Creepers Vertical Greening Strategies on High-rise Building

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Abstract. Vertical greening has many advantages, such as saving energy, relieving heat island effect, increasing green vision rate and beautifying the environment. Vertical greening of high-rise buildings requires more consideration in plant selection, irrigation, storage and drainage and safety. This paper introduces the classification and method of vertical greening of high-rise buildings with climbing plants, emphatically introduces the support system of vertical greening, selection principle and greening effect, and makes a comparison. It is pointed out that vertical greening with climbing plants is economical, simple and feasible.

1. Introduction
In the past three decades, large-scale urbanization has been carried out all over the world. More than half of the population lives in cities, and the number of high-rise buildings has increased significantly. The natural environment and ecological environment of cities have been seriously destroyed, and the heat island effect has been intensified. The combination of vertical greening and high-rise buildings can save energy, reduce the exposure of buildings in summer, reduce dust and particles in the air, reduce ambient temperature, reduce traffic noise and alleviate extreme temperature through transpiration. It can also increase animal habitat and diversity, and the rate of green vision, so that people who have lived in noisy cities have the opportunity to get close to green, relieve the pressure brought by urban life, and have a positive impact on human physical and mental health.

2. Considered factors of high-rise building wall greening

2.1 Plant selection
As the altitude increases, the solar radiation will be greater than that at lower places, the temperature changes will be more drastic, the chance of being attacked by wind will be more, and plants must be able to adapt to very harsh weather conditions. The wind at the top makes the soil dry, and plants must be resistant to the poor and wind. Even for the whole wall of the same building, the selection of plants is different due to the different heights. On top of the building, plants that are easy to grow, good to care for, and require relatively little water should be selected. In the middle of the building, plants should be selected with high drainage requirements. The lower part is selected with hygrophilous plants. Therefore, a full understanding of the size, shape, growth rate, life span, water consumption and illumination of plants is an important guarantee for the success of high-rise vertical greening projects and the maintenance of vigorous vitality after many years.
2.2 Irrigation
Higher plants receive more daily radiation and evaporation, so they are irrigated more often than lower plants. Irrigation is also affected by orientation, with more irrigation in the south and west directions, which are more exposed to solar radiation, than in the east and north directions.

2.3 Storage and drainage
The planting groove should not only have a certain storage capacity, but also consider the problem of excess water discharge, especially after the rainstorm, to prevent excessive water from rotting roots. The discharge of excess water should be centralized drainage to prevent water from flowing to the edge of the building, contaminating the building and disturbing the life of the lower floors. Use inorganic soil where possible, which decomposes very little without causing shrinkage or consolidation.

2.4 Safe
Plant with strong root system and not easy to deciduous should be selected to avoid branches and leaves falling from high altitude and injuring people. Safety concerns, such as strong winds, lightning strikes and heavy rains that can damage trees, should also be considered. In addition, the lower end of the building should be equipped with buffering and carrying components to prevent branches and leaves from falling directly to the ground. It is therefore important to prune plants regularly to make sure they do not grow too long and fall off.

2.5 Fire resistance
In winter, leaves and dead leaves and vines should be cleaned in time to avoid causing fires.

3. Vertical greening of climbing plants
Climbing roots take up less space and can be planted along the base of a wall. Small plants can also be placed along the wall or balconies in a movable planter with soil height of 45cm or more. But their climbing capabilities are limited in height up to 6-7 stories. Therefore, in high-rise buildings, the method of segmented greening is generally adopted, and it generally takes 3-5 years to achieve the optimal coverage [1].

3.1 Climbers attached directly
Direct climbing plants rely on aerial roots or suckers to climb. The rougher the surface of the wall, the better for the plants to climb. But now many of the top floors are made of smooth, fine materials, such as metal or some artificial material. Therefore, the practice of direct adsorption climbing is rarely used on the upper part of high-rise buildings, generally used for low dado with brick and rough stone as decorative materials.

3.2 Frame traction greening
Frame traction is to use a certain frame support, guide and help climbing plant growth, achieve the desired greening effect. Frame traction greening can be attached to the wall to reduce the damage from the climbing plants. It can also exist independently from the wall at a certain distance to form a green screen effect. Frame traction greening can be divided into two-dimensional plane system and three-dimensional grid system [2].

3.2.1 Two-dimensional plane system. Two-dimensional plane system refers to the framework supporting green plants in two dimensions of space. It can be divided into cable type, grid or wire mesh type and grille type.

Cable type. Cable type refers to the using high-strength steel cable to guide climbing plants by anchoring pieces fixed on the wall. The cables should be made of high-strength materials, and the
anchor should be securely attached to the wall to support tendrils and barbed climbers with fast growth, dense leaves and strong climbing ability (see Figure 1–3).

Figure 1. This is vertical cables fixed on the wall.

Figure 2. Tendrils climb the steel cables.

Figure 3. This is a two-direction cable.

Figure 4. This is a steel grid fixed on wall.

Type of Grid or wire mesh. The size of grid or wire mesh is smaller than that of cable, which is suitable for climbing plants with slow growth rate. Due to the existence of grid, the load attached to the supporting structure is shared. The strength of a single material can be much lower than that of cable type, but the grid formed as a whole can bear all the load brought by plants. There will be more choices of grid materials. Wooden, bamboo, concrete, metal, plastic and rope materials can all be used to make grid (see Figure 4–6). But bamboo, plastic and rope have poor durability, and once installed, high-rise buildings are difficult to replace, so it is best to use durable materials such as metal to support plants. Metal structure is light and easy to make, many can be customized. Because the spacing and size of the metal structure can be freely varied, forming different sizes and patterns of the grid, so it is the most widely used.

Figure 5. This is a bamboo grid fixed on the wall.

Figure 6. This is a rope grid fixed on the wall.

Figure 7. This is mainly a horizontal grille for climbers.

Figure 8. This is mainly a vertical grille for climbers.

Type of horizontal or vertical grille. The horizontal grille or sunshade can facilitate the climbing of plants, so the sunshade and the grille itself need to have a certain stiffness to bear the load requirements of plant growth. Horizontal grilles should not be too long, and the vertical supports should be provided at intervals to transfer the load to the main structure (as shown in Figure 7). Vertical grilles or louvers can also support the twining plants (see Figure 8). However, once the size of vertical components is too large, the winding capacity of plants will be reduced. At this time, a support of small size should be added in the middle to enable the plants to climb smoothly (see Figure 9).
3.2.2 Three-dimensional grid system. Compared with the two-dimensional system, the three-dimensional grid system not only has two dimensions of length and width, but also has thickness. Usually the three-dimensional frame system is made of welded steel wire material with a certain thickness of the frame [3]. Compared with other systems, the net structure is very lightweight, but the strength is quite amazing, effective support plant load. Not only can the system be attached to the external wall of the building (see Figure 10,11), but it can also be independently installed as a green barrier for shielding and dividing space (see Figure 12).

3.3 Overhanging greening
When using overhang greening, common practice is installing plant container in these positions such as stage, balcony, or cornice (see Figure 13). Trailing plants have no special climbing organs and have the weakest climbing ability, so they often need to be assisted in binding, but the hanging effect is good [4].
3.4 Comparison of the above vertical greening type systems

Table 1 below compares several typical vertical greening types.

| System                        | Maintenance | Relation to wall | Plant type                      | Fast greening |
|-------------------------------|-------------|------------------|---------------------------------|--------------|
| Attached directly             | Low         | Attached         | Sucker                          | No           |
| Frame traction greening       | Low         | Attached/isolated| Winding/tendril                 | No           |
| Two-dimension                 |             |                  |                                 |              |
| Cable                         | Low         | Attached/isolated| Winding/tendril                 | No           |
| Grid                          | Low         | Attached/isolated| Winding                         | No/Unless planted in advance |
| Grille                        | Low         | Attached/isolated| Winding                         | No/Unless planted in advance |
| Three-dimension               | Low         | Attached/isolated| Sucker/Winding/tendril/hook and thorn | No/Unless planted in advance |
| Overhanging greening          | Low         | suspension       | Trailing plant                  | No           |

3.5 Selection principle

The frame traction system anchored to the wall structure (Figure. 14) transfers plant and frame loads to the main structure. Plant load, wind pressure and snow load are considered together at the beginning of the design. If it is a modified vertical greening project, the additional load added to the external facade should be calculated to minimize the damage to the original wall. The support member must be strong enough to support the growing weight, wind pressure and snow load.

The independent structure system has its own foundation and can bear its own load and plant load. The relationship between the frame and the building is only a pull, without increasing the load of the main structure of the building. Therefore, it is also very suitable for the renovation of old buildings [5]. (See Figure 15, the frame can be fixed on the wall or can be installed independently with itself foundation. See Figure 16, this is a 3d grid steel frame independently installed.)

Attention should be paid to the relationship between the supporting components and the building, in line with the architectural style, without affecting the use and aesthetics of the building. In the north, climbing plants lose their leaves in winter, so you must pay attention to the effect of winter. The support system adopted directly affects the aesthetics of the building in winter, so the facade design of the building must consider the aesthetics of the support system. Also, make sure plants don't enter drains, vents, etc.

4. Conclusion

Climbing plants are used for vertical greening of walls of high-rise buildings, mainly because climbing plants have the following advantages. First, climbing plants grow rapidly and easily to scale. Secondly, the morphological decision of climbing plants depends on the guidance of supporting structure, and there are many varieties. Third, compared with the current popular life wall, the cost is low, the maintenance cost is low, the management and protection are simple, the support structure is diverse. Especially with the frame traction system support, plants can be separated from the wall without damaging the wall, which is the future development trend of wall greening and a good method of vertical greening reconstruction of old buildings.

Acknowledgments

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