

Research on the key points of revetment design in water-deficient areas

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Abstract. The design of river revetment is a difficulty in the landscape design in water-deficient cities. This paper analyzes the problems in water revetment's adaptive design in three different aspects, which are flood control, ecological compensation and water self-purification. Following the principle of "ecological priority", it proposes the best ecological revetment design strategy.

Organization of the Text

With the development of the concept of ecological revetment, we are aware of the fact that the emphasis of ecology will directly affect the sustainable development of the urban landscape ecology in water-deficient areas. On the basis of the explorations and practices of some early Loess Plateau landscape projects in water revetment construction, the comparative study of designs and countermeasures will be conducted with the focus on three aspects of flood control, ecological compensation, and water self-purification.

Problems in early revetment designs in water-deficient areas.

The uneven distribution of precipitation and high evaporation rate of the Loess Plateau bring difficulties to the construction of urban landscape. The early revetment designs in most water-deficient cities usually made use of reinforced concrete to build impermeable layer. Although this practice was in line with flood control needs, it blocked the ecological corridor needs of the rivers, the vegetation, and the living creatures, resulting in the ecological imbalance of the entire waterfront. The common problems include: steep revetment, river hardening, destruction of the original ecological sloping plant community structure and ecosystem's circulation and stability; irrational vegetation structure, the lack of analysis on the nature, the functions and the views of the landscape space; low ability of water self-purification; singleness of revetments' functions and forms, ignoring the multi-functional design of the integration of environmental aesthetics, ecological balance and human beings' behavior and psychological needs.

Reflections on the successful cases in China and abroad.

"Waterfront is a special area where the land and the water meets, and is called as ecotone by ecologists". [1] The revetment of the waterfront is the most viable zone, which has ecological value, ornamental value and educational value. In the aspect of revetment functional diversity, water ecological purification, and the organic integration of ecological elements and human beings' behaviors, foreign countries have gained plenty of experiences, and in recent years there have also been many measures worthy of learning within China:

Creation of revetment functional diversity --- Baltimore Inner Harbor, its design created a gathering place for tourists and residents which showed inclusiveness and accessibility to all people and connected together all the basic elements of Baltimore --- land, water, and people. Through the creation of a series of diverse spaces and the reduction of the feeling of lines of the scattered walkways along the Harbor, it created space nodes with functional diversity and guided users to participate.

Emphasis on water ecological purification --- Chengdu Funan River Park in Sichuan Province, on the basis of the ideas proposed by American scholar Ms. Ben Damon, was constructed into a park with the theme of water remediation. The sewage was conducted naturally ecological purification through the constructed wetland system and finally became “standard” living water and returned to the river. The overall design aimed at returning to nature and guiding the exploration of the mysteries of nature, having the significance of ecological education.

The organic integration of ecological elements and human beings’ behaviors --- Gantry Plaza State Square Park in New York, it preserved the historical memory in a relatively small space, creating a variety of changes in the place. “Through the introduction of local grasses and shore plants, it showed the feeling of pre-industrial period and its abandonment. The plants growing among the rusting sleepers and giant stones gave people rich reflections when recalling history”. [2]

Research on revetment design countermeasures in water-deficient areas.

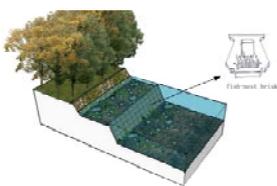
“The features of ecological revetment mimic the “permeability” feature of natural riverbanks, fully maintaining the exchange of water vapor between the riverbanks and riverside water and its adjusting function, and meanwhile meeting the engineering requirements of stability and strength, which plays an important role in improving the waterfront landscape and restoring the ecological balance”. [3] The ecological revetment design in water-deficient areas should meet the requirements of revetment functional diversity and water ecological purification, and make organic integration of ecological elements and human beings’ behaviors.

Requirements of the relevance between revetment design and human beings’ behaviors. In order to make the revetment form meet the needs of human beings’ behaviors, the requirements that the revetment design should meet include: being safe, being close to water, being ecological, being functional, and being reachable. Due to the special geographical features, the waterfront is more risky than other activity places, therefore its safety is particularly important no matter for sight viewing or playing in the water. In addition, being close to water is human beings’ most significant psychological characteristics in the space of waterfront environment, people need to carry out a variety of recreational activities on the water, and therefore the design should focus on shaping people’s activities by the form of ecological revetment and establishing a good biological circulation system and water self-purification system. The revetment design should also consider the space form and the diversification of functions, taking into consideration of the needs of different groups of people from the combining perspective of psychological and behavioral dimensions. Finally, it should meet the triple principle of being reachable by transportation, by view and by psychology.

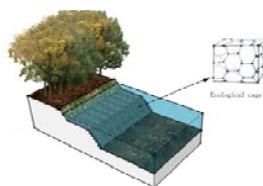
Key points in revetment design. The revetment design in water-deficient areas also need to pay attention to the functional needs of flood control, taking into consideration of aspects such as ecology, water self-purification and so on. “The spillway rivers in drought areas are often short with strong and swift water flow, the terrain of runoff area is with steep slope and spare vegetation, and if there is flood, its volume and magnitude would be comparative large. Especially when it flows through important areas in densely populated cities, the solution of safety risk in flood prevention is a primary issue”. [4] Secondly, the transformation of river revetment in water-deficient areas should be based on ecological priority, and conduct “ecological compensation design (the viewpoint of ecological compensation design is that in the design activities which mainly serve the human beings and social development... the design reducing the negative interference is the design of ecological significance)” [5] on the premise of guaranteeing safety. The design commonly applies the form of gentle slope to connect the revetment to the river bottom, selects plants which can both solidify the banks and meet people’s needs of being close to water, and makes plantations with reference to the water location. It offers the benefits that the ecological environment of the revetment would not be destroyed in large-scale and the landscape water conservation can be maximized.

Comparative study of countermeasures for several revetment types on ecological basis

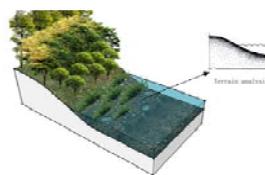
Key Issues	Present situation	Improvement strategy			
		Common problems	Behavior elements	Applicable revetment type	Countermeasures
Flood prevention	<ul style="list-style-type: none"> •closed, rigid, affecting ecological balance •singleness of forms, lacking aesthetic sensibilities 	Looking far into distance, enjoying the sight, gathering, fishing	Stepped artificial natural revetment	<ul style="list-style-type: none"> •river section with cascade of more than two stages •building blocks using fish nest brick and green brick •building ramparts by modular installation 	<ul style="list-style-type: none"> •highly safety •low-carbon level, environmental friendly •beneficial to earth reinforcement and ecological balance
			Ecological cage retaining wall revetment	<ul style="list-style-type: none"> •special steel wire woven rectangular cage •filling materials like stones, etc. inside •adjusting combination forms based on site conditions 	<ul style="list-style-type: none"> •good ecological effects •strong anti-erosion ability •restoring the natural forms
Ecological compensation	<ul style="list-style-type: none"> •channelization of natural riverbed •destruction of the habitation of the animals and plants in the river 	Playing water, resting, walking, physical exercising	Natural original revetment	<ul style="list-style-type: none"> •combination of natural riverbank lines with native plants 	<ul style="list-style-type: none"> •perfect combination with the natural inherent riverbank lines •meeting people's physical and psychological needs of being close to nature •maintaining ecological environment •creating a good green landscape
			Natural stone revetment	<ul style="list-style-type: none"> •combination of stone masonry with native plants 	
			Plant measure revetment	<ul style="list-style-type: none"> •mixing planting of trees, shrubs and grasses •maintaining riverbank stability by plants' developed root system 	
Water self-purification	<ul style="list-style-type: none"> •small water volume, high evaporation •high costs for water surface maintenance •low ability of water self-purification 	Playing water, resting, walking	Stone fixed foot vegetation revetment	<ul style="list-style-type: none"> •connecting the land and the water, establishing a reasonable water self-purification system •fixing the river's slop foot with big stones •planting aquatic plants with developed root system, fast growth, long lifespan and good adaptability on slop 	<ul style="list-style-type: none"> •providing habitat for living creatures •absorbing nitrogen(N) and phosphorus(P) in the water •capturing dust, controlling plankton



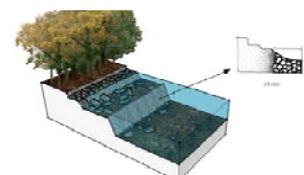
Stepped artificial natural revetment



Ecological cage retaining wall revetment



Natural original revetment



Natural stone revetment

Summary

The waterfront landscape design in water-deficient areas should pay special attention to the effects of geographical environmental conditions on landscaping elements. The revetment design should cautiously analyze a variety of factors, in order to meet the various needs of a particular landscape space, and to create a diverse revetment landscape.

Suitable design of being safe and ecological. First of all, “In the remediation of the waterfront green belts in water-deficient cities, because of the characteristics of the seasonal water flow in North China, it usually requires water storage in waterways, therefore “Blue Way” with perennial water flow must be retained in water storage planning of waterways, and the water storage surface must not be over the entire water bed, which prevents the destruction of water flow’s ecological corridor effect.” [6]

Secondly, it is suggested to try to select the local native trees to maintain the natural form, to adjust the revetment edge shapes in accordance with the land surface undulation, and to try to avoid the destruction of the original woodland as much as possible.

Thirdly, the application of ecological revetment should give comprehensive consideration of environmental factors, focusing on meeting the flood control requirements and the protection of ecological elements at the same time, different forms of revetment should be considered in accordance with the revetment space type, water depth and the morphology.

Comprehensive analysis from multiple perspectives. Emphasis should be laid on the functional diversity of the revetment, and analysis and design should be conducted through the aspects of flood control, ecological compensation, water self-purification, and human beings’ behavior while combining the landscape site conditions, in order to improve waterfront landscape and maintain ecological balance; to create the complex symbiotic ecosystem with the aquatic life and the terrestrial life living together and the diversified revetment landscapes while meeting the visual aesthetic needs and recreational activity needs.

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