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Research about Rain Flood Management in Campus Landscape Design

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Abstract: Taking Jiangxi Science and Normal University as an example, this article applies rain flood management into campus landscape design, utilizes the runoff coefficient method to calculate the amount of collectable rainwater in campus, further puts forward economical and practical rainwater collection and application schemes aiming at different rainwater collection approaches including roof, green land, square and water pond and so on, thereby setting up a "green" mode for the campus landscape design in Nanchang region.

Introduction

Water is one of the natural resources human being contacts most in daily lives. With the advancement and development of society, the problem of water resource consumption is becoming increasingly urgent. The total amount of our country's water resource is 2812.4 billion cubic meters, ranking 6th in the world. However, the water resource occupancy volume per capita in our country is only 2,695 cubic meters, lower than one fourth of that of the world average. The severe water shortage limits our country's urbanization process, GDP growth and the improvement of people's living level[1]. On the other hand, urbanization changes the original ecology of water circulation mode more and more, resulting in the increase of ground runoff water volume, the reduction of ground water infiltration rate and the deterioration of water quality. College campus generally has a vast area, a concentrated population and a big water demand, so utilizing rain flood management techniques in campus landscape construction can not only improve waterlogging disaster, but also relieve the contradiction between school development and environment maintenance.

1. Campus overview

1.1 Geographic position

Nanchang of Jiangxi province is located in the subtropics of the northern hemisphere. According to the division stipulated in *Climatic Standard of Construction Regions*, it has a subtropical monsoon climate with abundant rainfall, the average rainfall reaching 1,600 millimeters over the past years. While, its rainfall is not even in distribution, during the flood season from April to July, the rainfall approximately takes up 48% of that of the whole year. In addition, rainstorm, flood and other climatic disasters frequently happen. Jiangxi Science and Normal University is located in Hongjiaozhou, Honggutan New District of Nanchang. The region is in the mud flat of west bank of the Ganjiang River, having dotted lakes and interconnected water

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network, so it can not only drain off flood water, but also an important tourism resource in the urban area. Combined with the water system and terrain, a “three vertical and five horizontal” waterscape network is formulated in the district so as to forge a water town of Nanchang with heavy oriental charm. The Wusha river flowing through the college’s east edge, the campus is “walled” by the water channels and connects with the Wusha river, thus enjoying an advantageous water resource.

1.2 Campus environment

The campus base is an irregular trapezoid land, 1,400 meter long from east to west and 900 meters in width from north to south. Its net land area is 92.38 hectares, the total construction area being 411,761 square meters, building area being 73,977 square meters, having a plot ratio of 0.45 and a greening rate of 15.8%. The original location is mostly fertile farmland, so the underground water level is relatively high, the original landform had a low terrain and small fluctuation. In the west and middle parts of the college is a tract of water pond, covering an area of about 180mu.

2. Exploitable rainwater amount calculation

2.1 Rainwater collection formula

Collected rainwater amount m^3=area of rain collectionm^2 x annual average rainfall$m$ x runoff coefficient[2]

Area of rain collectionm^2=building roof aream^2+green land aream^2+road and square aream^2

Based on the statistical data from many years, the average rainfall of Nanchang is 1.6m. The runoff coefficient[3] values of different underlying layers are taken according to *Design Guidebook for Water Supply and Drainage*. In this research, the runoff coefficient of building roof is 0.9, that of park or green land is 0.15, while that of road and square being 0.8. The total building roof area within the research region is 73,977 square meters, that of green land is 117,165 square meters, that of road and square being 714,658 square meters. If utilizing the seasonal compensation of 80% for the calculation, the amount of collectable and exploitable rainfall of Jiangxi Science and Normal University is 839,525 square meters.

2.2 Potential analysis

Based on the calculation, the annual average amount of collectable and exploitable rainfall of Jiangxi Science and Normal University is 839,525 square meters. If these rainwater is directly discharged into underground municipal sewage pipes without treatment, it will intensify the discharge pressure on municipal water drainage network, prone to cause waterlogging while wasting a large amount of exploitable water resource. The treated rainwater via rain flood management technology can be used to irrigate plants and road surface, replenish landscape water, wash toilets and so on. In addition, this will reduce RMB 2million of campus water expense every year. Therefore, Jiangxi Science and Normal University has excellent natural conditions and expectable economic profit in terms of rainwater collection and application.

3. Rain flood management measures and approaches

The technical measures of rain flood management are mainly divided into two types, one is rainwater retention and infiltration, the other is rainwater storage and purification[4].

3.1 Rainwater retention and infiltration

Natural precipitation finishes its circulation process via natural evaporation, plant retention, ground surface sinking, depression filling and so on. While, large areas of ground hardening change the sinking coefficient of original ground surfaces, intercepting the natural circulation. In addition, changes of lower packing layer create large amounts of irregular ground runoffs, brushing vegetation and consequently bringing environmental pollution. Roof precipitation is directly guided to sewage pipes via downpipes, then directly discharged into rivers together with collected rainwater from roads, thus underground water loses infiltration and replenishment. The corresponding measures can be categorized in 3 aspects:

1) Build roof garden to intercept, retain and filter precipitation; the rainfall exceeding the treatment capacity can be guided to the ground by downpipes;

2) Permeable pavements should be adopted, greenbelts should be designed with proper amount of shallow grassed waterway, sunken green land, plant buffer strips so as to further retain rainwater, restore soil infiltration ability and replenish underground water;

3) The redundant rainwater after treatment by the above-mentioned two measures should be introduced into rainwater garden and underground storage pond in case of water usage by firefighting, greening and irrigation. The rainwater beyond the capacity should be finally discharged into natural water bodies through municipal pipes.

3.2 Rainwater storage and purification

The retained rainwater can’t be utilized directly because it may contain pollutants from air, waste water and soil. The impurities in rainwater are comprised of the basic substance in precipitation and additional impurity caused by the regions it flows through, which mainly include chlorine, sulfate radical, nitrate radical, sodium, ammonium, calcium, magnesium, other ions(density mostly lower than 10mg/L), some organic substance(being volatile compound mainly) and small amount of heavy metal(for example, Sn, Cr, Ni and etc.)[5]. Therefore, rainwater must be purified through the 3 main measure as follows:

1) The plant root system and plant layer of roof garden can filter rainwater preliminarily;

2) Ground greenbelt and rainwater garden can take secondary filtration, absorb and purify heavy metal and organic pollution in rainwater via plants(refer to figure 1);

3) Overground and underground water storage pond can finally filter and purify rainwater via techniques including microorganism degradation, plant absorption, anaerobic precipitation, aeration oxygenation.

Figure 1 Campus layout drawing of Jiangxi Science and Normal University

4. Campus landscape design planning under rain flood management

4.1 Rain flood management of roof

The building roof area of Jiangxi Science and Normal University reaches 73,977 square meters, in which the regions being able to be used as roof garden are mainly arts building cluster, comprehensive teaching building, vocational education training building, administrative building and student dormitories, which have all sorts of flat reinforced concrete roofs with good rigidity and small deformity. Based on rigorous seepage-proofing treatment for basement layers, roof greening design can be carried out combining with building shapes. Roof greening has the functions of retaining rainwater, reducing top floor temperature, decreasing heat loss in winter, as well as providing comfortable and environment-friendly resting surroundings for the teachers and students.

Plant species should be mainly focused on indigenous plants with short stems, shallow root system, strong drought resistance, cold resistance and adaptability, such as, Lagerstroemia indica, Forsythia suspense, Hibiscus syriacus Linn, Rosa chinensis, Rhododendron simsii Planch, Parthenocissus tricuspidata, Terram operimentum and so on.

Rainwater after preliminary plant filtration can be directed to ground green land via downpipes for further treatment.

4.2 Rain flood management of green land

Campus green land is mainly divided into two categories, that is, building environment green land and road landscape green land.

4.2.1 Rain flood management of green land of building environment

Building environment green land mainly refers to the greening region near buildings. The rainwater in this region includes collected rainwater from roof and rainwater collected by the green land itself. It is not big in area and distributed around buildings. The rain flood management mainly adopts sunken green land, the plant layer being 10 cm lower than roads. Generally, green land is higher than road or square, which causes rainwater on green land surface to flow rapidly down to much lower road or square, and discharge through rainwater outlets. Sunken green land matched with abundant moisture-proof plants can collect the precipitation on square naturally, then reduce its flowing speed in it, preliminarily purify the rainwater and sink it back to the underground by root system filtration and soil infiltration. Meanwhile, overflow ports are placed between plant layer and square layer. The rainwater beyond green land's storage capacity can be directed into wetland and pools for abandoned water via underground pipe network for further purification and recycling.

4.2.2 Rain flood management of green land of road landscape

The campus roads are mainly comprise of a "four horizontal and five vertical" road network, especially, Baihua Road, directly facing the main entrance of the south gate, is a spacious and flat road with a width of 108 meters. It directly reaches the round flag-raising square before the library, intersects with the 70-meter-wide Hongde Road and forms the main road. The road surface is concrete, which not only causes a lot of runoffs, but also intercepts soil sinking routes. Taking Baihu Road as an example, the first remedial measure is to use greenbelt to divide it into two single-way roads, that is, No.1 Baihua Road and No.2 Baihua Road, then on both sides, use greenbelt to divide again to get two non-vehicle lanes, further set sidewalks on both sides of each road, thereby controlling concrete road surface with the most proper area. The second remedial measure is to lay permeable square bricks on the sidewalks, then backfill gravels underneath them to form sewer, seepage well and etc.[6] so as to improve water permeability, make rainwater sink back rapidly and prevent water accumulation. In addition, water-absorbing bricks with different colors can be combined to form various patterns in order to improve the ornamental value.

As partitions of roads, the greenbelts have a remarkable area, so they can be combined via many approaches to facilitate rainwater recycling.

1) Big arbors can be planted to form the first water retention strip. Their big crowns and dense leaves can slow down the falling speed of rainwater. Specifically, the indigenous tree species, Cinnamomum camphora (L.) Presl can be adopted because it can adapt to local red soil, resist moisture, while having a strong pollution-absorbing ability and being able to remain green throughout the year;

2) Spaced road curb stone guiding pools and bio-retention pools can be arranged along green land edges, which can guide rainwater on road surface into the pools firstly, then filter them and make them flow into sunken green land and shallow grassed waterways in the middle area. Afterwards, the plant root systems can filter rainwater further, meanwhile reduce flood peak impact. Grassed waterways have the conditions to form ecological communities, then their bred insects and low grade plants are all beneficial for the stability of landscape environment and natural purification of the water body. [7]The grassed waterways are designed with wave and ripple shapes, thus having the sense of rhythm and tempo. In the middle of green land and grassed waterways, the indigenous species with strong resistance, in detail, some hygrophilous or anti-drought ones, can be planted, such as, Osmanthus fragrans (Thunb.) Lour, Dypsis lutescens, Hibiscus rosa-sinensis L. var. rubro-plenus Sweet, Lagerstroemia indica, Berberis thunbergii

var.atropurpurea Chenault, Rosa chinensis and so on. In this way, flowers with abundant colors can be seen all the year round. Permeable material including pebbles, gravels and ceramsites is laid under trees, which can enrich landscape details while enhancing water seepage;

3) Rainwater collection pipes are embedded at the bottom of road curb stone rims beforehand, which connect with overflow pipes of sunken green land. They can carry redundant rainwater, guide them into underground water storage pool for further subsiding and purification, thereby using for plant irrigation and road surface cleaning.

4.3 Rain flood management of square

Campus squares are mainly distributed around various teaching buildings, administrative building and canteen. These places have large area of hardened road surface, which damages soil sinking routes remarkably, easy to create large amount of ground runoffs. Restoring rainwater sinking routes is the primary approach. In detail, permeable square bricks can be laid to improve water permeability; water collection pipe network can be arranged underground. In this way, rainwater can be drained rapidly through water collection openings and finally guided into the water storage pool in the pond area for further treatment.

The administrative building square and library square are equipped with large ecological parking lots, which adopt water-permeable pavements and turfs. On the ground are grass-leaking bricks, underneath is granular-type underlying layer. Thus, rainwater can infiltrate into underground through brick holes to replenish underground water, the redundant is discharged into underground water-storage pools.

4.4 Rain flood management of water pond

In the campus, there are two large tracts of wetland ponds, respectively located at the both sides of the library and the front of the stadium, and connected by a river channel. The library water basin mainly gathers the collected rainwater from arts building cluster, comprehensive teaching building, Baihua Raod, Hongde Road, canteen; while the stadium water basin receives that from vocational education training building cluster, gymnasium, track and field stadium, Yangfan scientific building. Mainly based on terrain of different places the corresponding sized rainwater gardens are established, then specific species of plants are planted in the low-lying land around water ponds. In this way, the filtration function of soil and plant can be utilized to purify rainwater, which is finally retained temporarily and further sink into the ponds above or under the ground. The redundant water not digested is discharged into the sewage system or goes into external rivers through overflow pipes. The detailed measures can be divided into the following three categories:

1) Pools for abandoned water with the slope of 0.5% are excavated beforehand under the ground near ponds. The rainwater overflowing from road and green land can be guided into the pools to slow down its flow speed and deposit particulate matter. Large amount of grass-planting ditches and shrub strips are arranged on the surface to retain ground runoffs. The overflown rainwater from pools for abandoned water then flows into water ponds;

2) Wetland retention strips are deployed close to pond area and floating plants are planted to further retain rainwater and absorb toxic metal particles and pollutants while providing decoration and shading for pool water. Floating leaves can absorb minerals in water as well as blocking the sunlight shining into water and restraining the growth of alga in the water body. These plants mainly include Nelumbo nucifera, Nymphaea tetragona Georgi, Acorus calamus L, Nelumbonucifera, Wolffia arrhiza (L.)Wimm.—Lemna arrhiza L, Salvinia natans(L.) All, which

have short growth cycles while being able to provide excellent water decoration and beautify environment. Zigzag bridges, waterfront plank roads and platforms are set up on water surface, which can not only create landscape, but also enhance the interaction between human being and nature and make people feel comfortable.

3) Large volume ponds per se have the functions of rainwater storage, sedimentation and purification. These two ponds are connected with the moat around the campus. As per the future planning, peripheral Wusha River will be excavated to create flowing water, beneficial for flood drainage and water purification.

5 Conclusion

Based on the geographical position and environmental status of Jiangxi Science and Normal University, this article discusses campus landscape planning and design under rain flood management modes, which effectively retains and purifies rainfall while creating a beautiful studying, working and resting environment for all the teachers and students, improves the circulation of water resource, achieves the harmonious development goals between environment exploitation and natural conservation, meanwhile establishes a “green mode” for the landscape design of colleges in Nanchang region.

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