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Comparative Analysis of Ecological Revetment and Traditional Revetment

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Abstract:

Ecological revetment is a new kind of environmental protection technology, which combines civil engineering techniques with environmental engineering techniques. At the same time, it also considers the protection function of traditional revetment and provides unique humanistic and ecological value, which is a new trend and a new direction of revetment research. This paper mainly analyzes the advantages and disadvantages of ecological revetment compared with traditional revetment. First, the related concepts and functions of coastline resources, urban waterfront and waterfront buffer zone are defined. Then, around these two kinds of coastline in-depth study of three sub-projects are discussed in detail, including the traditional slope revetment, traditional wall revetment, traditional dam revetment, and ecological block revetment, grass brick revetment, medium screen revetment. Finally, the advantages and disadvantages of the two kinds of revetments are analyzed and compared. The results show that the ecological revetment has better ecological value and humanistic value, which is conducive to beautifying the urban waterfront environment, but there is a problem of high investment and maintenance cost.

Keywords: Ecological revetment; traditional revetment; coastline resources.

1. Introduction

Ecological revetment, as a combination of ecological engineering and civil engineering technology, has been widely used and studied. It not only focuses on protecting the stability of the bank slope structure, but also strives to maintain the sustainable development of the river ecological environment. Ecological revetment technology includes solidification technology, cutting-riprap technology, vertical ecological bank protection and so on, and plays an important role in urban wetland protection and restoration. In addition, artificial ecological revetment technology has also been widely used because of its functions of slope protection and ecological restoration [1].

In recent years, remarkable progress has been made in the study of ecological revetment. The research status of ecological revetment covers many aspects, including technical research, application practice, establishment of evaluation system and future development trend of ecological coastline protection.

Regarding the research progress on the connotation of ecological coastline, experts have proposed the definition of ecological shoreline [2]. At the same time, the comprehensive evaluation of ecological bank protection technology and benefits also shows that the existing problems of ecological bank protection research need to be further explored. In addition, the application and discussion of ecological revetment also show its importance in practical application.

Through the research of different types of shoreline design theory, this paper defines the concept, function and characteristics of shoreline resources, urban waterfront and waterfront buffer zone, and analyzes the concept of ecological shoreline and traditional shoreline. On this basis, the traditional slope revetment, traditional wall revetment, traditional dam revetment, ecological block revetment, grass brick revetment, medium screen revetment are detailed, and the advantages and disadvantages of ecological revetment and traditional revetment are summarized and analyzed. The results show that compared with traditional shorelines, ecological shorelines have additional functions of ecological protection and recreation.

2. Conceptual Interpretation and Theoretical Analysis

2.1 Shoreline Resources

As an important part of the water-land interaction zone, shoreline resources play a unique role in both nature and society due to their spatial characteristics. Coastal resources not only carry rich natural resources and economic value, but also face the dual challenges of ecological protection and sustainable development. This shows that the impact on the ecological environment must be paid attention to when using the shoreline resources. It is necessary to take effective measures to protect and restore ecological functions, balance the relationship between economic development and ecological protection, and achieve sustainable development. At the same time, it pays attention to the coordination of its natural water ecological environment and social service value, and creates a benign shoreline of sustainable development. The sustainable development of shoreline resources needs to be achieved through scientific planning, effective management and public participation and other efforts [3].

2.2 Urban Waterfront

The Coastal Management Act and the Coastal Zoning Plan of the United States define the scope of the waterfront including the water part and the land part. Specifically, the water section includes the section from the water to the sea, while the land section extends inland to a range of 5 miles. This definition reflects the geographical continuity and transition of the waterfront, aiming to protect and rationally utilize this important area [4].

As an important connection point between city and nature, waterfront area not only has unique value in ecology, landscape, culture and other aspects, but also an important resource in urban development. For example, urban waterfront plays an irreplaceable role in flood storage and drought resistance, soil and water conservation, improvement of urban ecological environment, and enhancement of regional biodiversity. In addition, the waterfront is also an important part of urban space, which has irreplaceable value for shaping the city image, improving the quality of life and improving the quality of the environment. In the renovation design of urban waterfront space, the structural form of embedded ecological revetments is proposed, and its mechanism and characteristics are analyzed, which not only enhances the aesthetics of revetments, but also improves their practical application value [4].

2.3 Waterfront Buffer Zone

Waterfront buffer zone refers to the transitional zone between the water body (such as rivers, lakes, reservoirs) and the land. It has a variety of ecological functions, including retarding runoff, settling sediment, conserving soil and water, controlling non-point source pollution, stabilizing river banks, providing animal habitat, etc. These functions are essential for maintaining the health of water bodies, protecting biodiversity, and preventing soil erosion. The waterfront buffer zone shows remarkable effect in reducing stormwater runoff, purifying water quality and controlling non-point source pollution. Waterfront buffer is a complex ecosystem, and its design and management need to consider many factors in order to maximize its ecological function. Through reasonable design principles and spatial regulation strategies, waterfront buffer zone can effectively protect water environment, promote biodiversity, and provide a healthy and sustainable living environment for human beings. The current academic mainstream believes that the waterfront buffer zone is an ecological filter zone between the river lake and the coastal vegetation to ensure the survival of aquatic and terrestrial organisms. Besides, the waterfront buffer zone has obvious boundary effect [4].

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3. Ecological Revetment and Traditional Revetment

3.1 Introduction to Traditional Revetment

Traditional revetment mainly uses cement, asphalt, concrete and other hard materials, and its design and construction lay emphasis on structural safety and economy. This type of revetment can be divided into vertical type, slope type or a combination of these two forms in terms of structural type, and the section is regular and channelized to meet the basic functional needs of flood control and drainage. However, such hard revealment has a negative impact on the natural environment and ecological balance [5].

3.1.1 Slope revetment

Traditional slope revetment is a kind of structure widely used in river control and dike engineering, its main purpose is to enhance the stability of river bank slope and meet the needs of flood control and drainage. Traditional slope revetment usually uses cement, stone, concrete and other hard materials as the main building materials [6]. This structural form mainly considers the stability of the slope in the design, taking safety and economy as the priority, but it will ignore part of the needs of ecological restoration. Traditional slope revealment should fully consider the influence of hydraulic characteristics of water flow, and do a good study in the early stage according to the form of river, vegetation type and growth environment. For example, because of its ecological environmental protection, corrosion resistance and climate resistance, simple process and strong deformation ability, lead wire cage slope revealment structure is widely used in some specific conditions [7]. Traditional slope revetment plays an important role in flood control and drainage, but it has a negative impact on the ecological environment.

3.1.2 Wall revetment

Wall revetment flood control measures are mainly to build retaining walls, which are suitable for the riverbank with no beach on the water side and easy to be washed by the water flow, the protection of the opposite direction is important, the river is narrow, and is restricted by the terrain conditions or the built buildings. The commonly used retaining wall structure forms are upright, steep slope and broken line. Design principles and objectives: The design of traditional wall revetment mainly considers the safety and economy of the structure, and needs to meet certain flood control and drainage capacity. [6] For example, the management of the Lanhe River Basin includes the design of wall revetment to stabilize the river regime and improve flood safety. Materials and technology: Traditional revetment projects usually use cement, asphalt, concrete, stone and other hard materials. Although these materials can provide sufficient structural strength, they may have a negative impact on the natural environment and ecological balance. The Lanhe River control project in Liaoyang County adopts wall revetment and slope gabion revetment design. After the design and construction, the river condition is not only stabilized, but also the flood control safety is improved, the safety risks and the loss of river water to land are reduced, and remarkable economic, social and ecological benefits are shown [8]. Traditional wall revealment has clear goals and wide applications in design and application, especially in the need for fast response and ensure the safety of the structure. However, it may have a negative impact on the natural environment and ecological balance.

3.1.3 Dam revetment

Traditional dam revetment is a kind of traditional river embankment engineering measure, mainly using cement, asphalt, concrete and other hard materials to build, to ensure the safety and economy of the structure. This revetment method is widely used in river protection and reinforcement, especially in areas that need to ensure long-term stability and flood resistance. The main characteristics of traditional dam revetment include the use of hard materials, the variety of structural types (such as vertical, slope or mixed type), and regular channelization of sections. Although these characteristics meet the basic functional needs of flood control and drainage to a certain extent, they also cause damage to the ecological functions of the river, such as affecting the growth of aquatic organisms and the natural flow pattern of the river. The traditional dam revealment plays an important role in some specific conditions. For example, in the Shenyang Hunhe River dike risk removal project, it has been proved through design analysis and years of operation that the traditional dam revealment scheme (the upper part is gabion and the lower part is sunk riprap dam) has a good protective effect on the revealment [9]. This shows that under specific geographical and environmental conditions, traditional dam revetment is still an effective solution.

3.2 Ecological Bank Protection Analysis

Ecological revetment pays attention to the protection and restoration of ecological environment. Ecological revetment features include the use of natural materials and plants, as well as a combination of soft and hard structures. Ecological revegetation is a linear landscape in urban waterfront area. This form of revetments can not only effectively prevent soil erosion and river erosion, but

also provide habitats for aquatic organisms and increase biodiversity. The design principle of ecological revetment emphasizes harmonious coexistence with the natural environment, and restores the natural state of the river by simulating the form and function of the natural river. Bank protection plays the functions of flood control and waterlogging control, environmental pollution control, soil erosion prevention, ecological diversity maintenance, water quality maintenance, water level regulation, regional climate regulation, etc. It also provides social service functions such as recreation, port development, industrial production and transportation for human beings [10].

3.2.1 Ecological block revetment

Ecological block shoreline is a new kind of river bank protection technology, which can protect and beautify the river bank by using specific materials and structural design, and promote the sustainable development of river bank protection project. Ecological block shoreline is an environmental protection shoreline built by ecological block, which is a wall material composed of cement, stone and plants. It has good compression resistance and durability, and can withstand the impact of river flow. At the same time, the plants above can absorb water and nutrients, providing biological protection function so that the block can effectively protect the riverfront and maintain the ecological balance of the water body.

The application of ecological block in river revetment has many advantages. First, they can effectively reduce the impact force and erosion force of the river to provide good erosion resistance and prevent flooding and soil erosion. Secondly, the design of ecological blocks usually considers the harmonious coexistence with the natural environment, which can protect the stability and integrity of the river structure. In addition, these blocks can also plant vegetation to enhance its ecological function, improve water quality, beautify the riverbank, add new landscape effects to the river, and enhance the environmental quality and tourism value of the river [11].

This revetment method has been applied in Shanghai. Application cases show that ecological block revealment can not only effectively improve the ecological environment of the riverbank, but also improve the stability and security of the riverbank, which is a technology worth promoting for river management and ecological restoration [12].

3.2.2 Planting grass and brick shoreline

Grass-planting brick shoreline is a new technology that combines ecological restoration and bank protection functions, aiming to improve the ecological environment of the riverbank and provide a stable bank slope structure through the application of vegetation cover and ecological materials. The design concept of grass-planted brick shoreline emphasizes the importance of ecological restoration. In the process of urbanization, the curving and hardening of natural river leads to the destruction of water ecology and the deterioration of water environment. By introducing technologies such as ecological inlaid grass brick revetment structure, prefabricated grass-planted concrete revetment and grass-planted precast concrete block, the shoreline of grass-planted brick not only strengthens the riverbank, but also promotes the restoration of biodiversity and reduces the impact of water pollution and water environment damage caused by hardened revetment [13]. The application cases of grass-planted brick shoreline show that this technology has good ecological and economic benefits. For example, the tip levee project of Lingshan Island in the starting area of Mingzhu Bay District, Nansha New District, Guangzhou, adopts the form of flood control concrete prefabricated grass-planting brick slope protection, which takes into account the structure and green environment, and has the advantages of easy construction, robustness and beauty [14]. At the same time, the presence of vegetation in the grassed brick shoreline changes the original roughness of the bank wall and increases the flow resistance, which can be applied to slow down the flow velocity of the river [15]. As a technology that combines ecological restoration and bank protection functions, grass-planting brick shoreline has the dual advantages of improving the ecological environment of the riverbank and providing stability of the bank slope structure, which can effectively promote the restoration of biodiversity, reduce the impact of water pollution and water environment damage, and have good economic benefits.

3.2.3 Medium screen shoreline

Medium screen shoreline is a technology that uses medium screen technology to improve the stability and water quality of bank line. By analyzing the distribution characteristics of riverbed media, the simulation scheme of seepage, stabilization and dredging process is designed to optimize the change of water level and improve the water refill efficiency. The application of this technology in Taohua River shows that after the stone embankment is transformed into a medium sieve bank, the diving supply in the dry season increases significantly, indicating that the medium sieve bank has a retarding and replenishing effect [16]. In addition, the application of medium screen shoreline technology is not only limited to improving the stability and water quality of the riverbank line, but also involves the field of groundwater pollution remediation. In groundwater pollution remediation, permeable reactive wall (PRB) technology uses different types of media ma-

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terials (such as adsorbent, precipitating, reducing, degrading, and combinatorial media) to remove contaminants. The selection and application of these dielectric materials are based on their permeability, long-term performance and evaluation of pollutant removal capacity [17]. The application of this technology demonstrates its importance and potential in environmental engineering and water resources management.

3.3 Contrastive Analysis

The comparative advantages and disadvantages of traditional shoreline and ecological shoreline can be analyzed from multiple dimensions, including environmental protection, ecological benefits, social and economic benefits, aesthetics, sustainability, etc., as shown in Table 1.

Table 1. Contrast between traditional shoreline and ecological shoreline

Types	Advantages	Disadvantages
Traditional Revetment	Structural safety and economy; Flood control and drainage function	Negative impact on the natural environment and ecological balance; Damage of ecological function; A single hydraulic characteristic is affected
Ecological Revetment	Ecological environment protection; Improving the ecological environment; Aesthetics and hydrophilicity	Ecological environment protection; High initial investment and maintenance costs; High technical requirements; Adaptability and flexibility issues

Traditional revetment engineering mainly uses cement, asphalt, concrete and other hard materials, emphasizing structural safety and economy. At the same time, the traditional revetment has the basic functions of flood control and drainage. However, the revetment project using hard materials is easy to bring negative effects on the natural environment and ecological balance, which may greatly damage the ecological function of the river. Moreover, the new influence of traditional revetments on the hydraulic characteristics of water flow needs to be considered.

Ecological revetment project takes into account structural safety and ecological environment, and conforms to the requirements of harmonious coexistence between man and nature. Ecological revetment not only has the basic functions of flood control, drainage, water diversion, shipping and so on, but also has the functions of ecology, environmental protection, leisure and entertainment. Ecological bank protection can ensure the sustainable and healthy development of river ecology, and is conducive to extending the construction life of the project. The design principle of ecological revegetation includes aesthetics and hydrophilicity, which improves people's quality of life. The construction and maintenance cost of ecological revetment is relatively high, and more capital investment is needed. The design and construction of ecological revegetation requires high technical requirements, including the consideration of river form, vegetation type and growth environment. In the practical application process, ecological revetment needs to get rid of its own limitations, combined with the current situation, comprehensive and flexible choice of river control scheme and bank protection type.

4. Conclusion

This paper mainly studies the advantages of ecological revetment compared with traditional revetment, and draws the following conclusions:

(1) Traditional revetment has advantages in terms of structural safety and economy, but it has a great negative impact on the natural environment and ecological balance. In contrast, ecological revetment is better in protecting the ecological environment, improving biodiversity, enhancing hydrophilicity and aesthetic performance. However, the initial investment and maintenance costs are high, and the technical requirements are relatively high, but with the development of science and technology, this shortcoming will be solved.

(2) With the enhancement of people's environmental awareness and attention to ecological environmental protection, ecological revetment has gradually become the development direction of bank protection construction at home and abroad. The application and promotion of self-embedded ecological retaining wall also reflects this trend. In addition, ecological revetment attaches great importance to the performance of natural materials through green revetment layer, slope porosity, roughness and diversification of nearshore flow patterns, which brings a series of beneficial inspirations for the design and construction of revetment.

(3) Compared with traditional revetment, ecological revetment shows obvious advantages in promoting the sustainable development of ecological environment, improving the river and coastal environment, and enhancing the aesthetics and practicability of urban waterfront space. These

advantages are not only reflected in the improvement of ecological functions, but also include the maximum contribution to economic and social benefits. Therefore, ecological revetment is an important direction in future water conservancy projects and urban planning.

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