Conceptual Planning and Design of Sponge Campus--Taking the South Campus of Puwan Campus of Dalian Vocational and Technical College as An Example

Liu Huiqun
(Dalian Vocational and Technical College, Dalian, Liaoning 116035)

Abstract: This article fully understands the goals and requirements of the national guidance to promote the construction of sponge cities. The author fully understands the current situation of research and construction of rainwater management, sponge cities and sponge campuses in domestic and foreign cities. Based on the natural and artificial environment characteristics of the South Campus of the Puwan Campus of Dalian Vocational and Technical College (hereinafter referred to as the campus), this article focuses on the prevention of waterlogging in the rainy season and the collection and utilization of rainwater in the campus, and follows the concept of LID, and proposes a sponge campus "2 principles→4 blocks→8 sub-items" conceptual planning and design plan. Through the conceptual design of small, source and decentralized control facilities such as permeable pavement, sunken green space, ecological grass ditch, rainwater garden, and underground storage structure, the author constructs a simulation of nature through in-situ collection, natural purification, and replenishment of groundwater.

1. Introduction

1.1. Sponge City Construction Promotion
Sponge city of international general term is "low-impact development rainwater system construction". It is a new generation of urban stormwater management concept proposed by our country, and it can also be called a "water resilient city". That is, when it rains, the city absorbs water, stores water, seeps water, and purifies water, and when needed, the stored water is "released" and used.

The concept of sponge city was first proposed at the Low-Carbon City and Regional Development Technology Forum in April 2012. Later, at the Central Urbanization Work Conference on December 12, 2013, General Secretary Xi Jinping put forward: “When upgrading the urban drainage system, priority should be given to retaining limited rainwater, and priority should be given to more use of natural power to drain water. Building natural reserves, a sponge city with natural penetration and natural purification". On March 5, 2017, at the Fifth Session of the Twelfth National People’s Congress of the People’s Republic of China, Premier Li Keqiang once again mentioned in the government work report: “Coordinate the construction of urban above-ground and underground construction, and then start the construction of urban underground comprehensive management. The corridor is more than 2,000 kilometers, and the three-year action to eliminate the key flood-prone areas in the urban area will be launched, and the construction of sponge cities will be promoted, so that the city has both "face" and more "lizi"." At the same time, the State Council and various ministries and commissions have introduced the construction of sponge cities. A series of opinions and measures have been adopted, and the state is also guiding and advancing the construction of sponge cities with...
rapid pace and high target requirements. (see picture 1)

1.2. Sponge Campus Pilots are Scarce

The General Office of the State Council requires that by 2030, more than 80% of the urban built-up area should meet the target requirements of "sponge cities". The Ministry of Housing and Urban-Rural Development, the Ministry of Finance, and the Ministry of Water Resources announced 30 sponge city construction pilots in two batches in April 2015 and February 2016. As of the previous year, the first batch of 16 pilot sponge cities has been accepted and entered the trial operation stage. Dalian City in Liaoning Province is the only one in the province and one of the second batch of 14 sponge cities in the country. Since the Sponge City project was launched in Zhuanghe City in September 2017, the pilot model area has covered many types of residential, industrial, hospital, commercial, and mountain parks, but lacks campus types.

The sponge campus is a derivative concept of the sponge city. As an indispensable and function-intensive carrier of the city, the campus is bound to be included in the pilot category.

1.3. Research Experience

Foreign research on urban stormwater management issues started early. From the beginning of the 19th century to the 21st century, many research results have been formed and used in practice. The experience and concepts of urban stormwater management in the United States, Britain, Australia, Germany, New Zealand, Japan and other countries have laid a theoretical foundation for the construction of sponge cities in my country. (See Figure 2)
The domestic research on sponge city construction started late, basically starting in the past 10 years. Moreover, the initial domestic research is relatively small. However, since 2015, the construction of sponge cities has been promoted by national policies, and research in this field has developed in a spurt. China has introduced foreign urban stormwater management experience. In addition, the researchers also study urban planning and garden landscape design from the perspective of comprehensive rainwater utilization. By 2012, researchers began to focus on solving the problem of urban waterlogging, and their research was also focused on green infrastructure and low-impact development facilities. After the launch of the pilot in 2015, researchers have added research on the design and practical experience of the pilot scheme. The research on the sponge campus includes planning concepts and design solutions, low-impact development technology research, the role of sponge campus construction in the construction of sponge cities, and the study of smart sponge campuses which based on the concept of sponge cities and smart cities.

In view of the above research, this article is a research on the conceptual planning and design of the sponge campus, a rare pilot model type in Dalian, under the guidance of the construction of the sponge city and on the basis of domestic and foreign research experience in this field.

2. Planning and Design Ideas
Take the Ministry of Housing and Urban-Rural Development's "Technical Guidelines for Sponge City Construction" and the "Guiding Opinions on Promoting Sponge City Construction" of the General Office of the State Council. Take the landscape environment renovation design of Tsinghua University Shengyin Institute (Tsinghua Sponge City Demonstration Park) and the renovation plan of the sponge campus of Shenyang Architecture University as a reference. The goal is to conceptually plan and design a sponge campus with natural accumulation, natural penetration, and natural purification. By understanding the current status of the hydrological environment and rainwater system in the South Campus of the Puwan Campus of Dalian Vocational and Technical College, we discovered the existence or potential problems of the campus flooding and rainwater collection and utilization. Researchers divide the sponge campus reconstruction and construction zones on the basis of existing campus development, following the concept of low-impact development (LID). Based on the conceptual sponge design of the campus buildings, roads, landscapes, facilities, equipment, pipe network, etc., a conceptual planning and design plan for the construction of the campus sponge campus is proposed. (See Figure 3)
3. Environmental Overview of the Campus

The South Campus of the Puwan Campus of Dalian Vocational and Technical College is located in Shihe Street, Jinpu New District, Dalian City, Liaoning Province. The campus plot is planned on the south side of Linpiahai Highway, and it is roughly square, covering an area of 350,000 square meters and a building area of 167,200 square meters. The construction area is concentrated on the west side of the plot, and the overall terrain is flat. There is one open-air standard playground in the northeast corner of the plot, two adjacent ponds on the east side, and one gentle slope mountain covered by vegetation in the southeast corner.

The Jinpu New District where the hospital is located is a low mountain and hilly area, with high terrain in the middle and low wings and no water for passengers. Most of the rivers in this area are seasonal rivers with short processes, and the per capita water resources are less than 500 cubic meters, which is a resource-type water shortage area. The region has a warm temperate semi-humid monsoon climate with oceanic climate characteristics. The region has a mild climate, humid air, four distinct seasons, obvious monsoons and strong winds. The rainy and dry seasons are distinct, precipitation is concentrated, and the annual precipitation is 300-900mm. Among them, more than 50% are concentrated in summer, and the annual precipitation in this area has shown a linear downward trend in the past 40 years.

4. Rain and Flood Problems in the Hospital Area

4.1. The Risk of Waterlogging in the Rainy Season

First, the hospital area is located in a resource-based water-scarce area. However, the summer rainfall is concentrated, and there are mountains in the southeast corner. During the rainfall period, the mountain land flow time is short, the production flow is large, and the infiltration volume and low water storage volume are relatively small. Therefore, most of the rainfall will be converted into surface runoff in a short time, increasing the discharge burden of the hospital area. Second, the large square in the center of the courtyard and its radiating trails are impervious floors with hard bricks, which are more conspicuous in rain. Although the playground in the courtyard is pavement with permeable asphalt, there are such problems. Third, the roads and parking lots of the hospital area are all permeable asphalt pavement. However, the raised curbs separate the roads and parking lots from the surrounding green spaces, and the green spaces cannot absorb the accumulated water in time.
4.2. Rainwater Collection and Utilization
First, the courtyard buildings are concentrated. Most of them are multi-storey buildings, most of them have sloped roofs, and some have flat roofs. The rainwater on the roof is directly discharged to the outdoor ground through the rainwater drainage system, and there is no rainwater storage function, so rainwater recovery and recycling cannot be realized. Second, the existing functions of the green space in the courtyard are mostly landscape and leisure, without the "sponge" function. Third, the pond in the courtyard has the function of rainwater storage. However, the ponds in the courtyard do not have supporting facilities for water treatment and recycling, and do not have the function of rainwater recycling and reuse.

5. Conceptual Planning and Design of Sponge Campus

5.1. The Basic Principle

5.1.1. The Principle of More Modification and Less Construction
Following the concept of low-impact development (LID), on the basis of the development and construction of the existing campus, the campus is divided into flooded areas and rainwater storage areas. Moreover, targeted construction is less, and more renovation is made to protect the original ponds, slope vegetation and other ecological systems in the courtyard to the greatest extent. In addition, maintain the natural hydrological characteristics of the campus.

5.1.2. Principle of More Storage and Less Discharge
Follow the sponge city's 6-character policy of "infiltration, retention, storage, purification, use, and drainage". This policy breaks the previous “quick drain” cognition that the faster and more rainwater drains, the better, and it closely combines rainwater infiltration, retention, storage, purification, reuse, and discharge. In addition, while solving the problems of waterlogging prevention and runoff pollution control in the hospital area, the utilization of rainwater resources and the maintenance of water ecology should be fully taken into account.

5.2. Planning Framework
Based on the two principles of more reconstruction and less construction, more storage and less drainage, the courtyard area is divided into four types of blocks: waterlogging inundation area, rainwater storage area, waterlogging area and rainwater storage area. Then, for the 8 objects in the block, including playgrounds, squares and their radiating trails, driveways, parking lots, buildings, green areas, mountains, and ponds, design "sponge" reconstruction or construction measures one by one. The specific measures are: the ordinary playground is changed to a plastic track and lawn. The square and its radiant walkway modify the linear drainage system. The open curb was modified on the road, and the parking lot was modified to brick permeable ground. At the same time, the building modified the roof rain drainage system. In addition, the surrounding sunken green space was constructed and the green space was changed to an ecological tree pond. Renovate recessed green spaces and build rainwater gardens in ponds. An ecological grass-planting ditch is built under the hillside in order to achieve the 6-character goal of "seepage, retention, storage, purification, use, and drainage" of the sponge campus. (See Figure 4)
5.3. Sub-design

5.3.1. Playground Renovation
Transform the original permeable asphalt pavement of the playground into a plastic pavement for runways and walkways. Construct a green lawn in the center of the playground. If possible, make recessed green spaces around the playground. In addition, the method of strengthening natural infiltration is adopted to solve the problem of water accumulation in the playground on rainy days.

5.3.2. Square and Trail Reconstruction
Renovate the hard-paved central square and the rain drainage system of the radiating walkway. Starting from the purpose of not destroying the landscape, increasing beauty, and enhancing drainage, a linear drainage system was added. The square area uses a slit linear drainage system, and the trail area uses a curb linear drainage system. A rainwater storage tank is set at the end of the linear drainage system, and the stored rainwater can be used for gardening and irrigation in spring and autumn, and it can also be used as a backup water source for fire fighting. The system also does not need to set up a storage tank, but connect the rainwater discharge outlet at the end of the system to the pit pond in the courtyard. When adopting this method, it is necessary to take measures to prevent backflow.

5.3.3. Road Reconstruction
The traffic road in the courtyard is pavement with permeable asphalt and rain drainage system. There are green belts along the road, but the raised curb separates the road from the green space. Therefore, the roadside needs to be transformed into open curbs to open up the function of green space to absorb road water. However, construction personnel should pay attention that the soil surface of the green land cannot be higher than the road surface. Otherwise, the soil is easily washed down by rain when it rains, which will not only cause soil erosion, but also block the road drainage system.

5.3.4. Parking Lot Renovation
The asphalt pavement of the parking lot was transformed into a permeable brick pavement. When it rains lightly, rainwater infiltrates directly through the permeable pavement without forming runoff. When it rains heavily, the rainwater that fails to seep in time will form runoff, or be discharged through the drainage ditch around the parking lot, or flow into the recessed green space next to the parking lot.
5.3.5. Building Rain Drainage System Transformation
Most of the buildings in the courtyard are sloping roof buildings with a slope of >150. Solar water heaters are installed on most roofs, and the monsoon wind is obvious and the wind power is relatively high. Because of the complexity of the green roof structure and high requirements for roof load and waterproofing, the difficulty of reconstruction and the high cost of construction, the sponge building renovation only renovates the roof rainwater drainage system and adds rain buckets with landscape and purification functions. In addition, we can also collect rainwater from the roof that was drained directly to the outdoor ground into a rainwater bucket. The collected and purified rainwater can be used for domestic water in the building, water for sanitation cleaning in the courtyard, and green irrigation in the courtyard in the dry season.

5.3.6. Green Space Renovation and New Construction
All existing green spaces in the courtyard will be transformed into recessed green spaces, and all ordinary tree pits in the courtyard will be transformed into ecological tree ponds. In addition, a recessed green space was added around each building. The purpose of these measures is to increase natural infiltration, conserve groundwater, delay the peak time of rainy runoff in the hospital area, reduce peak flow, and lay a solid foundation for "storage, purification, use, and drainage".

5.3.7. Mountain Reconstruction and Construction
The gentle slope mountain in the southeast corner of the courtyard is reserved for the expectation of building a mountain park. Before development and construction, in order to prevent rainy mountain runoff from leaking into the hospital area, it is planned to build a transmission-type ecological planting ditch with a width of 2m and a depth of 1m between the hillside and the courtyard. The transmission type ecological planting ditch is used to collect, transport, reduce and purify rainwater runoff. At the same time, it connects the rain garden to build an ecological sponge connector in the courtyard.

5.3.8. Pit Pond Renovation and Construction
Combined with the garden landscape design of the courtyard, it integrates two adjacent ponds and their surrounding terrain, vegetation and other factors. Comprehensive design and construction of a general rainwater garden. The content includes: ecological grass ditch, ecological retention area, artificial wet pond, etc. The overflow of the rainwater garden is connected to the municipal drainage pipe network to discharge excess rainwater. The rain garden should be connected to the third-phase construction of the mountain park, as an important part of maintaining the natural hydrological characteristics of the courtyard, and constructing the core function of the LID sponge campus.

6. Conclusion
The conceptual planning and design of the LID sponge campus of the South Campus of the Puwan Campus of Dalian Vocational and Technical College should be based on the maximum simulation of natural hydrological processes. In addition, in consideration of the natural and artificial environment of the hospital area, in view of the rain and flood problem in the hospital area, the proposal of "2 principles→4 blocks→8 points" is proposed. This program has played a role in water collection through "stagnation", "infiltration" and "drain". This program can effectively solve the problem of waterlogging on campus. Although the program has water storage, water purification and water use measures. However, the utilization rate of rainwater recycling is not high, and the plan does not involve content that is connected with the sponge city, which needs to be improved. In the future, we should further revise and perfect the sponge campus planning and design plan in practice, and provide experience support for the redevelopment of the campus and the construction of the sponge campus simultaneously. At the same time, we should connect the sponge campus with the sponge city. In addition, construct a high-quality and extendable sponge campus construction plan with source emission reduction, process control, and system governance.
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