Study on Arrangement of Waterlogging Control Storage Tank in City Village

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Abstract. In recent years, the problem of waterlogging in Chinese cities has become increasingly serious, and it is extremely urgent to solve the problem of waterlogging. Urban rainwater storage plays an important role in the prevention and control of waterlogging disasters. The control effect of the internal control of the storage tank is closely related to its layout position. On the basis of comprehensive consideration of the hydrological mechanism for reducing rainwater floods and the requirements for urban flood control, the Huangbian City Village of Panyu District, Guangzhou City was taken as an example to construct a one-dimensional, two-dimensional, pipe network coupled hydrological hydrodynamic model to study urban locusts and the optimal arrangement of the storage tank. The results show that compared with the centralized storage tank is arranged at the lower section of the pipe network bottleneck section and waterlogging point, arranging the storage tank in the upper section of the bottle neck section can not only significantly reduce the drainage pressure of the pipe network, reduce the flood area of waterlogging, but also reduce the storage capacity of a single storage tank and improve the feasibility of engineering construction. The arrangement method can effectively realize the storage function of the storage tank.

1. Background
In recent years, the waterlogging disasters in Chinese cities have become increasingly serious, restricting the rapid development of social economy. Since the release of the "Sponge City Construction Technical Guide" in 2014, various technologies, such as source reduction, midway transfer, and end storage, have adopted to achieve the city’s benign hydrological cycle by using means such as “infiltration, stagnation, storage, cleaning, use, and drainage”. The low-impact development concept of improving the ability to infiltrate, regulate, purify, utilize and discharge runoff rainwater has become the guiding concept of urban construction and waterlogging prevention [1-2]. As an important facility for reducing flood peaks and storing rainwater, the rainwater storage tank is widely used in urban flood control projects [3-5].

The storage tank used for the prevention and control of waterlogging can improve the storage volume of the rainwater system, reduce the flood peak, reduce the downstream pipeline flow, and reduce the water level of the downstream pipeline. However, its treatment effect is closely related to the arrangement position of the storage tank. In recent years, domestic and foreign scholars have gradually studied the location of the storage tank. Liao Chaoxuan et al [6-7] studied the hydrological mechanism of rainwater storage facilities to reduce rainwater flooding, and found that the storage effect of the rainwater storage tank near the upper and middle reaches of the urban drainage system is better than
near the downstream. Mascarenhas et al. [8] studied the effects of rainwater storage facilities on the prevention and control of waterlogging in highly urbanized areas. The results show that under the conditions of reasonable layout and volume design, the storage tank can effectively reduce the risk of waterlogging. Wu Xianping [9] combined with the engineering case study and concluded that the decentralized storage tank can achieve better results than centralized storage. The centralized and decentralized arrangement of the storage tanks has a small difference in the total storage and storage volume. However, the decentralized storage tank can effectively reduce the volume of a single storage tank, and is more implementable in areas where land is limited. Based on the comprehensive consideration of the hydrological mechanism for reducing rainwater in the storage tank and the requirements for urban waterlogging control, this paper takes Huangbian Village in Panyu District of Guangzhou as an example. According to the distribution of drainage capacity of the pipe network and the distribution of waterlogging location, the scale and location of the arrangement of the storage tanks are determined to reduce the waterlogging points.

2. Research area
Located in the south-central part of Guangzhou City, Huangbian Village is affiliated to Shiqiao Street in Panyu District. It has a population of 9,630 and an area of 0.4km². It is surrounded by Donghuan Road, Dexing North Road, Fuhua East Road and Dabei Road. It is surrounded by built-up areas and is one of the typical urban villages in Guangzhou (figure 1). The terrain of Huangbian Village is high on the edge and low in the middle. The elevation of the ground in the village is only 7.4~9.0m, and the elevation of the surrounding road reaches 8.1~20.0m, which is characterized by dish shape. The drainage network in the village and surrounding areas is mainly confluence system. The upstream drainage division is mainly in the north, east and south. The catchment area of each district is 13.48hm², 11.56hm² and 29.31hm² respectively. The current drainage network in the northern catchment area mainly flows along the north side of Donghuan Road and Huangbian New Road from north to south. The eastern catchment area mainly flows along the Dexing North Road and Huangbian Avenue from the east to the west. The south side catchment area mainly flows from the south to the north along the Huangbian New Road. The three catchment areas are converged to the intersection of Huangbian Avenue and Huangbian New Road, and then flow westward into Huangbian channel along Huangbian Avenue, and finally flow into Danshan River. The water level of the Danshan River is affected by the downstream sluice pumping stations and tides, and the top support of the Huangbian Village and the nearby regional pipe network is obvious. Because of the dish shape landforms, during the rainfall period, a large amount of water inflows, coupled with the water level of the Danshan River downstream, caused the problem of waterlogging in the Huangbian Village to be very serious. In recent years, waterlogging disasters have occurred frequently, which has seriously restricted local social and economic development.

Figure 1. Research area
3. Model building

Taking Huangbian Village as an example, this paper uses the MIKE series model to construct a one-dimensional, two-dimensional, pipe network coupled hydrological hydrodynamic model to study the optimal arrangement method of the waterlogging control storage tank. In order to simulate the role of the downstream river channel water level in the drainage of the pipe network, a Huangbian River one-dimensional river channel model was constructed. The model range is from the drainage outlet of Huangbian Village pipe network to the intersection of Huangbian channel and Danshan River, with a total length of 845m. The downstream water level boundary is taken from the measured water level of the Danshan River, and the upstream is coupled with the pipe network model. The two-dimensional model is constructed to simulate the in-situ hydrophobic process on the ground. The model range is 66.98hm². Orthogonal grid is used to construct 365×643 grids. In the building location, high elevation is unified. Construct a pipe network model to simulate the process of production and distribution of the Huangbian Village and its surrounding areas and the drainage process of the pipe network, and use the measured topographic data to divide the sub-catchment area. According to the land use data, the water impermeability of each sub-set water area is determined. The model range is 104.17hm², and a total of 389 sub-catchments, 989 tube wells and 956 pipelines are constructed. After the construction of the one-dimensional, two-dimensional model and pipe network model, a one-dimensional, two-dimensional, pipe network coupled hydrological hydrodynamic model is constructed. The upstream of the one-dimensional model is coupled with the drainage port of the pipe network model, the two-dimensional model is coupled with the pipe well, and the two-dimensional model and the pipe network model are combined to construct 960 coupling connections.

4. Problem analysis and programming

4.1. Problem Analysis

The main reason for the serious problem in the Huangcun village is that the rainwater pipelines along the north side of the Donghuan Road and the eastern side of the Dexing North Road are connected to the Huangcun Village. During the rainfall period, the pipeline in Huangbian Village not only discharges the rainwater from the village, but also discharges the rainwater from the north side of 11.93hm² and the east side of the 22.22hm² catchment area. The ability of the pipe network to absorb rainwater is obviously insufficient. In addition, the influence of the dish-shaped landforms and the water level of the Danshan River in the lower reaches caused frequent waterlogging disasters in the low-lying areas of the village. The tube network fullness distribution map and the waterlogging simulation results under the design of rainfall conditions are shown in figure 2. According to the distribution map of pipe network fullness under the condition of design rainfall, the pipelines along Huangbian New Road, Huangbian Avenue and Donghuan Road are too full, the drainage capacity is insufficient, and there is a high possibility of waterlogging disasters along the line. The storage tank should be arranged in the above-mentioned pipe section with low drainage capacity. According to the waterlogging simulation results under the design rainfall conditions, the main intrinsic point is located in the low-lying area along the Huangbian New Road and the Huangbian Road intersection and the southern side of the 70m Huangbian New Road. The waterlogging area with a water depth of more than 0.15 m is 2238m², and the maximum submerged depth is 0.95m.
4.2. Program development

In order to study the optimal arrangement method of waterlogging control storage tank, two remediation plans were formulated according to the centralized arrangement principle and the distributed arrangement method, combined with the drainage capacity of the pipe network and the distribution of low-lying and easy-to-waterlogging points. Heavy rains or continuous rainfall within the towns and cities exceed the capacity of urban rainwater facilities to cause water accumulation on the urban ground. The rainwater storage tank mainly reduces the flood peak by increasing the storage capacity of the rainwater system, reducing the downstream pipeline flow and reducing the pipeline water level. Therefore, the layout of the storage tank is closely related to the capacity of the rainwater system and the distribution of low-lying and easy-to-waterlogging points. It is advisable to comprehensively determine the scope of the arrangement based on the above two elements.

According to the drainage capacity of the pipe network and the distribution of low-lying and easy-to-waterlogging points, the treatment plan is formulated according to the centralized arrangement and the scattered arrangement method. Scheme 1: According to the principle of end energy treatment, a centralized arrangement method is adopted. In the lower section of the pipe drainage bottle neck section, a storage tank is arranged at the waterlogging point, and the total design capacity is determined to be 1500 m$^3$ according to the coefficient of separation factor, and the storage tank is set as the receiving pool. Scheme 2: According to the principle of system management, adopting the method of distributed arrangement, three upper storage tanks are arranged in the upper section of the pipeline drainage bottleneck, the passing water inlet point on the north side and the east side of the waterlogging side, and the south side of the waterlogging point. According to the coefficient of separation method, the design capacity is 300m$^3$, 650m$^3$, and 250m$^3$, respectively, and the total capacity is 1200m$^3$. The comparison between the arrangement position of the first and second adjustment tanks and the position of the bottle neck and the waterlogging point of the pipeline is shown in figure. 3.
5. Result analysis

In this section, the coupling model is used to simulate the effect of the waterlogging control of the first and second schemes, and the optimal arrangement method of the waterlogging control and storage tank is studied.

5.1. Pipe network fullness analysis

Arranging the storage tank in the lower section of the pipe network bottleneck section can effectively reduce the fullness of the downstream pipeline, reduce the pipeline water level in the vicinity of the storage tank, and weaken the upstream support. On the north side and south side of Huangbian New Road, the fullness of the pipeline along the east side of Huangbian Avenue decreased, but the improvement effect of the pipeline along the East Ring Road was not obvious. Distributing the storage tank in the upper section of the pipe neck section can also effectively reduce the fullness of the downstream pipeline, while the upstream influence range moves up, and the fullness of the pipeline along the East Ring Road also drops significantly. In general, the arrangement of the storage tank in the pipe network system can effectively reduce the drainage pressure of the pipe network during rainfall, and the effect of the upper part of the bottleneck section is significantly better than that of the central and lower sections. Under the design of rainfall conditions, the distribution of pipeline fullness in scheme 1 and Scheme 2 is shown in figure 4.
5.2. Analysis of the effect of waterlogging control
In the first scheme, the centralized storage tank is arranged at the waterlogging point to reduce the submerge area with a depth of more than 0.15m to 1236m², with a reduction of 46%, and the maximum submerged depth is 0.45m, a reduction of 53%; In the second scheme, by dispersing and arranging the storage tank in the upstream of waterlogging points, the submerged area is reduced to 437m², the reduction is 81%, and the maximum submerged depth is 0.32m, with a reduction of 66%. The control effect of dispersing and arranging the storage tank upstream of the waterlogging point is obviously better than arranging on the waterlogging point. In addition, on the basis of ensuring the effect of waterlogging, the second scheme storage volume is reduced by 300m³, and the volume of a single storage tank is less than 50% of the required volume of the storage tank. In the central city where the land is insufficient, the scheme is more implementable. The simulated results of Scheme 1 and Scheme 2 under the design of rainfall conditions are shown in figure 5 and table 1.

5.3. Comprehensive analysis
A comprehensive analysis of the waterlogging simulation results of the two schemes shows that the centralized storage tanks in the lower and waterlogging points of the bottleneck section of the pipe network only increase the storage capacity at the waterlogging point, and do not change the flow process of the upstream pipeline. When the pipeline flow is close to the peak, the pipe network and the storage tank cannot completely absorb the rainwater in a short time, while the ground point of the waterlogging point is low, the height difference between the ground and the pipeline is small. In the case of insufficient capacity, the waterlogging is prone to occur. Therefore, the maximum accumulated water depth of the waterlogging defect point after the implementation of the first scheme is still 0.45m, and the waterlogging situation will still occur in the low-lying area. Distributing and arranging the storage tanks in the upper part of the pipe network section and the upstream part of the inner bank point increases the upstream storage capacity, and the storage tank intercepts most of the upstream passing water, so that...
the upstream flow is reduced during the whole rainfall process. At the waterlogging point, the total amount of rainwater to be consumed by the pipeline is reduced. When the pipeline flow is close to the peak in the upstream of the storage tank, the capacity of the storage tank and the upstream pipeline is still insufficient, but the height difference between the upstream ground and the pipeline is larger than that of the low-lying waterlogging point. When the capacity for consumption is insufficient, the possibility of waterlogging is relatively small. Therefore, the maximum accumulated water depth of the waterlogging point is reduced to 0.32m after the implementation of the second scheme, and the situation of waterlogging in the upper low sloping ground is obviously improved, which is a more optimized layout scheme.

6. Conclusion
The establishment of the storage tank is an important part of the treatment project. With the gradual intake of relevant research, the role of the storage tank in the prevention and control of waterlogging will become more and more important. Taking the Huangbian Village in Panyu District of Guangzhou City as an example, this paper studies the optimal arrangement of urban flood control and storage tanks on the basis of comprehensive consideration of the hydrological mechanism of the reservoir to reduce rainwater and the urban flood control requirements. The results show that, compared with the end treatment, according to the principle of system management, the distribution of the storage tank in the upstream and downstream points of the bottleneck section of the pipe network can not only significantly reduce the drainage pressure of the pipe network, reduce the flooded area, but also reduce the storage capacity of the single storage tank and improve the feasibility of the construction of the project. The arrangement method can effectively utilize the storage function of the storage tank, and provide reference for the construction of the waterlogging control project. The rainwater storage project is a systematic project. The effect of the waterlogging control of the project is closely related to the causes of waterlogging defects, the layout of the storage facilities, and the volume of the storage tank. The arrangement of the control and storage tank for the waterlogging should be comprehensively determined on the basis of analysing the causes of the waterlogging, the distribution of the drainage capacity of the pipe network, and the distribution of the waterlogging points.

The prevention and control of waterlogging should be systematically planned from the concept of source emission reduction, process control and system management. The use of a variety of technologies such as "infiltration, stagnation, storage, purification, use, and drainage" to achieve a benign hydrological cycle in the city, improve the ability to infiltrate, regulate, purify, utilize and discharge runoff rainwater.

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