

Research on the Construction Technology and Ecological Restoration of Industrial Wasteland

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Abstract: With the acceleration of social economic development and urbanization, the industrial structure of resource-based cities has been transformed, leaving a large number of abandoned industrial land, which restricts the ecological development of urban construction land and building space. Therefore, in order to obtain regenerated resources and ecological environment, as well as retain the continuity of local historical context, the renewal and transformation of industrial wasteland has become a hot topic of sustainable development of resource-based cities. Taking East-Zhushan Quarry of Xuzhou as an example, firstly, we analyzed the formation reason of the quarry, expounded its background and construction process. Based on this, we introduced methods of ecological restoration and reconstruction, and offered proposals combined with the construction technology and status of East-Zhushan Quarry Park, which in order to provide reference for ecological development of industrial wasteland in resource-based cities.

Keywords: Construction Technology, Slope Cutting, Vegetation Restoration, Industrial Wasteland, Abandoned Quarry Mining Pit

1. Overview of Industrial Wasteland in Resource-Based Cities

China's environmental resources are distributed in regional areas and are an important part of the regional natural environment [1]. According to the statistics of the National Development and Reform Commission's 《Economic structure transformation of resource-based cities》 research group, China has a total of 118 resource-based cities, accounting for about 18% of the number of cities in the country, with a total population of 154 million people. Eighty percent of the resource-based cities are located in the central and western regions. Heilongjiang Province has the most, with 13 resource-based cities, Shanxi followed with 11. Jilin, Inner Mongolia, Shandong, Henan and other provinces have 7-10 cities respectively. There are 30 provinces in Northeast China, accounting for about 1/4 of the whole country [2]. East China is rich in ore resources, and the local government has vigorously mined mountain rocks for the purpose of economic development. "Dangkou", from 《Shuo Wen》, which is explained as a cave, cave house [3]. In the process of open-pit quarrying, due to the artificial operation and activities forming the empty stope, cavity and stope damage surface, forming dangkou, relegated to an industrial wasteland. Generally speaking, the dangkou formed by quarrying and coal has a high elevation and steep slope, and the growing environment of plants is extremely harsh. No grass grows all the year round, which leaves geological hidden dangers and also has a negative impact on the surrounding environment [4].

Xuzhou, in Jiangsu province, as a resource-based city which has a splendid history, rises from coal. The rich coal resources bring Xuzhou more than a lot of money, and there are also abandoned industrial sites left behind by over exploitation of resources, which become scars that are not coordinated with the development of the city and the environment [5]. According to the statistics of Xuzhou Natural Resources and Planning Bureau, there are more than 400 abandoned mines, including coal, rock and sand mining operations. "Ecological scar" not only causes visual pollution, but also has hidden dangers of geological disasters. As a result, coal mines and quarries have been closed since 2005, and the government of Xuzhou has begun to explore the restoration of abandoned areas. Nearly 70 of them have been restored in the past 15 years. The first project is located in Maling Mountain, Xinyi City, which has become the name card of the city. The most typical project in urban area of Xuzhou is East-Zhushan Quarry Park near Jinlong Lake in 2013. Now it is a landmark landscape in the eastern part of Xuzhou, and it has also become a typical case of mine management and quarry ecological

restoration [6].

2. Construction Process of East-Zhushan Quarry

(1) Background and formation process

East-Zhushan of Jinlong Lake was originally a quarry, but due to disorderly mining, the abandoned mine was formed until the resource was exhausted (Fig.1). As a result of indiscriminate mining, the original green mountain has been constantly destroyed, and a large number of steep and disordered open mining slope and mining abandoned land have appeared, causing serious hidden dangers of geological disasters and environmental pollution. The strong wind, sand, dust, not only seriously affect the health of nearby residents and the living environment, but also damage the urban environment. Stones piled up with quarries, vegetation and ecological have been destroyed. For economic development considerations, Xuzhou Economic Development Zone began to carry out ecological restoration and landscape restoration of quarry site formed by quarrying in East-Zhushan mountain, and planned to build a heritage park in the East-Zhushan site.



Figure 1: The former abandoned mine of East-Zhushan site

Mine management and landscape greening project of East-Zhushan Park includes the north, east and south slopes [7]. Specific construction project contents and measures are shown in the table below (Table 1). In May 2015, the third phase of southern slope greening was completed, and the tree-shaped square was built to connect with the rail transit exit. When people get out of the station, they can see the welcoming and displaying landscape shaped by the square, and at the same time, they can also overlook the ecological and green landscape built by East-Zhushan. So far, a large mountain landscape park with an area of more than 220,000 square meters has been appeared in our sights.

Table 1: Construction process of East-Zhushan Quarry

Project Number	Completion Time	Construction Content	Construction Method
Phase One	2010	Mountain risk elimination and ecological restoration, including the sites of Sun Pool, Moon Pool, Zhushan Waterfall.	Soil reconstruction and ecosystem rehabilitation of of the dangerous rock mass on the abandoned quarry mining pit.
Phase Two	2014	Mountain greening project on the north slope and east slope.	Slope cutting, vegetation restoration and natural plant community construction on the abandoned quarry mining pit.
Phase Three	2015	Mountain greening project on the south slope.	Vegetation restoration and natural plant community construction on the abandoned quarry mining pit.

(2) Methods of ecological restoration and landscape renewal

Located in Xuzhou Economic and Technological Development Zone, East-Zhushan Park covers an area of about 340.000 square meters with a total investment of 120 million yuan. The principle and the concept of landscape renewal mainly include the aspects of "ecological restoration", "green covering and landscape retention", and "condensed culture"[8].

First of all, "ecological restoration" means to restore the damaged ecology, create a rich plant community, and form a circular and clean ecosystem through measures such as clearing dangerous rocks, covering soil, planting, and diverting water into the mountains [9]. Technical measures mainly include clean the dangerous rock on the top of the slope, backfill the local soil, masonry the wall on the top of the slope, planting trees and shrubs and eliminate the geological danger. Sloping surface treatment is the key link of the entire quarry regulation. First of all, it is necessary to remove loose stones and debris on the surface of the slope by manpower to eliminate the hidden danger of rockfall. Then, technical treatment on the smooth slope surface to increase the roughness to improve the adhesion of the mixed soil shall be carried out. There are a lot of barbed wire hanging on the hillside, mainly for slope protection and soil covering (Fig. 2). The space between the net and the rock surface is filled with planting soil for plant roots and root tubers, so as to promote the regeneration and germination of seeds, root tubers and rhizomes of vegetation in the planting soil. The old potholes and ponds are leveled to build beautiful lotus ponds and goldfish ponds. A large number of vegetation is planted along the road, mainly selecting elm (*Ulmus pumila* L.), locust (*Robinia pseudoacacia* L.), privet (*Ligustrum lucidum*) and other trees suitable for the geographical environment of Xuzhou, and appropriately matching with dogroot (*Cynodon dactylon* (L.) Pers.), ryegrass (*Lolium perenne* L.), reptile (*Parthenocissus tricuspidata*) and other vegetation, so as to make the landscape more layered.



Figure 2: The technology of net covering for slope protection

Secondly, "green covering and landscape retention" is to give full play to the natural restoration ability of ecology, selectively cover some rocks and hang a net spraying according to the terrain and landform to form a green barrier, so that the ornamental value of the rock exposed landscape. Function of landscape ecology, is to suppress weed growth, keep soil moisture, increase soil fertility, and adjust the soil temperature, promoting plant growth, dust fall haze, and improve landscape ecology. The application of different texture, color, moderate plant in bare land can form a good landscape effect, at the same time can leave space to plant growth and adequate to, keep sustainable landscape ecosystem. On the other hand, the application of landscape covering greatly saves the input of labor, material and financial resources in the early stage of construction, and at the same time, the cost of maintenance in the later stage is also effectively controlled (Fig. 3).



Figure 3: The technology of net-hanging spray-broadcasting

Last but not the least, "condensed culture" is to retain the past mining when the stone wall and other relics, skillfully borrow the site combined into a new cultural landscape. Through the innovative design

concept and advanced mine management technology, the industrial wasteland may achieve the artistic conception of "although made by man, like from heaven". In terms of vegetation planting methods, East-Zhushan Park has also made a technical attempt -- the net spraying seeding technology can not only cover the whole mountain with a green coat, but also play a very good auxiliary role in the soil fixation of the mountain. During this period, domestic greening experts made an in-depth investigation of the local ecological environment. After mastering the first-hand information of climatic conditions and vegetation distribution, they improved the ratio of grass seeds and introduced rich varieties of wild flowers to make it more in line with the local ecological environment of Xuzhou [10].

3. Feasibility Suggestions for Landscape Improvement of East-Zhushan Park

After finishing restoration in 2015, the East-Zhushan Park appeared in front of the public with a new look. It not only serves as a visual art, and provides a activity space for citizens, but also brings new development opportunities for the region. After several years of use, the ecological environment of the park is also being tested by tourists. In order to improve the landscape effect and environmental impact, the following suggestions are put forward.

(1) Natural elements

First of all, in the selection of tree species, it is suggested to select different age and varieties mosaic combination to form a reasonable plant community. At the same time, different texture, color, moderate plant can be applied in bare land and sufficient space should be left to keep sustainable landscape ecosystem. In terms of waterscape, it is suggested to increase the sense of hierarchy and scattered sense by introducing the waterfall stone pattern at the bottom of the valley from the mountain. Referring to Huangguoshu Waterfall in Guizhou, the light can be projected on the waterfall to form the lighting effect. Stacked stones can be used in the bottom of the pool. The rainbow will appear under the sunlight, which creates the landscape artistic conception.

(2) Artificial elements

It is suggested to incorporate more regional cultural elements, such as service sketches with Han culture characteristics and landscape sculptures, to increase cultural atmosphere and sense of belonging. In terms of structures, service facilities shall be increased in leisure space, with the combination of self-service vending machine business. As for the pavement design on the ground, the entrance and exit of the park can be paved with rubber sidewalks for visitors fitness walk, and encouraging slogans shall be set up every 100-200 meters to arouse the enthusiasm and interest of tourists.

4. Conclusion

Turning the abandoned quarry area into mountain park, saves considerable land resources. Various elements of the quarry can be transformed according to local conditions through landscape planning, so that they can re-participate in the cycle of the ecosystem. New social and economic benefits can be generated through the way of "resource reuse", which is a positive utilization idea of turning waste into treasure. East-Zhushan Quarry is just a wonderful epitome of Xuzhou's efforts to promote the restoration of industrial wasteland. By means of ecological greening, rock wall landscaping and historical relics protection, Xuzhou has successively restored the quarries at Guishan and Jiulishan. At present, Xuzhou is actively promoting Wushan park, Tuolongshan park, and so many mountain park constructions. At the same time, further enhancing the technology concept of mountain repair and combining "sponge" technology application have been implemented to explore the Xuzhou mode for the abandoned industrial land, which may provide the reference of ecological development for other resource-based cities.

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