minimize the adverse effects of construction operations on the surrounding ecological environment, adopt the concept of green development, and solve the construction water pollution from the root. While improving the efficiency of rainwater utilization within a city, it can also promote effective urban afforestation and optimize urban landscape projects.

4 Issues needing attention in the construction of water supply and drainage for integrated pipe corridor in sponge city

The construction of integrated pipe corridor for water supply and drainage can be carried out in detail, but in combination with past experience, there are still some practical issues that need attention, including: (1) The setting of the hole of the underground pipe rack needs to be combined with the actual situation. The general pipeline can use waterproof casing and can also use the pipeline shaft. Rainwater circulation ventilation of underground pipe corridors should use mechanical ventilation, and underground ventilation of wastewater should use mechanical ventilation. Disinfectants plan the number of air changes per hour as required. (2) According to the length of the integrated pipe corridors, the lifting of the pipe corridors and the location of the lifting equipment and straight line sections are usually one for each group. The depth of the underground pipes is determined, and the relative cable tunnels are selected based on the plant equipment basis. (3) Pipeline maintenance facilities set up at the bottom of each pipe as an empty pipe drainage facility. Corridors may also appear in the groundwater seepage, drainage pipes, and water collection wells on both the sides or side of the pipe rack. The well depth is 800–1000 mm. The pool drainage pump can be

installed to each well pump with a pump flow of 10–20 m³/h or according to the pipe diameter, length, inlet, etc. In addition, it is recommended to use a submersible pump with good corrosion resistance. (4) The various facilities of the underground pipe corridor such as water collection wells, hole drainage pumps, pipes, ventilation shafts, and serial numbers should be the same. Outdoor underground utility tunnels are usually planned by multiple structural planners. When planning, the boundaries between the tunnels must be in a consistent order to ensure that their readings are accurate and prevent omissions. (5) Control of storm runoff pollution. Rainwater runoff can be polluted. Therefore, in the process of urban water supply and drainage, it is necessary to pay attention to the control of stormwater runoff pollution. In particular, it is necessary to combine construction planning goals with actual operating conditions in accordance with the requirements of relevant departments. In the more polluted areas of China, construction workers and relevant department leaders need to combine the special experience of the region in the process of carrying out their work, and choose the water supply and drainage design scheme suitable for the construction and development of the region according to local conditions, and try to use as many solutions as possible. The most appropriate programs and methods are selected to ensure that during the process of constructing a sponge city, pollution control of the entire process can be achieved, and the water cycle capacity of the urban ecosystem can be restored to ensure a substantial breakthrough in the construction of urban water supply and drainage systems in China.

In short, in the sponge city, the importance of an integrated pipe corridor is even more prominent. Sponge

city is not only a concept but also requires it to actually solve the problem of water accumulation in the city. This poses a high requirement for the performance of the city's comprehensive pipe corridor. It is very necessary to analyze the current problems of the water supply and drainage system of the integrated pipe corridor in the sponge city and to discuss feasible proposals.

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