Application of Ecological Technology of Concrete Retaining Wall in Urban Dyke

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Abstract. Traditional concrete and mortar-masonry retaining walls are mature, safe and reliable, widely used in urban river embankment, and play a great role in disaster prevention and mitigation in towns. However, such retaining walls lack of ecological characteristics. In order to give the traditional concrete and mortar-masonry retaining walls ecological characteristics and provide conditions for the unfortunate people who fell into the water to rescue themselves and go ashore, two traditional retaining wall ecological technologies were invented, which are suitable for new retaining walls and existing retaining walls. When the new retaining wall is built, the slope ratio of the wall should be appropriately slowed down and several rows of planting grooves should be arranged. For the retaining wall that has been built, the planting groove is anchored on the wall. Landscape plants are selected and planted in the planting groove, and automatic irrigation system is arranged according to the needs. The engineering application shows that applying these two technologies to river improvement projects at the same time can form a full coverage of ecological beauty on the water-side wall of the traditional retaining wall. People who fall into the water can climb on the planting trough and wait for rescue, or climb along the planting trough to reach the goal of harmonious coexistence between people and water.

1. Introduction
Due to the limitation of land for urban river embankments, traditional retaining walls such as vertical concrete and mortar and masonry are widely used. Although this type of traditional retaining wall saves land, has stable structure, mature technology, safety and reliability, and strong resistance to water erosion, it weakens the ecological function of the river and the ecological coordination between the river and the surrounding environment, and is not conducive to the harmonious coexistence of humans and nature. For example, concrete and mortar-masonry retaining walls cut off the connection between water and land, preventing frogs, snakes and other creatures from freely moving between land and water. In addition, the smooth wall reduces the roughness of the river course and increases the water flow velocity of the river course, which is not conducive to the growth of aquatic organisms. For those who fall into the water, it is difficult to climb on a smooth and steep wall. Therefore, the traditional retaining wall is not conducive to the self-rescue of those who fall into the water.

In order to solve the above problems of traditional retaining wall, two kinds of ecological technology for traditional retaining wall were put forward. The first ecological technology is for the new retaining wall, the slope of the wall is appropriately slowed down, several rows of planting grooves are set on the wall, and then landscape greening is carried out. The second ecological
technology is for the existing retaining wall, where the planting grooves are directly anchored to the wall and then landscaped. These two ecological technologies have been patented in China, and the patent numbers are ZL201610076592.4 and ZL201720747501.5 respectively.

The two ecological technologies were written into DB44/T2283-2021 "Guidelines for Ecological Design of Water Conservancy Projects", participated in the China Innovation and Entrepreneurship Fair in 2018 and 2019, and selected in the "Guangdong Province 2020 Water Conservancy Science and Technology Promotion Guide".

2. Ecological technology of traditional retaining walls

Ecological technologies are proposed for the newly built retaining wall and the existing retaining wall respectively.

2.1 Ecological technology for new retaining walls

When building a new traditional concrete or mortar-masonry retaining wall, the steep wall should be appropriately slowed down, and several rows of planting troughs should be set on the wall. The distance, depth and width of the trough meet the needs of plant growth and meet the climbing or climbing requirements of the falling water personnel[1]. When building a new retaining wall, according to the sequence of construction of the groove wall and the retaining wall, there are two construction methods: one is the integral type, and another is the stepped first and then the groove wall type.

Integral ecological technology refers to the ecological technology in which the planting trough is used as a part of the wall and the concrete or mortar masonry of the wall is constructed at the same time[2](Figure 1). The eco-technique of building the trough wall after the steps is to construct the retaining wall concrete or mortar masonry in advance, and form a ladder on the wall surface, and then construct the trough wall on the edge of the ladder to form the ecological technology of the planting trough (Figure 2).

![Figure 1. Sectional view of integrated ecological technology](image1)

In order to meet the requirements of the ecological characteristics of the retaining wall and the convenience of climbing and self-rescue functions for the falling into the water, Table 1 gives a set of economical and feasible key parameters[3].
Table 1. Key parameters of traditional retaining wall ecological technology

| Construction method of planting trough | Net width of planting trough (cm) | Net height of planting trough (cm) | Thickness of planting trough (cm) | Distance between adjacent planting troughs (cm) | Comprehensive slope ratio of retaining wall |
|----------------------------------------|----------------------------------|----------------------------------|----------------------------------|-----------------------------------------------|---------------------------------------------|
| integrated ecological technology       | ≥40                              | 40–50                            | 8–12                             | 80–100                                        | 1:0.4~1:0.6                                 |
| ecological technology of building wall | ≥40                              | 40–50                            | 12–15                            | 90–100                                        | 1:0.4~1:0.6                                 |
| prefabricated ecological technology    | ≥30                              | 40–50                            | 3–8                              | 90–120                                        | 1:0.4~1:0.6                                 |

2.2 Ecological technology of built retaining walls

The existing retaining walls in cities and towns have invested huge investment and made great contributions to urban flood control. If they are still safe and stable, they should not be demolished. Planting troughs can be anchored on the waterfront wall to achieve ecological purposes. The prefabricated ecological transformation technology refers to the ecological transformation technology of retaining wall anchored to the built wall in the later stage of the planting trough[4].

![Sectional view of prefabricated ecological technology](image)

Figure 3. Sectional view of prefabricated ecological technology

2.3 Key points for implementing ecological technology of traditional retaining walls

The engineering level, design standards, engineering layout, load, stability calculation, structural calculation, and foundation treatment of traditional retaining walls should implement relevant technical regulations[5]. The ecological technology of traditional retaining walls should follow the principles of adapting measures to local conditions, ecology, applicability, economy, beauty, safety, and energy saving. According to environmental conditions and viewing needs, appropriate plant materials and appropriate construction techniques should be selected. Before the ecological technical design of the traditional retaining wall, technicians should survey the project site to investigate the geological conditions and hydrology of the river section where the retaining wall is located, the orientation of the planting trough arrangement, the illumination, the utilization of rainwater, and the facade conditions of the retaining wall.

The prefabricated ecological transformation technology shall not affect the safety performance and use function of the existing retaining wall. The planting trough can be directly fixed to the retaining wall by using anchor bolts (planting bars), or can be fixed on the supporting frame anchored to the
retaining wall[6]. The anchoring design should meet the requirements of self-weight, wind load resistance, water erosion resistance, resistance to floating objects impact, and climbing of people falling into the water. The anchoring form should be selected reasonably and the anchoring safety should be ensured in accordance with relevant regulations[7][8].

2.4 Implementation points of planting trough plant configuration

It needs to be configured according to factors such as climate conditions, light conditions, water and fertilizer conditions, functional requirements, ornamental effects, maintenance and management. Plants should be mainly native plants, and backbone plants with strong stress resistance should be selected, and the planting gap, layered configuration, and color matching should be coordinated. At the same time, the corresponding plant watering and maintenance methods should be determined[9].

In addition, when selecting suitable plants, factors such as water level, water depth, flood duration, distance between planting troughs, and retaining wall height should also be considered. Submerged plants with strong water purification performance should be selected for underwater areas; shallow-rooted plants that are resistant to flooding and drought, extensive management, well-developed root systems, and resistant to water erosion should be selected for drawdown areas; herbaceous and woody mixed configurations should be selected for water areas. Plants that combine flower-viewing species and foliage-viewing species. The purpose of these practices is to ensure the effect of the landscape.

3. Engineering application example

3.1 Project overview

A river improvement project is located in Guangzhou City. The main task is to prevent floods and drain waterlogging as well as improve the water environment, water ecology, and beautify the city. There are villages and schools on both sides of the river. The total length of the river is 4.5km, the current river width is 8m-20m, and the drainage area is 6.04km². The annual average rainfall is 1670mm, and the annual average temperature is 21.8℃.

The current river line is tortuous, the floodplain is chaotic, the comprehensive average slope is 28‰, and the designed flood flow in 20 years is 21.98m³/s. The regional geological structure is relatively stable. The strata on both sides of the river channel are mainly artificial fill, silty silty clay, medium-coarse sand, etc.

3.2 Section design of river embankment

The population on both sides of the river of this project is densely populated, and the land space for the river improvement project is limited. After comparison and selection of plans, the dikes on both sides of the bank adopt the traditional ecological technology of retaining walls, which is safe and reliable, and has ecological characteristics, and it also provides climbing conditions for the unfortunate people who fell into the water, as shown in Figure 4.

The dike is a compound section, divided into upper and lower parts. The lower part of the dike adopts a steep concrete retaining wall with a wall height of 4.0m and a slope ratio of 1:0.15. The anchored planting trough on the lower retaining wall of the dike has a net width of 0.45m and a net depth of 0.48m, made of engineering plastics. First, the bracket is anchored to the lower retaining wall, and then the planting trough is fixed in the bracket. The upper part of the dike adopts a slope-type retaining wall with a wall height of 1.5m and a slope ratio of 1:1.7. 3 rows of planting troughs are arranged on the wall. The gabion net is equipped with a gabion as the wall of the planting trough, with a thickness of 0.3m and a height of 0.45m.
3.3 Implementation effect
According to the local natural geography, climate, and river hydrological conditions, suitable landscape plants have been selected and an automatic irrigation system has been arranged. After the completion of the treatment project, an ecological retaining wall with multiple functions, such as beautifying the ecological environment, facilitating falling ashore, and providing living space for animals, has been formed, which promotes the harmonious coexistence of man and water (Figure 5 and Figure 6).

4. Conclusion
Ecological retaining wall technology is based on traditional concrete and mortar-masonry retaining walls. By setting rows of planting troughs on the wall, the traditional concrete and mortar-masonry retaining walls are endowed with ecological characteristics. At the same time, the proper slot distance can facilitate the unfortunate overboard to climb ashore to save themselves. The planting trough can be implemented in an integral type, stepped first and then trough wall type, or assembled ecological technology. The main design parameters of the ecological retaining wall technology are: the slope ratio.
of the retaining wall, the distance between adjacent planting troughs, the thickness of the planting trough, the depth of the trough, and the width of the trough. These parameters directly affect the project cost and ecological performance.

The engineering application shows that the two kinds of ecological retaining wall technology are safe and reliable, and can form an ecological beauty where humans and water coexist harmoniously.

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