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Analysis of the vertical greening structural techniques of residential facades

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ABSTRACT

This paper studies the types and structural classification of vertical greening, and studies the application of vertical greening technology in people's daily lives from the vertical greening of residential buildings, such as the villas, aggregate residence, dormitory buildings and other civilian residential building facade. Main types of vertical greening are climbing greening on building facades, balconies greening, house roof garden, which combined with the plant species of vertical greening to study the necessary structure type for plant growth to smoothly cover the surface of building and obtain the main use scope and architectural forms of various structure forms. From the perspective of building energy efficiency, this paper research the energy-saving consumption effects of green facade and green roof on the building's air-conditioning electricity in the vertical greening, and compares the energy efficiency of the two ways. Finally, this paper summarized and analyzed the constructed form when using facade vertical greening in various forms of residential buildings, and analyzed the operability of construction-related technologies of facade vertical greening in urban residential building and practice application in the future residential facade greening.

KEYWORDS

Vertical greening; Residential construction Structural techniques.



INTRODUCTION

As the development of China's urban, the construction land area available in urban was dwindling. The city is the centralized function area that people to produce and living, so maintaining the necessary basic conditions for urban greening rate is suitable for living. As the contradiction was more prominent between the urban greening rates with the construction can be used, while green facades for building can reduce green covered area, which can effectively alleviate the problem. Vertical greening of house can be simply understood as the green building in three-dimensional direction, mainly for, in order to fully use of building space in the house, we planted climbing greenery in available area such as windowsill, scaffolding, balconies and walls, thereby to increase the rate of building green. It can effectively alleviate the shortage of urban green area of family and has a positive effect to improve the living environment. The most basic life behavior for people is the living, and the quality of the living environment is closely related to the quality of living of people. The problem we urgently needed to solve during the construction of urban planning is how to maintain adequate forestation rate in high-density urban living environment and improve the greening-planning framework. To solve this problem, the vertical greening technology that latest developed is one of the effective solutions that increase environment green rate. Vertical greening mainly refers to the green technology that green plants cling, hanging, stickers and other forms of vegetation along the building facade or surface of the structure. In the current urban development, vertical greening can not only occupy a small area, have good effect, beautify the environment and can enhance the artistic aesthetics of the building, so that the living environment has become more clean, lively and vivid.

THE TYPE OF VERTICAL GREENING

Climbing greening

Vine plants like creeper, galleria, ivy and contact stone have strong attachment role, these plants can be self-climbing rose along the walls, walls, fences, which do not have to add any new support bracket and traction structure artificially. The greening of these plants can reach 20 meters.

Balcony Greening

Balcony greening has a variety of different forms, for example, it can lead the green vine to windowsill and balcony to composed of green screen and play landscaping decoration for windowsill and balcony; also it can allow the plant develop in downward vertical direction to eventually form a hanging style green curtain. In the process of planting greening, you can choose the annual and biennial herbaceous green plants, such as peas, morning glory, etc. which can also plant longer growing season green plants, such as vine rose, honeysuckle, hanging money, etc. We also can decorate a variety of bonsai, flowers and trees, the choice of plant species are numerous.

Roof garden

There are various greening forms of roof garden, due to the venue area and small use restrictions, it not only can achieve the greening effect, but also can achieve good visual aesthetic effects. For example, by placing flowers and potted reasonably with color matching to form a little beautiful bonsai garden, according to the specific circumstances of the roof venue to furnish fixed pergola and potted plants, by planting flowers and climbing plants arranged on the daughter wall. If circumstances permit, we can also take the landscaping construction follow the distribution of small garden or garden, such as the construction of the pool, stacking rocks, arranged in small fountains, sculptures, etc., can also open up paths, placing tables and chairs sitting, talking, sightseeing and other activities for people when playing in the roof garden. The requirements of roof greening garden is different with the above two categories vertical greening ways in the former text. The design and the frame of the building were more stringent with higher technical requirements to ensure building safety. In the construction process, we should note the following matters:

(1) During the construction of the roof structure, the total load should be considered for roof greening to ensure the roof structure has sufficient carrying capacity. If the original architectural design of the roof structure is not included in the greening loads, the roof greening cannot be implemented in the roof from the building's security considerations.

(2) In the building with planed roof garden, waterproof of the roof structure should pay particular attention, which generally requires to lay a layer of planting bed with 2 ~ 3cm diameter of building materials such as gravel, ceramic or coke ballast. When lying ceramic, glass fiber layer is typically added to ensure the water seepage and ventilation in roof garden.

(3) Plant trees and straw in roof garden. The main trees planted are dwarf species for the arbor branch, the main choice are shallow-rooted plants such as flowers shrub class or dwarf species with not high and thin trunks, large crown and wide root growth. Grasses are generally opting the grass varieties with vitality and good adaptability to subsequent maintenance work in the garden.

(4) Chairs, rockery, rock fill, pavilion, flower racks, flower bed, sculptures, etc. should choose the small size with lighter light weight and better environmental suitability.

CLASSIFICATION OF VERTICAL GREENING STRUCTURE

Planting in ground

The initial inquiry of vertical greening is taking the ground plant as the basic direction. Ground plant refers to that green plants depend on their own means climbing ability to cover the greening. Plants which grown in the ground in general with a wound, prostrate, adsorption, hanging several capabilities.

No aid support

Plant of this type is generally planted directly in the ground plane around the direction of the building, plants dependent on their climbing abilities simplify to adsorb on the facade of the building and take the natural growth from top to bottom in the growth process. The roots of plant that can grow freely in the building facade are generally adsorption type aerial roots. Since no auxiliary support, such greening ways have less demanding to the building construction of shape and does not need to set extra support with low cost and low cost of late greening maintenance, so green vegetation is currently the most widely used vertical greening technology.

Aids support

The aids supportive greening technology refers to the ability that plants without out a strong climbing ability or adsorb the facade of the building, which needs to installed a number of brackets on the surrounded wall of the building and support components for green plants climbing surrounded on the exterior walls, which can make the green plants can rely the auxiliary support on the external walls to grow upward smoothly.

Auxiliary support type includes potted hanging, additional from the wall and traction mural style. Potted hanging refers to decorate greenery by hanging, placing or planting on the top of the wall planters, house balcony, window cornice or equal parts. Additional from the wall refers to through the auxiliary support member such as metal grid components or wooden components, etc. to ensure greenery have a smooth climbing along the facades facing. Traction mural style refers to green plants can climbing upward smoothly along the draw lines or nets by using the wire or mesh structure with nylon twine or wire on the outside of the building structure. So plants can cover the walls to reach the greening goal.

Artificial planting site

Artificial planting site is the fabricated vertical green way commonly used. This article divided the artificial planting site into pockets, boxes and media plate based on combinations type.

Pocket

Most of the pockets are made with wool material, the size of the high 38cm, width 61cm (see Figure 1), and the structure of each pocket is a separate system units. Pocket system includes green potted plants, soil and adequate nutrients for plant growth with a year. The plants in pocket system are generally greenery with underdeveloped root system and shallow root growth. Pocket generally fixed on the wall by the anchors to hang in the air. Pocket plants generally require nursing staff to regulate green drip water system depending on the nature weather conditions. Worth noting that drip water systems are generally not placed inside the high-rise buildings, while placed in the building's exterior windows account or balcony around. Meantime, due to each pocket cell is not difficult to stack, we need to pay attention to the lower portion of the pocket insufficient light conditions or excessive accumulation of water that may occur. And accumulated too much moisture at the bottom of the pocket may cause the insects gathered at the bottom of the pocket system to produce parts erosion damage to the building facade.

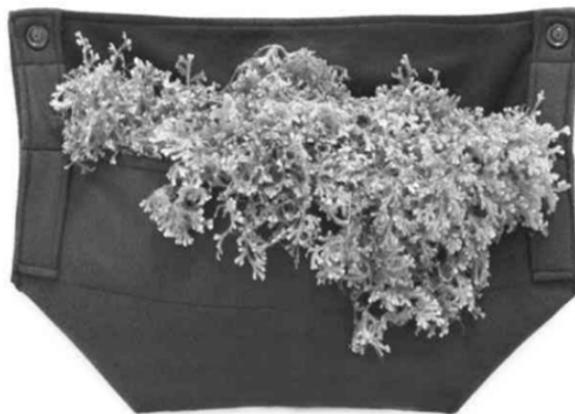


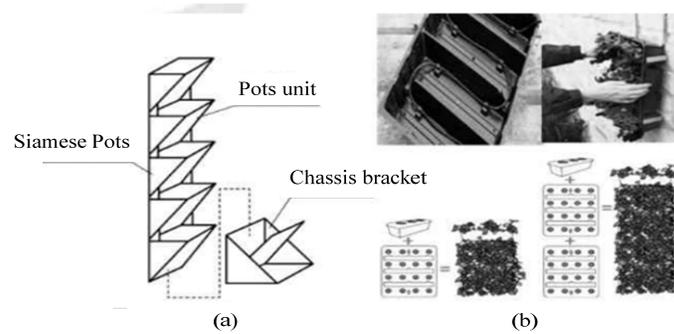
Figure 1 : Diagram of wool pocket system

Boxes type

This form of green technology was used in a wide range at home and abroad. Box greening technology emphasized that a variety of green elements to form a greening wall system, which are two ways: cassette and box.

Cartridge system refers to the green wall system is made up of many classes of green units independent of each other. As to the performing system maintenance work, few green cell systems may need to take the repair work. Each greening unit of the green cassette system has the same composition, which generally by irrigation, growth media and green parts. Irrigation system is generally taking the recycling repetition cycle operation of the system by the connection to work

through a variety of green elements. Figure 2 (b) shows that the cassette system is provided by the galvanized steel to support with a plastic box-shaped unit cell which size is 50cm * 40cm * 9cm, and the unit consists of the drainage system and composting systems. The green plants can grow in cassette are generally not more than 10cm and not more than 16. The cassette unit is divided into four sections from the inside, each part can be planted 4 plants. After watering a cassette greening system, the excess water flows into homeopathy followed by passage of the next cassette unit system. Research areas of cassette system is greater in our country, Figure 2 (a) shown the combined straight wall flower pots by Yueyi Huang, which used low basin to bracket and let multiple unit siamese pots connected by plug stack to form a green wall system.



(a) Combination arm-type of pots raised by Yueyi Huang (b) Vertigarden unit assembly and installation
Figure 2 : Cartridge systems

The box type systems are generally the green wall container system supported by steel frame, the volume is generally very large. During the design, we usually reserved the working channel for activities and maintenance. Due to its large size, large weight, and vulnerable wind and earthquake, so this system is made more stringent fixed requirements to ensure the safety and stability of the system. The green wall box-type container produced by G-sky Company was the represent of the green box system; its box-type systems have the entire covering mesh sieve with high 0.9144m and width of 1.52m. The containers are made with weld angle add-ons and high-strength bolts to connect, and then fixed generally at 40m far from the ground with high-strength bolts around the building facade.

Media plate type

Patrick Blanc is the represent that use medium plate vertical greening systems for residential building facade vertical greening. This paper illustrated such a system (see Figure 3) from the vertical greening projects on the building facades in medium plate Milburn of Patrick Blanc. The project installed a metal structure that can support 10mm thick PVC plate in the load-bearing wall surface which is the load-bearing frame of building, and PVC plate is covered with two 3mm thick layers. It used the blade to cut out a 5cm to 10cm wide size hole in the felt to plant green plants. Irrigation system is a pipeline valve controlled by the network, because of the permeability of felt material, plants can obtain nutrition growth needs, and then the rest of water will be collected and loop again.



Figure 3 : Projects in Milburn of Patrick Blanc

Analysis of green energy-saving effect

In specific practical applications, vertical greening has not only beautiful visual effects, but also good energy saving effects. People have explored the effects of different green building energy methods. The internal space volume of select test building was 55.7 m³ and the roof area was 36.2m² (Figure 4). The average electricity consumption and energy efficiency of air-conditioned are shown in TABLE 1. From the TABLE, the energy-saving effect of facade is superior to energy-saving effect of roof garden.



Figure 4 : Test building

TABLE 1 : Average electricity consumption of air conditioning and the power saving rate of test building

Project	Daytime	Night	All day
Average electricity consumption of air conditioner without green building /(kWh /d)	3.73	3.40	7.13
Average electricity consumption of air conditioner with the green roof /(kWh /d)	3.55	2.79	6.34
Average electricity consumption of air conditioner with the three-dimensional green /(kWh /d)	2.41	1.88	4.29
Saves electricity consumption with the green roof /(kWh /d)	0.18	0.61	0.79
Saves electricity consumption with the three-dimensional green /(kWh /d)	1.32	1.52	2.84
Conserve electricity rates with the green roof /%	4.83	17.94	11.08
Conserve electricity rates with the three-dimensional green /%	35.39	44.71	39.83

VERTICAL GREENING OF RESIDENTIAL FAÇADE

On the basis of residential buildings in different building categories, it can be divided into villa, collective dormitory and residential building. The vertical greening of the three will be different because the factors such as the height of the building, customer demand and so on.

Villa buildings villas

Villas are usually single with multi-storey or low-rise buildings, which demanded the beautiful extent of facades and structure form. First, villa as a pure living life, which demanded beautiful living environment, so the level of greenery of villa surrounded also generally higher and coordinated with the external environment, which need to create a certain harmonious beauty of vertical greening of facades shall. Secondly, if child and elderly lived in villas, the greenery that not easy to attract insects gather should be chosen generally. At the same time, you should choose a higher pollen content of less greenery.

Collective dormitory

Collective dormitory buildings are mostly civilian high-rise residential buildings in urban which take the family as the unit; generally the beautiful requirements of facade are not very high. Since the height of the building is generally higher, green plants of building facades are often in high altitude, which made higher requirements of the selection of green plants. It generally require placement vertical sturdy anchoring member on building facade to pull green plant growth. So that greens

can smoothly green cover the building facade, due to the higher altitude, the stability degree of the traction device and post-maintenance updates work has proposed a high technical requirements. In the current high-rise residential building façade, vertical greening means have two methods: segmented and box.

Segmented vertical greening means a kind of composite mode that take the integration between the form of potted hanging of green plants and the form of other types of green plants on surface. At the high-rise position of residential buildings, we use the trench holes and the arrangement of pot to make the greenery growth freedom to the down direction along the outer wall of the building to covered building wall. While at the bottom position of the construction, we make green plants climbing along the outer wall to cover the wall by planting vertically green plants in the ground.

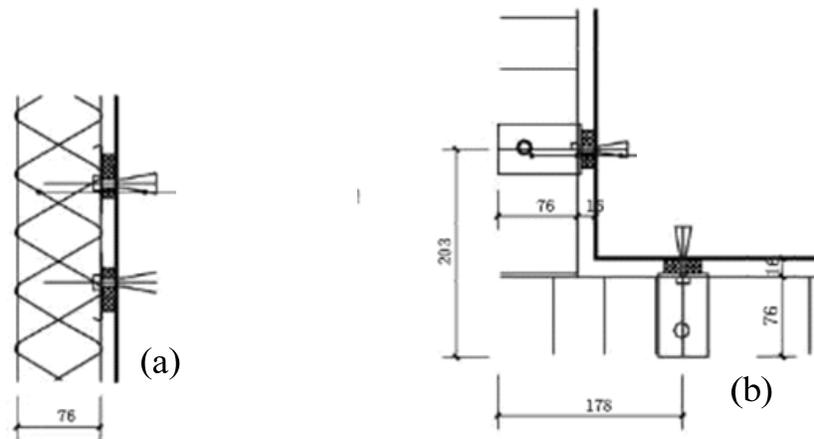
The combination of component systems of the vertical greening technology of box is more easily and freely and the late stage of the maintenance work is more convenient compared with the segmented vertical greening technology. And the system of vertical greening box technology is assembled by unit form with supporting greenery, which can only replace separate unit in the late maintenance.

Compared with vertical greening box technology, segmented vertical greening way often need to combine a variety of repair and maintenance methods to update the system when carrying out maintenance work due to the strong integrity of the system. In residential construction, especially residential buildings with higher altitude, box greening technology is more suitable than segmented vertical greening for this type of building because of its more liberal system consisting, small difficulty of the post-maintenance work.

Dormitory building

Dormitory building is generally high volume multilayer construction, which mainly focus on practicality of residential buildings without low requirement of appearance. Because of the limited funds, it mostly used the single form of a green vertical greening technology to save costs. Cassette, media away from the wall plate with additional vertical green technologies have strong practical.

Vertical greening technology of dormitory building multi-use grid from the wall (see Figure 5), which was mainly composed by metal mesh and fixed components, and its fastener size, gasket thickness and strength of installation pieces are based on plant category and load of the upper part.



(a) Connection cross-sectional view of grid and wall (b) Connection plan view of grid and wall

Figure 5 : Configuration diagram of grid off the wall

THE ROLE THE EXISTED PROBLEMS OF VERTICAL GREENING

The vertical greening process on the outside wall of the building can make the building wall temperature drops 2 to 7°C, especially the west of the wall to withstand prolonged sunlight, and the vertical greening covering process can significantly reduce wall temperature. In the hot summer, after the surface of the roof and walls covered with green plants, the air humidity will increase about 10 to 20 percent in treated surface, which can do favor of eliminating fatigue for nearby people and improve comfort environment. Regardless of vertical greening covered what kind of building; we must deal with local conditions. For example, when building a certain size scaffolding structure near the entrance of the building, planting green plants easy climbing at scaffolding, it can effectively alleviate the hot environment at door and improve people's environmental comfort. Placing some planting and flowers or some climbing green plants to shade at windowsill or balconies in building can significant improve the environment. Also the outside walls of building usually used climbing sprawling greenery to take the overwrite process.

In practical applications, vertical greening construction techniques have two main problems: one, greening plant species and vertical greening applied technology are still relatively single; 2, the practical effect of vertical greening technology needs to be further improved.

CONCLUSIONS

Conservative vertical green technology has become the leading residential building vertical greening technology in long time due to its frame securely and relatively simple form, but there is also very obvious shortcomings, the most important is the damaging effects that vertical greening on the wall outside the facade framework of the building. For example, ivy may through external wall of residential buildings and the plant roots extend into the wall of the structure, which will destroy the structure of the wall. Thus, we need to conduct more in-depth research to vertical greening technology to full play the advantages of vertical greening technology in residential buildings.

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