Journal of Southeast University (English Edition) Vol. 30, No. 2, pp. 169 – 174 June 2014 ISSN 1003—7985

Practice and analysis of recycling non-drinking water from air-condition and reverse-osmosis system into rainwater collection system

Wang Xiaohong Shao Yuran Wang Jinghua

(Architectural Design and Research Institute, Zhejiang University, Hangzhou 310007, China)

Abstract: This paper is based on the rainwater collection project in the retrofit of the Dongyi teaching block in Zhejiang University Xixi Campus. The analysis incorporates the local meteorological data, recycling water utilization, and precipitation adjustment. The rainwater collection system in this program also adds the condensation water from the heating, ventilation and air conditioning (HVAC) system and the concentration from the reverse-osmosis system used for watering greens and supplying waterscapes. By calculating, the quantity of the HVAC condensation water in summer is 3.48 m^3/d, and the quantity of the reverse-osmosis concentrated water is 198 to 396 L/d. This method solves the water shortage caused by high evaporation in summer and low precipitation in winter. Supported by empirical monitoring data, the proposed method significantly increases the economic efficiency of the system during the summer period.

Key words: rainwater collection; heating, ventilation and air conditioning condensation water; precipitation analysis; reverse-osmosis concentrated water

doi: 10.3969/j.issn.1003 – 7985.2014.02.006

As urbanization has sped up in recent decades, the water resources and urban water environment are crucial to human existence and development. This phenomenon is more significant in developing countries, especially nations or regions of booming economies[1]. Currently, more than 400 cities in China suffer from moderate or severe water shortage[2]. In order to solve the dilemmas of water shortage, environment and ecology, the enviromental experts have shifted their focuses on the collection and utilization of rainwater.

Hangzhou, a typical southern city in China, has abundant water resources. However, the pollution from rainwater, domestic and industrial wastewater has exceeded the self-purification capacity of the water body, resulting in a reduced amount of usable water sources. Owing to this, Hangzhou is now a representative city with a water-quality-induced water shortage. Fortunately, the city receives sufficient rainfall with an annual volume of 1 403 mm on average. The water shortage can be significantly improved if rainwater is exploited effectively. Among the medium for collecting the rainwater, building surfaces are the best choice for the relatively higher water quality, convenience for water collection, and suitability for water recycling[3]. Other suitable surfaces to collect rainwater include road, square, playground, and green spaces. The number of potential water-collecting places in Hangzhou makes the rainwater collection scheme feasible and promising. Apart from mitigating the water shortage, the rainwater collection and recycling scheme may also contribute to reducing the increasing pressure on water supply (especially in Shanghai), as well as to relieving problems such as water and soil erosion, and river pollution.

1 General Information

Zhejiang University Xixi Campus is located in the north-west of the city center in Hangzhou. The campus has an area of 456 000 m^2 and the footprint of school buildings is 370 000 m^2. The Dongyi teaching block is seated at the east of the main entrance of university with the Tianmu Road on its south side.

The Dongyi teaching block was built in February, 1983 with a building footprint of 1 461.2 m^2, and the overall floor area of 6 949 m^2. This building was reconstructed in 2009 as an office building for the Architectural Design and Research Institute of Zhejiang University. There are about 300 people working in the Dongyi teaching block. The roof area is 1 223 m^2. The building is surrounded by 2 343 m^2 of green space and 122 m^2 of water landscape.

2 Material and Methods

2.1 Conventional rainwater system analysis

The conventional rainwater system, also known as the natural rainwater system, balances the rainfall volume, the water requirement of grassland and landscape water, the runoff volume and evaporation capacity. The number of days with insufficient rainfall can be calculated based on the conventional rainwater system. Supplement water will be added into the system manually to meet the water demand. The climate of Hangzhou is warm and humid.

Received 2013-10-31.

Biography: Wang Xiaohong (1960—), female, senior engineer, 449353165@qq.com.

Citation: Wang Xiaohong, Shao Yuran, Wang Jinghua. Practice and analysis of recycling non-drinking water from air-condition and reverse-osmosis system into rainwater collection system[J]. Journal of Southeast University (English Edition), 2014, 30(2): 169 – 174. [doi: 10.3969/j.issn.1003 – 7985.2014.02.006]

There is the plum rain season during June and July, followed by the typhoon season with heavy rain in the middle of August.

2.1.1 Balance system of daily precipitation and water requirement

The annual average precipitation of Hangzhou is 1 403 mm, with a daily average of 3.8 mm. The design rainfall intensity is 31.8 mm/d [4]. The rainfall intensity is uneven during different months and days. When it rains heavily, the redundant rainwater overflows and is discharged. However, during the period with continuous sunny days, there is a severe lack of water for the grassland and waterscape.

2.1.2 Balance system of monthly precipitation and water requirement

The monthly precipitation and evaporation is demonstrated in Tab. 1.

In the conventional rainwater system, evaporation is higher than precipitation in July, August, October and November. The runoff volume and the evaporation volume of green plants make the grassland and waterscape around the Dongyi teaching block face water shortage.

Tab. 1 Monthly precipitation and evaporation

Month	Precipitation/mm	Evaporation/mm
January	66.0	42.9
February	80.3	56.4
March	127.8	81.3
April	128.8	113.6
May	160.8	146.5
June	217.4	144.5
July	148.8	212.9
August	154.9	181.6
September	156.6	129.4
October	78.1	103.7
November	60.2	68.8
December	51.3	53.7
Annual	1 403.0	1 335.3

2.2 Existing rainwater collection system analysis

In this project, the rainwater collection system is employed to collect the rainwater from the roof. The water is filtered and disinfected by the millipore system. Subsequently, it is stored in the collection tank. The water collected will be used to water the greens and supply the waterscape. The specific process is shown in Fig. 1.

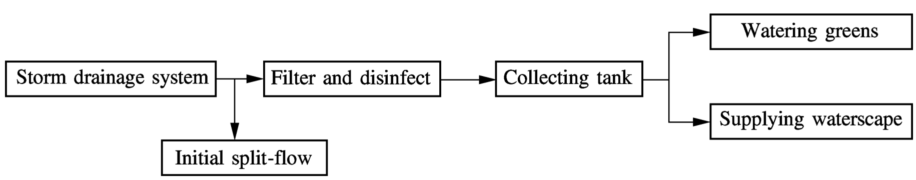

Fig. 1 Technological process of rainwater collection system in the Dongyi teaching block

The roof water is collected with the siphon rainwater collection system via the initial flow device into the rainwater utilization structures, which consist of plastic modules. The design is calculated with a 57.5 mm hourly precipitation rate in Hangzhou at one year recurrence intervals. The initial 2 mm rainwater is discharged in the initial split-flow system. After filtering and disinfecting, the water will be stored to supply water for the greens and the waterscape.

The structures are of integrated design, and the collecting tank is built with plastic modules whose loading capacity is higher than 0.45 N/mm^2. A connecting rod is used to connect each layer of plastic modules in the tank, and clamping slots are utilized to connect each line. The structure of the system is completely underground.

2.2.1 Quantity calculation of rainwater collection

1) Water quantity for watering the greens

Since Hangzhou is located in the subtropical transition zone, the climate is warm and wet with abundant water. So the majority of plants around the Dongyi teaching block are drought tolerant indigenous plants. According to Ref. [5], the quantity of water for greens can be calculated with 0.28 $m^3/(m^2 \cdot a)$. There is 2 342 m^2 grassland in this project; therefore, the annual water demand for greens is

$$Q_{greens} = 0.28 \times 2\ 342 = 655.8\ m^3/a$$

2) Water quantity for supplying the waterscape

According to Ref. [6], the volume of the supplying water should be 3% to 5% of the water circulating in the waterscape system outside. In view of the climate of the city and the situation of this reconstruction project, the quantity of the supplying water is chosen to be 5%. The area of the east waterscape is 41 m^2 and the area of the big waterscape beside the north door is 81 m^2. The depth of these two waterscapes is 0.35 and 0.45 m, respectively. So the volumes are 14.4 and 36.5 m^3, respectively. One cycle of the water circulation is 5 d. Therefore, the volume of the circulating water should be 2.88 and 7.3 m^3/d. Moreover, this system will be working for 365 d/a. As a result, the annual supplying water of waterscape including evaporation can be calculated as follows:

$$Q_{waterscape} = 5\% \times (2.8 + 7.3) \times 365 + 179 = 363\ m^3/a$$

3) Total water quantity

Overall, the volume of water for watering the greens and the waterscape are 655.8 and 363 m^3/a, respectively. The total water quantity is 1 019 m^3/a.

The annual average precipitation of Hangzhou is 1 403 mm. According to Ref. [7], the total quantity of the design runoff water can be calculated as follows:

$$W = 10\psi_c h_y F$$

where W is the total design quantity of runoff water, m^3; ψ_c is the storm water runoff coefficient; h_y is the design precipitation, 1 403 mm; F is the catch ment area, hm^2.

As shown in Tab. 2, the quantity of recycled water is estimated as 90% of the total design quantity from the runoff water, the initial split-flow is 10% generally. So the recycled water quantity Q_r is

$$Q_r = 90\% \times (1-10\%) \times h_y \times F \div 1\ 000 = 90\% \times (1-10\%) \times 1\ 403 \times 1\ 223 \div 1\ 000 = 1\ 389.9\ m^3/a$$

Tab. 2 Catchment area and quantity of collection water in project

Catchment place	Catchment area/m^2	Under layer	Runoff coefficient	Initial split-flow	Total runoff water/($m^3 \cdot a^{-1}$)
Roof water	1 223	Stereoplasm roof	0.9	10%	1 389.9

Because of the instability of rainwater, the control rate is set to be 87.9%. As a consequence, the design quantity of rainwater collection Q_d is as follows:

$$Q_d = Q_r \times 0.879 = 1\ 389.9 \times 0.879 = 1\ 221.7\ m^3/a$$

The quantity of the collected rainwater is higher than that of the annual water requirement (1 019 m^3/a). Therefore, it is feasible to fulfill the requirements of non-traditional water sources in this project.

In order to save the cost of installing the pipes and to avoid intersecting with other pipes outside, the collection tank is installed under the grassland behind the Dongyi teaching block. The rainwater is thus collected and elevated by the elevator pump before being utilized. The design daily precipitation p_d is 31.8 mm, and the control rate is 87.9%. Therefore the storage volume V is

$$V = 0.9 \times (1-10\%) \times F \times p_d \div 1\ 000 \times 0.879 = 0.9 \times (1-10\%) \times 1\ 223 \times 31.8 \div 1\ 000 \times 0.879 = 27.7\ m^3 \approx 30\ m^3$$

However, as shown is Tab. 3, the precipitation rate in a year is uneven, and the water required for watering the greens fluctuates. The collecting tank cannot be filled to its full capacity every day.

Tab. 3 Monthly precipitation and evaporation for waterscape

Month	Precipitation/ mm	Evaporation/ mm	Water inflow/ m^3	Water evaporation/ m^3	Profit and loss/m^3	Continuous precipitation/m^3	Overflow/ m^3
January	66.00	42.90	8.1	5.2	2.9	0.00	2.9
February	80.30	56.40	9.8	6.9	2.9	0.00	2.9
March	127.80	81.30	15.6	9.9	5.7	0.00	5.7
April	128.80	113.60	15.7	13.9	1.8	0.00	1.8
May	160.80	146.50	19.6	17.9	1.7	0.00	1.7
June	217.40	144.50	26.5	17.6	8.9	0.00	8.9
July	148.80	212.90	18.2	26.0	−7.8	−7.8	0.00
August	154.90	181.60	18.9	22.2	−3.3	−3.3	0.00
September	156.60	129.40	19.1	15.8	3.3	0.00	3.3
October	78.10	103.70	9.5	12.7	−3.2	−3.2	0.00
November	60.20	68.80	7.3	8.4	−1.1	−1.1	0.00
December	51.30	53.70	6.3	6.6	−0.3	−0.3	0.00
Annual	1 403.00	1 335.30	174.6	163.1	11.5	−15.7	27.2
Monthly average	119.25	111.28	14.6	13.6	0.1	0.13	15.6%

4) Monthly profit and loss vs. quantity of rainwater collection

The precipitation rate in Hangzhou is higher than the evaporation rate normally. However, in the second half of the year, the monthly average precipitation volume is smaller than the evaporation volume. In this project, the areas of the waterscape are 41 m^2 and 81 m^2, with depths of 0.35 and 0.45 m, respectively. The calculation of the monthly gain and loss of waterscape leads to an annual gain of 11.5 m^3 and a continuous precipitation of 0.13 m. As there is 0.3 m regulatory height in the waterscape in this project, it will not affect the waterscape.

Based on the calculation of this rainwater collection design in the project, the roof water is collected to water the greens and supply the waterscape; the runoff coefficient of the roof and the ground is estimated as 0.9. The quantity of rainwater is calculated as 10% of the initial split-flow.

According to the calculation, if the rainwater collection system is designed as shown in Tab. 4, it is enough to fulfill most of the water requirement in a year. However, there are periods that require supplement water due to the unevenness of the precipitation rate.

Tab. 4 Numerical procedure of annual water collection

Month	Precipitation/mm	Collection roofwater/m^3	Collection water in tank/m^3	Watering greens/m^3	Supplying waterscape/m^3		Total saving water/m^3	Profit and loss/m^3	Continuously supplying/m^3
January	66.00	71	56.8	16.8	5.7	15.3	37.8	19	0
February	80.30	86.3	69	16.8	7.6	15.3	39.7	29.3	0
March	127.80	137.4	110	50.5	10.9	15.3	76.7	33.3	0
April	128.80	138.5	110.8	50.5	15.3	15.3	81.1	29.7	0
May	160.80	172.9	138.3	50.5	19.7	15.3	85.5	52.8	0
June	217.40	233.7	187	100.9	19.4	15.3	135.6	51.4	0
July	148.80	160	128	100.9	28.6	15.3	144.8	−16.8	16.8
August	154.90	166.5	133.2	100.9	24.4	15.3	140.6	−7.4	7.4
September	156.60	168.3	134.6	50.5	17.4	15.3	83.2	51.4	0
October	78.10	84	67.2	50.5	14	15.3	79.8	−12.6	12.6
November	60.20	64.7	51.8	50.5	9.2	15.3	75	−23.2	23.2
December	51.30	55.1	44.1	16.8	7.3	15.3	39.4	4.7	0
Annual	1 403.00	1 538.4	1 230.7	656	179.4	184	1 019	211.6	0

Thus, the innovation in this project includes both the rainwater collection system design, the supplement water supply with the HVAC condensation water and the reverse-osmosis concentrated water. The latter two parts of water reduce the influence of the unevenness from rainwater collection. In addition, it helps the system to gain a stable water resource in the long term to insure sufficient water supply.

2.2.2 Influence of adding HVAC condensation water to the system

The majority of the HVAC condensation water in China is discharged. However, the HVAC condensation water is formed by condensing the water vapor in the air, which means that it is pure water. Reusing the HVAC condensation water is beneficial to protecting the environment, thus improving economic effectiveness and maximizing resource utilization. Moreover, although it often rains in summer in Hangzhou, the temperature outside is very high, leading to a higher evaporation rate. In addition, the higher quantity of condensation water in summer from more intensive use of the HVAC system makes it possible to balance the supply and demand when evaporation is taken into account.

The amount of the HVAC condensation water can be calculated by the moisture content of the outside air, the design moisture content of inside air and the fresh air volume in the system equilibrium state[8].

Therefore, the total fresh air volume is 22 600 m^3/h. The external dry-bulb air temperature in Hangzhou is 36.5 ℃, the wet-bulb air temperature is 27.9 ℃, the relative humidity is 80%, and the moisture content is 21.403 g/kg. The internal dry-bulb air temperature of the Dongyi teaching block is 26 ℃, the relative humidity is 60%, and the design moisture content is 12.947 g/kg. The density of air is 1.136 g/L. Therefore,

$$Q_{\text{HVAC condensation}} = V_{\text{fresh air}} \times (d_{\text{outside}} - d_{\text{inside}}) = 22\,600\ \text{m}^3/\text{h} \times 1.136\ \text{g/L} \times (28.403\ \text{g/kg} - 12.947\ \text{g/kg}) = 217\ \text{L/h}$$

Since the air conditioners work on average 16 h/d, the daily HVAC condensation water is calculated to be 3.48 m^3/d.

2.2.3 Influence of adding the concentrated water to the R-O system

The advantages of reverse-osmosis include no phase transition, easy operation and less pollution to the environment. It is thus widely used in water treatment. However, it produces water with a higher concentration of organic and inorganic matters[9]. In this project, all of the drinking water system in the tea rooms utilizes the reverse-osmosis system to transform tap water into potable water. As drinking water is one of the necessities in daily life, the volume of the reverse-osmosis concentrated water is relatively stable.

The key in utilizing concentrated water is to ensure the quality. Since the concentrated water in this project is produced by the reverse-osmosis system with tap water, the quality is relatively good. The disinfection and the dilution with rainwater make sure that it fulfills the standard of non-drinking water. The quality of concentrated water is shown in Tab. 5.

The design quantity of daily drinking water in the office building is about 1 to 2 L/(person · d). There are

Tab. 5 Water quality of concentrated water

Parameters	Value
pH	7.17
Chroma	1
Stink	None
Turbidity/NTU	0.22
TDS/(mg · L^{-1})	3.2
Ammonianitrogen/(mg · L^{-1})	0.02
COD/(mg · L^{-1})	12.7
BOD_5/(mg · L^{-1})	3.81
DO/(mg · L^{-1})	7.14
C_{Fe}/(mg · L^{-1})	0.08
C_{Mn}/(mg · L^{-1})	0.055
Totalresidual chlorine(mg · L^{-1})	0
Escherichia coli/(unit · L^{-1})	0

300 people working in the Dongyi teaching block. So the quantity of daily drinking water is 300 to 600 L/d. According to the product description, the amount of concentrated water is 60% of the effluent pure water leading to 198 to 396 L/d concentrated water produced daily.

2.3 Practical application of the existing design system

The amount of water collected from the condensation and the rainfall compensates for the unevenness of precipitation effectively. This makes the water tank more effective during the months with water deficits. Therefore, this part of water yield should be included in the quantity of efficient water.

We calculated the water balance, taking into account the air conditioner condensation water and reverse-osmosis concentrated water. Taking July as an example, monthly precipitation is 148.8 mm, and roofing rainfall harvesting is 160 m^3. After multiplying it with runoff coefficient and abandoning part of the initial flow of rainwater, the rainfall collection tank is 128 m^3. Combining with the quantity of air-conditioner condensation water, the reverse-osmosis concentrated water, the concentrated water discharge of 9.21 m^3 and the condensation water of 107.6 m^3, the total amount of water in the storage pond is 244.8 m^3. The landscape water demand is 144.8 m^3 in July. As above, it is easy to say that the water collected is higher than the demand, this system can, therefore, solve the water scarcity problem.

3 Results and Discussion

After a period of test runs and normal operations recently, the rain water collection system has operated in a stable and safe fashion in the Dongyi teaching block. It is an independent and self-sufficient system, which does not require extra water supply from taps.

The quality of water reaches the miscellaneous urban water quality standard.

Tab. 6 indicates that the quality of water fulfills the standard both before and after being filtered. However, the sample before filtering is of better quality than the sample after filtering. This is because the former is collected on a sunny day while the latter is collected on a rainy day. Thus, the former is made up only of condensation water and concentrated water, while the latter is mixed with rainwater. In addition, the tank was washed one day before the second sample was collected. The sediment which was at the bottom of the tank was likely to have stayed in the water with suspension. This situation should be improved when the system runs for a long time.

It was a sunny day when the samples were tested.

According to the actual measurement, it collected 6 m^3 of reclaimed water in the collection tank between 13:30 PM and 13:30 PM the next day. The water was made up of only condensation water and concentrated water. As the calculation above indicates, the amount of condensation water and concentrated water was 3.88 m^3. It seems that the actual value is twice the design value. The design quantity of condensation water can be calculated with the moisture content of air outside and inside while the system reaches the equilibrium state. Nonetheless, the actual quantity is much higher than that in the design. The reason is that the moisture content of air outside is higher than the standard value in these days in Hangzhou. Some staff in the office turned on air conditioners with windows open to ventilate the room because the building was newly renovated. It leads external air into the building, which makes it impossible for the air to reach the equilibrium state. As a result, the mass of water vapor was passively added into the system.

Tab. 6 Comparison of water quality of urban landscaping and this project[10]

Items	Urban landscaping	Before filtering	After filtering
pH	6.0 to 9.0	7.21	7.12
Chroma	30	1	2
Stink	None	None	None
Turbidity/NTU	10	6.43	7.82
TDS/(mg · L^{-1})	1 000	8	14
BOD_5/(mg · L^{-1})	20	3.84	6.78
Ammonia nitrogen/(mg · L^{-1})	20	0.28	0.2
C_{Fe}/(mg · L^{-1})		0.118	0.415
C_{Mn}/(mg · L^{-1})		0	0.002
DO/(mg · L^{-1})	1.0	6.25	6.61
Total residual chlorine/(mg · L^{-1})	Contact after 3 min ≥1.0, end of pipe≥0.2	0	0
Escherichia coli/(unit · L^{-1})	3	0	0

The area of grassland is 2 342 m^2 in this project and the daily water requirement for watering the greens is 2 L/(m^2 · d), equivalent to 4.68 m^3/d. In summer, the evaporation rate is much higher than that in other seasons, so it is in urgent need of water. As the discussion suggests, the reclaimed water together with condensation water and concentrated water can solve this problem completely.

4 Conclusions

1) Condensation water as a part of the water resources was added into the rainwater collection system in this project in Hangzhou. This is an effective mitigation measure for the high water consumption in low rainfall months. Air conditioners will be turned on for eight to ten hours daily in summer; the output volume of condensation water is sufficient and stable. After disinfecting the condensation water, water can be recycled to irrigate the greens.

2) Reverse-osmosis concentrated water as another part of the water resources was also added to the rainwater col-

lection system in this project. This is another effective way to mitigate water scarcity in low rainfall months as well. Drinking water consumption in the office building does not change much during the whole year (it is slightly higher in summer than in winter). The quantity of concentration water is 60% that of the pure water, produced by the reverse-osmosis system. Therefore, the production of concentrated water is mostly stable on a daily basis. In addition, the concentration of pollutant in reverse-osmosis concentrated water is lower than the standard for non-drinking water. Therefore, this design resolves the problems of water shortage on rainless days and helps to drain off the concentrated water.

3) In summary, rainfall is easy to collect and be used as the second low quality water. However, rainfall is unstable in a year and the high evaporation rate on hot summer days adds to the unreliability. Therefore, rainfall water alone cannot meet water demand for landscape irrigation. Condensation water from air-conditioners and reverse-osmosis concentrated water, together with the rainfall collection systems, can resolve the problems of the unstable water supply. It helps to decrease the volume of the collection tank and save the cost. It also resolves the problems of water shortage caused by seasonal rainfall and effectively recycles wasted condensation water and reverse-osmosis concentrated water.

References

[1] Gan Can, Wang Hua. Research of urban rainwater collection and utilization [J]. *Shanxi Architecture*, 2009, **35**(7): 202-203. (in Chinese)

[2] Guo Fengtai. Study on rainwater utilization engineering mode in northern cities of China [J]. *Procedia Engineering*, 2012, **28**: 453-457.

[3] Mi Sihui. Discussion of rainwater collection utilization system[J]. *Flood Control and Drainage*, 2012, **6**(6): 172-175. (in Chinese)

[4] Pan Guoqing, Che Wu. Study on the volume optimization for rainwater collection by storage tank[J]. *Water and Wastewater Engineering*, 2008, **34**(12): 42-47. (in Chinese)

[5] Ministry of Housing and Urban-Rural Development of the People's Republic of China. GB 50555—2010 Standard for water saving design in civil building [S]. Beijing: China Architecture and Building Press, 2010. (in Chinese)

[6] Ministry of Housing and Urban-Rural Development of the People's Republic of China. GB 50015—2003 Code for design of building water supply and drainage [S]. Beijing: China Planning Press, 2003. (in Chinese)

[7] Ministry of Construction of the People's Republic of China. GB 50400—2006 Engineering technical code for rain utilization in building and sub-district [S]. Beijing: China Architecture and Building Press, 2007. (in Chinese)

[8] Liang Renjian. Analysis and application of air-conditioning condensed water reusing technology [J]. *Journal of Guangdong Industry Technical College*, 2009, **8**(2): 13-16. (in Chinese)

[9] Du Anping, Zhang Dongle. Application of reverse-osmosis concentrated water recycling for circulating water[J]. *Science and Technology Information*, 2010(25): 93. (in Chinese)

[10] Zhang Jianhong, Zhang Jianmei. Green building rainwater collection and water reuse [J]. *Pollution Control Technology*, 2011, **24**(1): 41-44. (in Chinese)

回收空调凝结水与饮用水反渗透浓水并入雨水收集系统的实践与分析

王小红　邵煜然　王靖华

(浙江大学建筑设计研究院,杭州 310007)

摘要:通过浙江大学西溪校区东一教学楼改造的雨水收集工程实践,分析了本地的气象资料、回用水使用与降水时段调节等,将房间空调器凝结水与饮用水反渗透浓水予以收集归入整个雨水收集系统,用于教学楼周围的绿化浇灌与景观水的补水.通过计算,教学楼夏季空调器凝结水量约为 3.48 m^3/d,每日饮用水反渗透浓水的水量可达到 198 ~396 L.在气温较高的夏季能有效地补充因大量蒸发导致绿化浇灌及景观补水不足的缺陷,同时在降雨量较少的冬季也能一定程度上进行添补.雨水与冷凝水以及反渗透浓水一同收集大大提高了整个收集系统的经济性.项目实测数据验证了系统的经济合理性.

关键词:雨水收集;空调凝结水;降雨量分析;反渗透浓水

中图分类号:TV213.9