Discussion on Ecological Protection Technology of High and Steep Slope of Expressway

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Abstract. The construction and development of expressways have played a positive role in promoting regional economic and social development, but the construction process and behaviour have caused disturbance to the original landform and caused various damages to the slope. It is currently reasonable protection of the slope is one of the important works of highway construction. This article takes the Huizhou-Qingyuan section of the Shan-Zhan Expressway as an example, analyses and studies different slope ecology from the three aspects of the slope ecological protection mechanism, the slope ecological protection difficulties and the slope ecological restoration design, combined with the current situation of the slope along the line and the main restoration difficulties. This article studies the principles, forms, characteristics of protection technology, and the design of typical slope ecological restoration. The results show that reasonable ecological protection of slopes according to local conditions can achieve slope protection, prevent soil erosion, restore and improve the local ecological environment, and improve highways. The integration and coordination of road landscape and natural landscape are of great significance to ecological environmental protection and driving safety.

Keywords: Slope ecological protection, highway, engineering protection, plant protection, ecological restoration.

1. Introduction

With the rapid development of the national economy, China's road construction has achieved remarkable results and played an active role in regional economic and social development [1]. China has a vast territory, different geological conditions, and environmental characteristics. Although the consciousness of building green highways continues to increase, the concept of sustainable development is more and more implemented in the entire highway construction cycle [2]. However, due to geographic geology, spatial location, Restrictions on the natural environment, etc. make the construction of expressways and local natural environmental protection not well coordinated. Due to the construction of highways, high-filled roadbeds or deep excavations have caused damage to the ecosystem along the roads, loss of vegetation cover, and exposed rocks, which have caused serious
soil erosion, and more serious will lead to the collapse of mountains, landslides and mudslides, giving people's lives Property pose a huge threat [3],[4]. Nowadays, slope protection during the construction of highways is getting more and more attention, and the slope ecological protection technology formed by using vegetation or the combination of vegetation and geotechnical technology is being increasingly used in engineering practice. Compared with the traditional simple engineering slope protection, the slope ecological protection technology can not only conserve water, reduce soil erosion, but also purify the air, protect the ecology, beautify the environment, increase driving safety and comfort, and have good economic, social benefits and ecological benefits [5],[6]. This article takes the Huizhou-Qingyuan section of the Shan-Zhan Expressway as an example to analyze and discuss the principles, forms, and characteristics of commonly used slope protection techniques and combines several typical slopes to carry out slope ecological restoration design, with a view to the slope ecological restoration technique at high speed Provide a reference for more and better applications in highway construction.

2. Project Overview

The Huizhou-Qingyuan section of the Shan-Zhan Expressway is located in the central part of Guangdong Province. It is an important section of the second horizontal line in the main framework of the Guangdong Highway Network Planning "Five Horizontals". The bridge-to-tunnel ratio of the whole line is 60.6%, and the roadbed is 33.5 meters wide. The main line of the whole course adopts a two-way six-lane construction standard with a design speed of 100 kilometers per hour. The impact of the project involves multiple tourist areas, environmentally sensitive areas, and nature reserves, which are of high concern. And there are many difficulties such as a large scale of project, large scale of investment, high technical difficulty in construction, difficulty in implementation, and difficulty in environmental protection.

The project has a long mileage and the main soil type along the route is red soil, which is soil type that is prone to soil erosion. During the construction of the highway, if you do not pay attention to the protection of the slope, it may cause serious soil erosion, and in serious cases, geological disasters such as landslides may occur.

3. Ecological slope protection technology mechanism

Plant slope protection mainly depends on the underground root system of the plants on the slope and the stems and leaves on the ground. Although it has obvious protection benefits, it also has certain limitations. Due to the longer overall cultivation period of plant slope protection, in the early stage of plant growth, the coverage is low, and the root system is sparsely distributed. In the short term, the expected goals of stabilizing the slope and maintaining soil and water cannot be achieved. However, compared with traditional civil engineering measures, slope protection measures combining vegetation and engineering measures have advantages that traditional civil engineering measures cannot compare with slope ecological protection technology [7]. It can quickly restore the ecological environment destroyed by engineering construction; vegetation slope protection costs are low and economical. It is superior to engineering slope protection; and it can avoid the problems that the engineering reinforcement measures will decrease in strength and become worse and worse with the passage of time, weathering of rocks, aging of concrete, and corrosion of steel bars. On the contrary, the use of vegetation for slope protection, as plants grow and reproduce, increases the slope stability and reduces soil erosion. Because of this, the ecological slope protection that combines vegetation and concrete frame and other engineering measures has long-term protection benefits and can promote the restoration of the ecological environment, which has been favored and paid attention by engineers [8]. Ecological protection is not only a measure of slope greening but also a way of restoration and reconstruction of natural ecosystems. It has an irreplaceable role and position in engineering protection and other types of protection. Ecological slope protection combines plant measures and engineering measures to create favorable conditions for the growth and restoration of vegetation. It can not only prevent and control slope soil erosion but also restore the ecological environment caused by highway
construction and maintain the ecological balance along the highway landscape with reconstructed slope [9].

4. Analysis of ecological slope protection from Huizhou to Qingyuan on Shan-Zhan Expressway

4.1. Main repair difficulties

4.1.1. Stability protection of high and steep slopes. The soil quality of the slopes along the project is mainly silty clay, strongly weathered granite and fully weathered granite. The slopes along the line are steep, and some slopes have poor stability. The area along the project belongs to the mid-subtropical monsoon climate. The annual average rainfall is relatively large, and the heavy rain is concentrated, which has a greater impact on the slope. In the case of silty clay slopes, under the condition of rainfall infiltration, when the rainfall is not large, the slope failure is mainly shallow collapse and slump [10]. With the increase of rainfall infiltration, the mechanical properties of the slope rock and soil gradually change, and the slope of the stability is significantly reduced. Therefore, based on the traditional high-steep slope protection technology such as filled vegetation slope in the reinforced concrete frame and pre-stressed anchor frame beam vegetation slope protection, taking into account the landscape effect of slope restoration, which new ecological slope is adopted Surface restoration measures are the primary factors to be considered in ecological restoration.

4.1.2. Effective protection of unstable slopes and uneven slopes. There are 14 unstable slopes and 7 uneven slopes along the project line. What kind of supporting structure is used to stabilize the slope, which surface soil fixing, and improvement methods are used to restore the unstable and uneven slopes? Avoiding problems such as slippage and plant degradation in the guest soil layer is the key content of slope ecological protection.

4.1.3. Vegetation protection of weathered granite slopes. There are a large number of weathered granite slopes along the project line, which has poor erosion resistance and is severely eroded by rain. As the excavation time of the slope increases, the erosion of the slope will increase, and large gullies will be formed. Therefore, how to solve weathering the stability of the granite surface layer is to improve the reasonable soil quality of the soil formed by weathered granite to create a stable plant growth environment. For the granite slopes with different weathering degrees, choose the appropriate slope vegetation protection method, which is the key issue of restoration of the weathered granite slope by vegetation.

4.1.4. Scientific configuration of phytoremediation. To restore the excavated slope to its natural state within a short period of time, it is necessary to combine site conditions and climatic characteristics, and consider how to determine the ratio of plant seeds according to the structural characteristics of the local self-dominant community, and clarify the plant distribution that the dynamic relationship between the ratio and the final formed plant community [11]. Only in this way can the construction be properly guided, otherwise the plant growth on the slope will not be able to achieve the smooth succession of artificial forced greening to the original plant community.

4.2. Ecological restoration design of typical slope

4.2.1. Cut slope. According to the content of ordinary soil, the cutting slope along the line can be divided into soil slope, stone slope and soil stone slope. The cutting slopes along the line are mostly stone and soil, and the number of soils cutting slopes is relatively small. Among them, the rock cutting slope is mainly concentrated in the K55 ~ K97 section, and the soil and soil rock cutting slope is mainly concentrated in the K97 ~ K182 section. The height of the cutting slope decreases from east to
west, with the super high slope above 15m in the east, the middle high slope with 5-15m in the middle, and the middle low slope with 0-10m in the west; Between 1: 0.8 ~ 1: 1.3, see Table 1 for details.

Table 1. Slope situation analysis table along the line.

| Section        | K55 ~ K97 | K97~K140 | K140~K182 |
|----------------|-----------|----------|-----------|
| Height         | 15m+      | 5~15m    | 0~10m     |
| Slope          | 1:1~1:1.3 | 1:0.8~1:1| 1:0.8~1:1 |

(1) Soil cutting slope

① Basic situation of the slope

The soil cutting slopes along this project are mainly concentrated in the K97 ~ K182 section. The area where this section is located is rich in light, heat and water resources, and is basically suitable for the growth of trees, shrubs, and grass. The ground condition of the soil cutting slope along the line is good, and it can realize the reasonable co-existence of multiple functions, so the ecological restoration design should be emphasized.

② Repair measures

For the ecological restoration of the soil cutting slope, according to the slope stability, the herringbone or arch skeleton grass planting technology, hydraulic spraying technology or the soil and water conservation and greening technology based on the W-OH material are used for the ecological restoration of the highway soil slope. And the reasonable arrangement of trees, shrubs or flowering shrubs with rich hue and seasonal colors in the more stable part of the slope can not only increase the stability of the plant community but also make the road landscape more abundant and diverse. The above three techniques are generally applicable to soil slopes with a slope ratio of 1: 0.75 to 1: 2, and the slope surface is not severely eroded [12]. For some slopes with large slopes and low soil weathering degree, pre-treatment is carried out before spraying, and auxiliary measures such as excavation of horizontal trenches are adopted to improve the local terrain of the slope body and create a suitable small environment for vegetation growth.

Figure 1. Soil slope after restoration.

③ Recommended plant selection

Due to the poor ecological environment along the highway, poor soil, drought, poor water, and fertilizer retention capacity, choose light, shade, warm climate, drought, infertility, high-temperature resistance, SO2 resistance, and other strong pollution and resistance plant. In addition, the native tree species in Guangdong should be the main species, and deep-rooted plants should be selected for planting as much as possible, focusing on the combination of irrigation and grass, increasing the types of irrigation and grass, maintaining landscape diversity, and establishing stable communities.
The types, plant types, and colors of trees can be considered equal, and the vegetation planting treatment method without borders with the surrounding vegetation can be adopted to consider its ecological restoration and landscape effects. Pay attention to choose plants with deep roots and good landscaping, such as Schima Superba, Michelia Sibiricus, S. Chinensis, etc. Shrubs can play a good role in covering the slope and fixing the soil. You can choose shrubs with strong slope fixing ability, large crown width and beautiful plant type, such as Locust, Acacia, Black Locust, and more Mulan, Myrtle, Bougainvillea, etc. The selection of herbs focuses on the concept of mixed-use of various types. Often in various grass planting techniques, the selection and proportion of grass species are the keys to the success or failure of ecological restoration effects. According to the types and mixing ratios of grass species, dominant species, associated species, pioneer species, and other matching grass species, and some types of shrubs are added, the slope restoration can achieve a multi-level natural landscape combining shrub and grass and increase the community. stability. The grass species are selected from bermudagrass, Baxi grass, manila, zoysiagrass, molasses, broadleaf grass, perennial ryegrass, and other native grass species in combination with southern alfalfa, locust, myrtle, etc. design. The ratio of plants should consider the natural conditions of sunny slopes and shaded slopes and pay attention to the selection of grass species.

(2) Earth and rock cutting slope

① Basic situation of the slope

The earth and rock cutting slope are distributed in all sections along the line, and the proportion is higher. The slope ratio of this type of slope is between 0.75 and 1.25, the slope is relatively slow, and it is mainly medium-high slope, and contains a small amount of super-high slope. The content of common soil in the cut slope of soil and rock is from 30% to 70%, and the soil condition of the slope is quite different. Moreover, due to the characteristics of heavy rainfall along the line and excessive heavy rain, it is easy to cause erosion on the soil and rock slopes and affect the slope stability. According to the project geological report, there are 14 unstable slopes and 7 uneven slopes along the line. The soil and rock slopes account for a large part, so it is necessary to focus on preventing and controlling the collapse and instability of such slopes, to provide a safe and long-term restoration surface for plant ecological restoration.

Figure 2. Earth and stone slope before restoration

② Repair measures

The ecological restoration of earth and rock cutting slopes must first consider the slope stability. For unstable slopes or uneven slopes, engineering protection and other slope protection measures should be adopted. On this basis, targeted ecological restoration.

The content of common soil in the soil and rock slopes along the route varies greatly, and the ecological restoration measures are also slightly different. For the soil and stone slopes with high common soil content and slope less than 1: 1, the three-dimensional geonet mat grass planting slope protection technology is adopted to appropriately increase the number of trees and shrubs planted and
cooperate with some flower shrubs as embellishment. Highlight the diversity of plants and increase the appreciably of slopes; for the soil and rock slopes with high rock content, use guest soil spraying technology, and select some Arbor and shrub plants with strong resistance, infertility, and drought resistance. Focus on covering the slope to reduce the visual impact of the exposed rock on pedestrians; for the slope protected by the grid, the soil can be directly filled with hydraulic spraying technology; for the slope ratio of 1: 1 to 1: 1.25 Slopes can be sprayed with thick substrates. In some areas with high landscape requirements, planting bag technology should be used together to carry out the ecological restoration of slopes.

Drainage facilities such as intercepting drainage ditches are provided on various slopes along with the soil, earth, stone, and rock, and shrubs with large crowns and good growth are used to shield and soften them to reduce artificial traces and reach the surroundings fusion of landscape.

![Figure 3. Earth and stone slope after restoration](image)

③ Recommended plant selection

In the earth-rock slope, trees can be added or subtracted according to the soil quality of the slope. Considering its ecological restoration and landscape effects, attention should be paid to selecting plants with deep roots and good landscaping, to obtain good soil-retaining slope protection and landscape effects, such as Guangyulan and Michelia. Shrubs can play a good role in covering the slope surface and solid soil slope protection in the soil and stone slopes. You can choose shrubs with large crowns and beautiful plant types, such as Leucaena Leucocephala, Safflower, Magnolia, Robinia Gardenia, Rhododendron, etc. The selection of herbs follows the principle of selection of herbs in soil slopes, combined with the selection of native grass species such as Bermudagrass, Zoysia japonica, Baxi grass, Molasses grass, Broadleaf grass, Perennial Ryegrass, and in combination with southern Alfalfa, Astragalus, Myrtle, and Acacia are designed for matching.

(3) Stone slope

① Basic situation of the slope and repairing principle

The steep slopes along the line from 30 ° to 60 ° are mainly concentrated in sections K55 to K97, and some of the slopes are even steep slopes from 60 ° to 90 °. The slope height is mainly between 20-40m, and the slope ratio is 1: 1.
Repair measures

The ecological restoration of high and steep slopes should be flexibly designed according to the height of the steps and can be repaired by using perfusion planting material slope protection and greening technology, guest soil spraying technology, high steep hard slope software repair technology, etc. Also, for the stable high and steep stone slopes, the technique of hole-drilling and digging holes on the slope surface is better.

Recommended plant selection:

The selection of plants on high and steep rocky slopes is dominated by drought-tolerant shallow root plants. Choose shrubs, locust trees, edamame, etc. for the shrubs; the selection of herbs follows the principle of selection of herbs in soil slopes, combined with the selection of native grass species such as Bermudagrass, Zoysia grass, Baxi grass, Molasses grass, Perennial Ryegrass.

4.2.2. Subgrade slope. ① Basic situation of the slope:

Embankment slopes along the line are mainly concentrated in sections K97 ~ K182. The slopes are mainly soil, rock and stone, and the content of stone slopes is relatively small. The slope ratio is between 1.5 and 1.75, and the distribution range is relatively concentrated. The slope height varies, the low slope is between 0 ~ 9m, and the high slope is between 15 ~ 20m. Embankment slopes generally have only one level, and a few higher slopes have two levels.
② Repair measures
For the restoration of soil and earth-rock embankment slopes, the design should be combined with ecological and non-marking treatment methods.

First, according to the actual situation on the spot, the stability analysis of the slope is carried out. For more stable embankment slopes, the dominant species in the surrounding plant community can be used as the basic elements of ecological restoration and landscape shaping, or the retained native vegetation can be replanted to achieve the purpose of integration with the surrounding vegetation.

For the grass protection of the more stable embankment slopes, the soil and water conservation and greening technology based on W-OH material or the three-dimensional net grass planting technology can be used; for embankment slopes with unstable slopes, the use of perfusion type planting materials for slope protection Greening technology Geotechnical room slope greening technology, three-dimensional vegetation network composite permeable concrete slope protection grass planting brick technology, herringbone or arch skeleton, etc.; for stone embankment slopes, the slope ratio is about 1.75, the slope is steep, Slope protection and greening technology of perfusion type plant-grown coiled material can be used.

③ Recommended plant selection
The plants on the slope of the embankment are mainly deep-rooted plants that prefer light, shade, drought, infertility, strong toxicity and resistance. For the embankment slope, the slope itself is steep, so it is not suitable to plant trees or large shrubs on the slope, and it can only be planted at the slope protection 2m below. Arbor is mainly used as the road background, so green or dark green plants can be selected, such as camphor, deep mountain smile, wood lotus, etc. The shrubs are mainly composed of Amorpha fruticosa, Phellinus linteus, and other legumes such as southern alfalfa. Southern alfalfa is a leguminous plant with strong nitrogen fixation. As a pioneer species, it can increase the nitrogen fertilizer content plays a role in improving the soil.

The selection of herbaceous plants follows the principle of selection of herbaceous plants in soil cutting slopes, combined with the selection of native grass species such as bermudagrass, hydrangea, broadleaf grass, molasses grass, manila grass, perennial ryegrass, Zoysia grass, white clover, And with the southern type of alfalfa, purple locust, edamame, Leucaena, etc. for the proportion design.

5. Conclusion and outlook
The slope ecological restoration should follow the new concept of "natural harmony and green development", select native species according to the local climate type and soil characteristics, and emphasize the principle of adapting to local conditions and suitable trees. Slope engineering protection is the basis and premise of slope greening and beautification. The design of slope ecological restoration should be based on the principle of engineering protection and supplemented by greening protection. Related engineering protection such as intercepting ditches and drainage ditches should be protected in place. The formula design of plant communities should pay attention to climate and regional characteristics. Before the slope greening and beautification construction, first, investigate the slope plant in the road area and determine the native plant community as the target. In the early stage, the pioneer plant is mainly formed, and the purpose of covering the surface is first achieved. Species continue to invade, and eventually, gradually form plant communities suitable for local zonal characteristics. This article takes the Huizhou-Qingyuan section of the Shan-Zhan Expressway as an example, analyses and discusses the principles, forms and characteristics of commonly used slope protection techniques, and combines several typical slopes for ecological restoration design of slopes. More and better applications in highway construction provide a reference basis.

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