Environmental change of rainfall erosivity based on GIS system and architectural design of sponge city

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Abstract
With the continuous development of society and the continuous improvement of scientific and technological level, it has greatly promoted the development of many fields. Especially civil engineering, civil engineering plays an important role in the development of China. Civil engineering survey is an indispensable part of civil engineering work. The application of GIS system technology in engineering survey helps to improve the accuracy and efficiency of survey, ensure the orderly development of the project, and improve the construction quality. However, rainfall erosivity reflects the potential ability of rainfall to cause soil erosion. Many scientists use R value of rainfall erosion rate to calculate soil erosion coefficient and draw curve equation. Therefore, it is an important guideline to study the spatial and temporal distribution characteristics of R value, establish simple regression function, quantitative prediction of soil and water loss, and soil and water conservation plan. With the continuous changes of economy and society, the global environment is also changing, which inevitably affects human beings. With the accelerating process of new urbanization, urban planning and architectural design are also deepening. On the one hand, it is necessary to improve the urban living environment and seriously implement the construction of sponge city. On the other hand, the green roof design of urban rainwater drainage and storage must be coordinated with it. The sustainable development of economy and society promotes the strong rise of construction industry. Architectural design is an important part of construction engineering, which can represent the construction standard of construction engineering. Based on the research of GIS system and rainfall erosivity environment change, this paper applies it to the architectural design of sponge City, and then promotes the vigorous development of urban construction.

Keywords GIS system · Rainfall erosivity · Environmental change · Sponge city · Architectural design

Introduction
In recent years, China’s socio-economic and technological development trend is good, compared with the past has made considerable progress, more and more advanced technical means and methods are highlighted in the process of urban construction. For example, GIS technology uses digital information to describe the objective entity, and uses relevant hardware and software to collect, analyze and calculate the relevant data in spatial geography (Lu et al. 2015). This paper briefly introduces and explains the definition of GIS technology and rainfall erosion, analyzes the role of GIS technology in monitoring mountain terrain, and discusses the terrain monitoring based on GIS technology (Zhang et al. 2017). In addition, by investigating the spatial and temporal distribution characteristics of precipitation and rainfall erosivity, a more accurate regression equation of precipitation erosion is established, and the recorded precipitation data are divided into days/months/years. Many factors are inseparable, such as the integrity of data and the distribution of hydrological stations (Perkins and Alexander 2013). But in the actual operation, the precipitation data of the whole survey area is difficult to obtain, it is impossible to extract the data completely and accurately, so the accuracy of the survey results cannot be guaranteed. Environmental change is the most concerned problem of many scholars at present (Piticar 2018). More energy is needed to protect the ecological environment (Rahimzadeh et al. 2009). In
the process of specific operation, we should raise funds from different angles, innovate technology, and effectively use environmental resources. Since the beginning of the new century, the climate continues to deteriorate, rainstorm events continue to increase, all kinds of floods have caused serious damage to the safety of life and property around the city, which is a major natural disaster factor affecting urban safety (Schar et al. 2004). The results show that the increase of rainfall, urban development, unscientific urban design, increased road construction and urban environmental damage are the main causes of frequent floods (Watts et al. 2018). At the same time, fresh water resources are scarce in China, and people do not pay enough attention to water saving. However, after the concept of sponge city is recognized and put into practice, it points out a new direction for urban development (Tomczyk and Sulikowska 2018). It can not only effectively reduce the risk of flood disaster, but also make better use of rainwater and flood. This is an effective way to solve the problem of urban flood (Ye et al. 2019). The core of construction project depends on architectural design (Smida et al. 2019). The quality of design work directly affects the quality of the whole project. From project quality, project investment, project schedule to the operation cost, investment return and project design after completion, it runs through the whole project and plays a vital role in the construction of the whole project (Varfi et al. 2009).

**Materials and methods**

**Data sources**

The data in this paper are collected from 9 rainfall stations in Pingjiang basin of a Provincial Bureau of hydrology, with a total period of 30 years, and the time interval is 1 h; due to the lack of rainfall process data of gulonggang station, the rainfall erosivity analysis of the station is based on the calculation results of the simple algorithm built in this paper. The information of rainfall stations in the basin is shown in Table 1.

### Digital elevation model design

Digital elevation model (DEM), a key component of basic geospatial data, is used to represent the elevation data set based on regional surface. In short, it is a numerical representation of surface morphology, and the mathematical expression format is \( Z = f(x, y) \). DEM data acquisition methods mainly include paper map, ground survey, aerial photography, and so on, which are widely used in national defense, surveying and mapping, early warning, rescue, planning, meteorology, and other fields. Table 2 shows the comparison results of the three models.

Create a 3D model of the study area based on DEM. As shown in Fig. 1, 3D rendering can improve the three-dimensional effect of the area compared with the plan view, improve the line shape, filling color and 3D quality of the area surface, and provide higher quality geographic information services.

### Calculation of erosion force of rainfall

Because of the limitation of time precision of rainfall data (only reaching 1H interval), and the research on rainfall erosivity index of the area similar to the rainfall characteristics of the study area by Huang Yan and wusuye all show that EI60 index is more suitable for rainy areas in the south. Therefore, the calculation method of the erosion force of rainfall in this paper is based on the general soil loss equation USLE. The calculation formula is as follows (this paper calls the value “calculated value,” which is different from the estimated value of each model, and based on the value, the accuracy of each simple algorithm is compared and the parameters of the simple algorithm are adjusted):

\[
R = E_{60}I_{60}
\]

\[
E = \sum_{k=1}^{P} e_k \Delta V_k
\]

| Data sources | Main content | Obtaining method/application |
|--------------|--------------|------------------------------|
| Surveying and mapping data | Topographic map | Hand drawn |
|                     | Video material | Camera shot |
|                     | Satellite image | Tile stitching |
| Water body data     | Length data   | Field survey |
|                     | Area data     | Field survey |
|                     | Water volume data | Survey statistics |

**Table 1** Comparison of main data sources, collection methods of urban water supply planning
Table 2: Comparison of three commonly used DEM models

| Model               | Advantage                                           | Insufficient                                      |
|---------------------|-----------------------------------------------------|---------------------------------------------------|
| Digital elevation model (DEM) | Simple data structure, convenient computer processing, automatic terrain extraction | Data is redundant, grid axis is exaggerated, and terrain is not accurate enough |
| Regular grid model  | Contour model                                       | Only part of the elevation value is included, and the interpolation calculation is more complicated. |
|                     | Triangular Model                                    | The elevation value in the triangle is obtained by interpolation from only three vertices. |

\[ e_k = \begin{cases} 0.119 + 0.0873 \log_{10}i & \text{if } i \leq 76 \text{mm/h} \\ 0.283 & \text{if } i > 76 \text{mm/h} \end{cases} \] (3)

**Model evaluation parameters**

The simulation results of each model are evaluated by NSE, RSR, and MAPE based on the academic ideas of Moriashi et al. The calculation formula of each model and parameter is as follows:

\[ \text{NSE} = 1 - \frac{\sum_{i=1}^{n} (Y_{\text{obs}} - Y_{\text{sim}})^2}{\sum_{i=1}^{n} (Y_{\text{obs}} - Y_{\text{mean}})^2} \] (4)

where \( Y_{\text{obs}} \) is the calculated value, \( Y_{\text{sim}} \) is the estimated value of the model, and \( Y_{\text{mean}} \) is the average value of the calculated value. The simulation results and NSE values correspond to each other. Generally, NSE values greater than 0.5 indicate that the simulation results of the model are good.

\[ \text{MAPE} = \frac{\sum_{i=1}^{n} |Y_{\text{obs}} - Y_{\text{sim}}|}{\sum_{i=1}^{n} Y_{\text{obs}}} \] (5)

In the formula, the parameters are the same as the NSE calculation formula, and \( n \) is the number of samples. The calculation formula of MAPE shows that when the absolute value is closer to 0, the simulated value is closer to the calculated value; when the absolute value is less than 0, the simulated value is larger than the calculated value; otherwise, the simulated value is smaller than the calculated value.

\[ \text{RSR} = \frac{\text{RMS} \text{DEV}_{\text{obs}}}{\text{RMS} \text{DEV}_{\text{obs}}} = \left( \frac{\sum_{i=1}^{n} (Y_{\text{obs}} - Y_{\text{sim}})^2}{\sum_{i=1}^{n} (Y_{\text{obs}} - Y_{\text{mean}})^2} \right)^{1/2} \] (6)

The closer the RSR is to 0, the better the simulation result is. If the root mean square error is equal to 0, the simulation result is the same as the calculated value. The smaller the RSR is, the better the simulation result is.

**Results**

**Verification analysis of rainfall erosivity calculation**

Referring to the classification of rainfall grade by China Meteorological Administration, erosive rainfall can be divided into moderate rain, heavy rain and rainstorm. The statistical results of rainfall frequency and rainfall proportion at all levels.
of each station in the basin are shown in Fig. 2. It can be seen from the figure that moderate rain is the most frequent type of erosive rainfall. Among the nine stations, the moderate rain frequency of erosive rainfall in station a is the highest, accounting for 50.2%, and that in station D is the lowest, accounting for 46.3%; The average ratio of rainfall occurrence times to erosive rainfall is 48.7%. The second is heavy rain. Except for stations B and D, the frequency of heavy rain is higher than that of heavy rain. Station f accounts for 35.3% of the total erosive rainfall, while station D accounts for only 17.6% of the total erosive rainfall. The average ratio of heavy rain to the total erosive rainfall is 30.4%. The proportion of rainstorm occurrence times to total erosive rainfall is the smallest, and the average value of each station in the basin is 20.9%. Among the nine stations, station D has the largest proportion of rainstorm occurrence times, which is 36.1%, more than that of moderate rainfall; The rainstorm frequency ratio of H station is the lowest, which is 15%. Generally speaking, the number of erosive rainfall in individual stations is more than that in heavy rain.

The statistical results of rainfall proportion of different rainfall duration of each station are shown in Fig. 3. It can be seen from the figure that most of the erosive rainfall in the basin is completed within 12–18 h, 18–24 h, and more than 36 h. Among them, the rainfall of 12–18 h of erosive rainfall is the largest, and the rainfall of 12–18 h of erosive rainfall at 9 station in the basin accounts for 26.55% of the total erosive rainfall; followed by the rainfall of more than 36 h, accounting for 24.52% of the total erosive rainfall; The proportion of erosive rainfall with rainfall duration of 30–36 h is the smallest, which is 9.20%.

Based on the above analysis, it can be seen that the rainfall duration of most erosive rainfall in the basin is between 12 and 24 h, most of the rainfall is completed within 12 to 18 h, or the rainfall duration is longer than 36 h, and the sum of the two rainfall accounts for 51.07% of the total erosive rainfall. The erosive rainfall with rainfall duration of 12–18 h in the basin not only occurs frequently, but also has a large amount of rainfall.
According to the maximum continuous rain intensity for 1 h, the erosion secondary rainfall in the basin is divided into four categories, as shown in Fig. 4, respectively, $I \leq 5$, $5 < I \leq 10$, $10 < I \leq 16$ and $I > 16$ (in mm/h). From the frequency of rainfall, the proportion of rainfall with rain intensity less than or equal to 5mm/h in all erosive rainfall is the smallest among all stations, with an average proportion of 18.5%, which is the smallest (13.10%) of station a, that is, the minimum of the heavy rainfall in 9 stations in the basin; The maximum value is in station D, that is, the rainfall with strong rainfall in station D is more frequent in the basin. The most frequent rainstorm in the basin is $I > 16$mm/h, accounting for 29.20% of the total erosion rainfall, of which station a accounts for the largest, reaching 36.25%, that is, the probability of heavy rain in station a is relatively large; The minimum value is 24.26% in station g, that is, the probability of heavy rain and aggressive rainfall near g station is smaller than that of other stations.

From the point of view of rainfall, it is basically consistent with the law of rainfall frequency. The rainfall in the basin accounts for the largest proportion of $I > 16$mm/h. The rainfall of 9 stations accounts for 41.9% of the total erosive rainfall, which is the largest of station a, reaching 49.89%, that is, nearly half of the erosive rainfall of station a is caused by the heavy rain of $I > 16$mm/h; The lowest proportion of rainfall in station g, which also reaches 35.17%, the lowest proportion of rainfall is the heavy rainfall with $I \leq 5$mm/h, and the ratio of rainfall in this kind of rainfall to total erosive rainfall is about 13.86%, among which, the ratio of station D is the largest, reaching 18.89%, and station a is the smallest, only 8.30%.

In a word, the areas with high rainfall are A, C and I, and the terrain is generally high and the rainfall of heavy rainfall is larger, while the rainfall with strong rainfall is more likely to occur in the middle of the lower basin. Therefore, more attention should be paid to the impact of heavy rainfall on the upper reaches of the basin.

As shown in Fig. 5, a total of 9539 erosive rainfall events were screened out from 9 stations in Pingjiang River Basin in recent 30 years. Taking rainfall P, maximum continuous rain intensity $I_60$ and rainfall duration $t$ as classification characteristic variables, fast clustering and classical discriminant analysis methods were used to classify them. Finally, 9539 erosive rainfall events were divided into three categories. The boundaries of type I and type II rain patterns intersect, while the boundaries of type II and type III rain patterns are far different, and the characteristics of type III rain patterns are obviously different from those of type I and type II rain patterns.

The rainfall erosivity of 9 stations in Pingjiang River Basin from 2016 to 2020 is calculated by USLE and RUSLE equations respectively (it should be noted that the selected index in
this paper is $E_{60}$. The annual average of each station is shown in Table 3.

In addition, in order to compare the correlation between rainfall and rainfall erosivity in the calculation results of the USLE and RUSLE methods, stations A, H, and E in the upper, middle, and lower reaches of the basin were selected to perform nonlinear fitting on them, and the two were compared. The results of the correlation difference between the two are shown in Fig. 6. In general, the calculation result of RUSLE leads to a correlation between rainfall $P$ and rainfall erosivity $R$ being about 12% smaller than the calculation result of USLE, which is close to the result of $R$ value. Among them, the H station in the middle of the basin The performance is more obvious. The correlation between $P$ and $R$ calculated by RUSLE is nearly 20% smaller than that of USLE. The other sites have similar results.

In summary, not only the calculation result of RUSLE is about 12.2% smaller than the result of USLE, but the correlation between the rainfall and rainfall erosivity will also be reduced, which is not good for the construction of a simple algorithm. Therefore, this paper chooses the method in USLE to calculate the rainfall erosivity of the Pingjiang River Basin, and analyzes it on this basis.

### Table 3  Comparison of mean annual rainfall erosivity of the two algorithms in Pingjiang River Basin

| Site | USLE     | RUSLE    | Deviation | Underrate |
|------|----------|----------|-----------|-----------|
| A    | 5538.94  | 4916.71  | 622.24    | 11.23     |
| B    | 4344.59  | 3802.83  | 541.75    | 12.47     |
| C    | 5142.01  | 4583.45  | 558.56    | 10.86     |
| D    | 3729.34  | 3228.36  | 500.97    | 13.43     |
| E    | 4021.44  | 3499.93  | 521.51    | 12.97     |
| F    | 3331.29  | 2855.24  | 476.05    | 14.29     |
| G    | 3645.51  | 3191.83  | 453.68    | 12.44     |
| H    | 4539.73  | 4060.58  | 479.15    | 10.55     |
| I    | 4203.85  | 3712.56  | 491.28    | 11.69     |

Fig. 6  Comparison of the correlation between rainfall and rainfall erosivity calculated by USLE and RUSLE. (a) USLE comparison chart at station A; (b) RUSLE comparison chart at station B; (c) USLE comparison chart at station C; (d) RUSLE comparison chart at station D; (e) USLE comparison chart at station E; (f) Bridge F RUSLE comparison chart.
**Temporal and spatial distribution characteristics of regional rainfall**

With the help of wavelet analysis, the periodic analysis of the annual precipitation erosion sequence in the Pingjiang Basin in recent years is carried out. Figure 7 shows the true contours of the wavelet coefficients. It can be seen from the figure that the annual precipitation sequence in the Pingjiang Basin changes periodically from 13-15a, 4-6a, and 1-3a over the entire time range.

Based on the statistics of rainfall in different time scales such as year, flood season and four seasons, the Kriging interpolation method is used to analyze the rainfall in different time scales of the basin. The spatial distribution of rainfall at different time scales of the basin is shown in Fig. 8.

The spatial distribution of rainfall in flood season and summer is basically consistent with that of annual rainfall, forming an “i-h-d” line. In the north of the line, the rainfall in flood season and summer is generally more, and the maximum value appears near station a, while in the south of the line, the rainfall is generally less, and the minimum value appears near station F. To a large extent, summer rainfall determines the distribution of rainfall in flood season, and the rainfall in flood season basically reflects the spatial distribution of rainfall in the whole year.

The spatial distribution of rainfall in spring and autumn is similar, and the high value area of rainfall centered on stations a, b, and e (36 mm in spring and 230 mm in autumn) is formed. However, the low value distribution center of rainfall is slightly different between the two stations. The low value center of rainfall in spring is mainly station f (529 mm), while that in autumn is station H (201 mm).

In winter, more rainfall is distributed in the central and southern part of the basin, especially near e, reaching 279 mm, while less rainfall is found in the northern part of the basin in winter, which is opposite to the performance of flood season and summer with more rainfall.

**Spatial and temporal distribution characteristics of regional rainfall erosivity**

The annual distribution characteristics of rainfall erosivity and precipitation are shown in Fig. 9. The results show that the distribution of the two peaks is bimodal, reaching a peak in June and August respectively, which may be related to the Meiyu season and the rainy season in Taiwan. The maximum rainfall in June is 238 mm, accounting for 13.6% of the annual rainfall. Currently, the monthly rainfall erosivity is also the maximum of the whole year, accounting for 18.8% of the annual rainfall erosivity.

The monthly rainfall erosivity is the smallest in December, which is 52 mm, accounting for 3.4% of the annual rainfall and 2% of the annual rainfall erosivity. The rainfall in flood season (April September) is 1009 mm, accounting for 66% of the annual rainfall. The rainfall erosivity in the same period is 3395 MJ mm h⁻¹ hm⁻² h⁻¹, accounting for 79% of the annual rainfall erosivity. The spring rainfall is 553 mm, accounting for 36.2% of the annual rainfall, and the rainfall erosivity accounts for 30% of the annual rainfall erosivity. The summer rainfall is 544 mm, accounting for 35.6% of the annual rainfall, and the corresponding rainfall erosivity accounts for 48.9% of the annual total. It can be seen that although the rainfall in summer is equal to or even slightly less than that in spring, the contribution rate of rainfall erosivity to the annual total rainfall erosivity is far more than that in spring, which may be related to the rainfall characteristics of the two seasons, that is, the rainfall duration in summer is often short, so the greater the rainfall intensity, the greater the rainfall erosivity. Based on the statistical analysis of rainfall intensity of 9 rainfall stations in the whole basin from 2016 to 2020, it is found that the total rainfall intensity in spring accounts for 32.7% of the whole year, while the total rainfall intensity in summer accounts for 39.9%. The rainfall in the basin mainly occurs in the flood season, and the rainfall erosivity is mainly concentrated in spring and summer. We should pay attention to the prevention of Rainfall Erosivity in...
Fig. 8  The spatial distribution of rainfall at different time scales in Pingjiang River Basin (A) Annual rainfall (B) Rainfall in flood season (C) Spring rainfall (D) Summer rainfall (E) Autumn rainfall (F) Rainfall in winter

Fig. 9  Annual variation of rainfall and rainfall erosivity in Pingjiang River Basin.
summer, so as to minimize the harm of soil erosion caused by rainfall erosivity.

Using Mann Kendall and linear regression, we calculated the Z and b values of each time scale of rainfall erosion Series in recent year, flood season and four seasons in Pingjiang basin, and tested them with 95% confidence level. The test and calculation results of significance level are shown in Table 4 below. The variability of rainfall erosion series in autumn is the largest, reaching 0.84 on different time scales. The coefficient of variation is 0.62. The erosion rate of the average rainfall in summer and winter decreased slightly in the year, but increased slightly in the flood season.

Figure 10 shows the spatial characteristics of the 30-year change trend of precipitation erosivity in the Pingjiang Basin. The annual rainfall erosion in the middle and east of the basin has been increasing, and there are more stations showing a downward trend than those with an upward trend. On a seasonal scale, the performance of each station in the basin is not the same.

In the mutation test of hydrological time series, due to the difference of algorithm itself and the corresponding benchmark selected by human, the results will be different, so a variety of methods are usually used to comprehensively test the mutation points of hydrological time series. In this paper, according to the mutation test results of cumulative anomaly, m-k and Pettitt, the mutation time points of Rainfall Erosivity in different time scales of year, flood season, spring, summer, autumn and winter in Pingjiang River Basin are 2016, 2017, 2018, 2019, and 2020 (Table 5).

Wavelet analysis is used to analyze the precipitation erosion sequence of Pingjiang River Basin from 2016 to 2020, and the real contour map of wavelet coefficient is shown in Fig. 11.

| Time period  | Cv   | Z    | b/MJ-mm-hm-2-h-1-10a | Significance  | Trend       |
|--------------|------|------|----------------------|---------------|-------------|
| Annual average | 0.26 | -0.034 | -100.31               | Not obvious decline |
| Flood        | 0.30 | 0.34  | 28.44                 | Not obvious rise  |
| Spring       | 0.36 | 0.37  | 20.56                 | Not obvious rise  |
| Summer       | 0.38 | -0.07 | -43.17                | Not obvious decline |
| Fall         | 0.84 | -0.31 | -3.3                  | Not obvious decline |
| Winter       | 0.62 | -1.56 | -74.4                 | Not obvious decline |

Fig. 10 Spatial distribution of precipitation erosion degree
The wavelet variance of annual rainfall erosion series is calculated and the wavelet variance diagram is drawn, as shown in Fig. 12. The peak value in the diagram is the main period in the change process of the first year rainfall erosion series. The annual rainfall erosivity of Pingjiang River Basin in recent 30 years showed significant periodic changes, and there were three peaks in the wavelet variance map.

Based on the time series of annual precipitation, annual precipitation, flood season, spring, summer, autumn and winter rainfall erosivity of Pingjiang basin in recent years, the inverse distance weight method in ArcGis10.2 platform is used for spatial interpolation, and the continuous spatial distribution of each time scale in the region is obtained, as shown in Fig. 13.

**Discussion**

Function and benefit of roof architecture design based on sponge city concept

With the rapid development of the city and the increase of high-rise buildings, greening and water resources are gradually lacking. In this case, many roofs have not been reasonably used, or simply used as "garbage dump," and their value has not been effectively utilized. From the perspective of urban development and management, people often do not put their perspective into it. Based on this, under the suggestions of scholars in related fields (ecological environment, urban planning, architectural design), the concept of roof greening with low degree of attention has attracted more and more attention. It can improve the beauty of the building and save resources, and optimize the ecological environment (Aalijahan et al. 2019). Roof greening system helps to block and store rainwater, reduce power consumption peak, prolong rainy season, and reduce the total amount of rainwater transported after rainwater. Roof greening can absorb and block 75% of the annual average rainfall, eliminate the cost loss of rainwater discharged into the sewer, improve the urban thermal environment and reduce the phenomenon of heat island (Austin et al. 2020).

With the advancement of urbanization, more and more green space is swallowed up, the ecosystem is seriously damaged, the carrying capacity is significantly reduced, and the impact of environmental change is becoming increasingly serious, which has gradually become an obstacle to urban development (Barnett et al. 2012). Therefore, the construction of greening concept can increase the urban green coverage, create enough living conditions for all organisms, and restore the balance of the ecosystem as soon as possible. Roof greening can alleviate a series of
environmental problems caused by urbanization, especially optimize the urban hydrological ecosystem.

With the continuous progress of today's social economy, the scale of transportation and industrial production is gradually increasing, which brings more serious noise pollution and obstacles to people's daily life. Even if some sound insulation equipment can be used to deal with the buildings, it has caused damage to the appearance of the city (Darand et al. 2015). In view of the above situations, urban greening is the most direct and effective way to solve this problem. In the high-rise city environment, the monotonous sidewalk is difficult to meet the aesthetic needs. However, the roof greening of buildings will bring new natural landscape lines to people. Most of the outer layers of buildings are treated with waterproof coating, but the color and shape are relatively simple. Under strong direct light, glare is usually harmful to human beings. Through the green building roof, we can enrich the city color and meet the spiritual needs of the citizens. From an aesthetic point of view,
plants of different colors and textures replace the gray and dull surfaces of buildings in a healthier way.

**Sponge city concept in the design principle of roof architecture**

China has a monsoon climate, the rainy season is difficult to evenly distribute, low temperature and less rain in winter, high temperature and more rain in summer. Due to the great damage to the environment caused by urban construction, the particularity of dry season and rainy season is very obvious. In order to increase urban rainfall and scientifically control surface runoff, it is necessary to take appropriate measures to optimize the control of ecosystem and lay the foundation for rainwater reuse. Green building should not only meet the basic functions, but also be conducive to the ecological environment (Ekamper et al. 2010). Only in this way can it be considered as an effective green roof. In the greening practice, we should strictly control the greening rate index. Only when all the requirements meet the standards can greening play its due role and bring more ecological benefits. At the same time, it is also necessary to establish a rainwater recycling system to meet the needs of plant irrigation, promote the transformation of buildings into real “sponge,” and enhance the overall practicability of buildings.

From the perspective of structural engineering, it is necessary to choose a suitable overall injection method to increase the bearing capacity. Otherwise, if the building collapse due to the deviation of architectural design, the design will be meaningless. The design process needs to carefully consider the bearing capacity of the building in order to achieve the desired goal. In some cases, structural engineers need to be invited to plan together to get better design results (Feudale and Shukla 2011).

In the planning, try to avoid using components that will damage the roof design. In the construction stage, the roof is often protected by waterproof coating, but in the horticultural process, when there are problems in the construction or operator errors, the waterproof layer is likely to be damaged. Because of this, the construction site should be far away from the weak waterproof layer. In order to avoid new problems after completion, the staff responsible for planning, site management, and construction must always ensure that the water treatment and drainage of the building are not damaged (Ghavidel Rahimi 2011).

The greening of buildings is relatively unique, so the design and construction of roof garden and country garden should be treated separately. In addition, the weight of the building itself is also limited, so the planning must fully consider the needs of compactness and aesthetics. As the roof area is constant, it is necessary to maintain an appropriate proportion of green space area and corridor. To sum up, the two core aspects of green building planning and construction are “precision” and “intelligence.” Only on this premise can the expected effect be achieved.

Due to the limited load-bearing capacity of the roof itself, it is necessary to select suitable soil for plant cultivation. Combined with practical experience, new materials such as artificial soil and peat soil are selected to reduce weight. It is difficult to support the roof when the soil is thick, and it is difficult to maintain water, temperature and nutrients when the basin soil is thin, which is directly related to the survival rate of plants.

The design process must highlight the selection of plants, and try to make a wide range of colors, such as grass and small trees (Ghavidel Rahimi and Abrams 2015). The arrangement of terrain, terrain and various objects should be uniform, and the colors must be adjusted and supplemented.

When the plant grows, the root system is not controlled and has a strong osmotic force. In the case of roof greening, considering the waterproof, it is necessary to inhibit the growth of plants, such as to avoid adverse effects on the waterproof layer and bearing layer of buildings. Therefore, it is necessary to effectively induce plant root growth in order to fully protect the top of the building. According to the above explanation, it can be said that the roots of plants should not be left to the greening of buildings. In order to avoid excessive inhibition and affect the survival of plants, and let plants grow normally, it is necessary to take control measures and give appropriate guidance.

Compared with the land, the planting of roof plants is unique, high wind, and long time exposure to the air, cannot get good protection, living environment is also very bad; therefore, in the selection of plants, we must pay attention to the requirements of wind resistance, heat resistance, cold resistance, in order to ensure the normal survival of plants and achieve its greening goal. As one of the necessary conditions for plant growth, light directly affects the growth of plants. When the sun is not ideal, plant growth is affected to varying degrees, more likely to die. The light on the roof is more than that on the ground, and there is no protection in the building. It is difficult for shade loving plants to survive when they are exposed to the sun for a long time. In addition, local wild plants should be selected according to the geographical environment. These plants have strong vitality and high survival rate, which can reduce the nursing pressure in the later stage (Gosling et al. 2009).

Plant selection requires careful consideration of water and nutrient requirements. Water is the basis of plant life. Each plant needs different amount of water. Plants that like sunlight usually need less water, which is suitable for roof cultivation. According to relevant data, Sedum is suitable for roof greening.
Design method of roof architecture under the background of sponge city

Under the background of sponge city, roof greening is the most direct performance in the process of architectural design, which highlights its uniqueness. Green roof is not only a simple meaning, successful planning and construction will bring more ecological and social benefits. As time goes on, people gradually understand the value of roof greening. In practical application, it can not only effectively protect the environment, greatly improve the ecological environment, but also reduce the heat island effect, reduce rainwater loss, and maximize the utilization of the city (Hoseini et al. 2013). Green roofs are an integral part of sustainable architecture. Flat roof green installation and maintenance is convenient, the biggest advantage is that it helps to save land and water, reduce heat, do not occupy more space and increase available space.

After in-depth study and comparison, if all conditions meet the requirements, we should carry out simple roof greening. For this type of roof, the depth of the base should not exceed 300 mm. This further improves the effectiveness of rainwater management based on traditional management mode. This kind of roof has high ecological, aesthetic and economic value. From the ecological point of view, rainwater can be effectively discharged and stored through the permeable plant surface, so as to avoid the financial cost of establishing rainwater management system, which is their important economic advantage. Generally, the construction depth of simple roof greening is 100-300 mm, because the main purpose of simple roof greening is to block rainwater and prevent loss, and the irrigation requirements are relatively simple (Maze 2006). Due to the lack of regular and continuous watering, these plants are planted in flat soil and exposed to strong sunlight, and must have certain drought resistance. Simple green roofs are also suitable for converting existing roofs, because the roof structure usually has only a few special structural requirements, and the typical load value is similar to that of the roof. On this premise, this simple green roof optimization design has a strong potential to promote the construction of rainwater storage in sponge city.

Conclusion

This chapter focuses on the flood disaster and its causes and characteristics, and promotes the planning and construction of rainwater storage facilities based on the background of sponge city construction. In general, the impact on roof greening of rainwater storage buildings under the background of sponge city plays a very positive role in promoting the construction of rainwater storage facilities in sponge city. In short, the construction of sponge city is a process of gradual development and promotion. Under this background, it is urgent to promote the planning and construction of rainwater reservoir roof greening. Based on the sponge city construction theory, through comprehensive planning and implementation, the internal relationship between people and flood, urban development and construction and ecological environment is combined to promote the concept of safe, environmental protection and more stable urban development.

Declarations

Conflict of interest  The authors declare that they have no competing interests.

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