Study on rapid ecological protection of rock slope

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Abstract. In recent years, with the construction of domestic infrastructure and mining of ore, a large number of bare rock slopes have been produced. Failure to protect these rock slopes in time will cause driver's visual fatigue, water and soil erosion of rock slopes, and in severe cases, geological disasters such as rockfalls and landslides, which will block roads and affect traffic and pedestrian safety. Based on the above, this article puts forward two types of slope ecological protection methods: assembled rock slope ecological protection and cast-in-place rock slope ecological protection. This method can solve the rapid greening of high and steep slope, the weathering of the slope surface, the effect of the road capacity, and the improvement of the local small environment.

1. Introduction

Due to the complex and diverse terrain of our country, in the construction of foundation projects in rugged areas, it is inevitable to dig high and fill low, resulting in a large number of artificially exposed rock slopes. In order to meet the demand for raw materials for infrastructure construction, a large number of quarries also appeared in China, and then exposed and steep rock walls were formed. For the above-mentioned rocky slopes that have lost plant cover due to various factors, it not only destroys the original terrain and topography but also affects the original stability of the slope, the original ecological balance of the surrounding area, and is exposed to the natural world for a long time. Blowing rain is easily eroded and weathered by rain. These rock slopes caused by the construction of the project have a large number and wide distribution, and most of them have exceeded the natural self-recovery ability. According to the research[1] for the damaged soil slope, even under the condition of abundant rain vegetation it takes at least six to seven years for natural recovery, and for rock slopes, due to the steep and smooth slope, the poor rock debris and the lack of nutrients and root growth space for plant growth, it is difficult for plants to survive. These slopes are under artificial ecological restoration, and the maximum slope of the rock slope (slope coefficient is 1: 0.1-1: 1.25) is 85 degrees, which is almost perpendicular to the ground plane. It will be more difficult to survive under the lack of nutrients and moisture on such steep slopes. It may take decades or centuries to restore the plants naturally[2].
The author proposes two rapid rock slope ecological protection methods. Both ecological protection technologies can isolate the slope from natural air, avoiding rainwater erosion, dripping and natural weathering of the slope. Preventing the soil erosion on the slope has a certain protective effect, and also prevents the detriment of the rock debris from damaging the organism; due to the sound absorption of the material, it also has the effect of absorbing the road noise, and the green plants on the slope. It plays the role of purifying the air, beautifying the road surface, and improving the local small environment; the ecological protection of the rock slope will also play a good social and economic benefit.

2. Ecological protection theory of rock slope
The two methods studied in this paper are ecological slope protection methods that combine the main material polyurethane and other construction aid materials. Different from the existing thick layer spraying methods for ecological protection, this study is intended to use polymers as the material for the combination of two technical methods, and proposes two types of slopes: assembled and cast-in-place rock slopes. The ecological protection method combines the engineering protection measures with the ecological protection of plants without destroying the original slope structure, and strives to achieve the unity of greening and stability of the slope.

2.1 Material properties
Polyurethane as a polymer compound—a compound that does not exist in nature, has attracted much attention since its synthesis for decades, and its application is relatively extensive. It can be used to prepare products with different properties and applications according to different raw materials and formulas, such as soft comparable cotton and hard comparable wood. The soft and rigid foams produced by the polyurethane according to different processes also have different characteristics. The main application of this test is the rigid polyurethane. The following are some characteristics of the rigid polymer:

1. Small density and light weight;
2. Small water absorption;
3. Good adhesion;
4. Strong sound absorption;
5. Dimensional stability under extreme temperature conditions;
6. High durability;
7. Good crack resistance;
8. Good environmental protection: polymer material has low VOC value and zero ODP is a green material recognized by the US National Environmental Protection Agency, the European Union, Japan and the Ministry of Industry and Information Technology of China, and the waste materials in the process of productization are reused for this research and application Recycling of industrial waste is achieved to minimize the load on the environment.

2.2 Slope ecological protection theory
The ecological protection technology method studied in this paper is to use the dimensional stability, durability, crack resistance and environmental protection characteristics of polymer materials under extreme temperature conditions to make a structure of plant. The structure of the plant is combined with some engineering auxiliary materials (plastic anchors, anchors) to fix its structure on the slope, and the plant is placed in the structure of plant, which can carry out plant restoration on the rock slope. Green, can also increase the friction and stability of the slope by using auxiliary materials such as anchors. This method can avoid secondary damage to the rock slope, and also allows the slope to be covered by plants, and also uses the structure of the plant to cover the rock slope. It is isolated from the air, avoiding the erosion and erosion of the slope by wind and rain, and because the material is light-weight, it will not increase the excessive load on the slope. Since the structure of the plant of this study can be made at the factory and the plants can be cultivated at the base, this method can be directly constructed and installed on the slope, and it can also be called rock slope assembly type ecological protection.

The sprayability of the polymer material is used to spray the rock slope on site. Due to the cohesiveness of the material, a special spraying tool is sprayed onto the slope surface and can be bonded to the slope surface to form. It can also be filled with the cracks of the slope body to increase the friction force of the slope surface to improve the stability of the slope. The material is sprayed on the slope to form a certain thickness. The space in the plant hole can also be used for shallow reinforcement of the
slope body after the root system is stabilized in the late stage; in addition, the crack resistance and dimensional stability of the material can also slide on the slope surface after the spray slope solidifies. Rock blocks that have moved or fell off the slope body are given an early warning; this method is called in-situ ecological protection of rock slopes.

3. Technology Introduction

3.1 Assembled ecological protection

The structure-assembled ecological slope protection is composed of three parts: water supply system, plant growth foundation structure and plant seedlings. Three plant foundations of the same type will be used on the same height slope as a unit with a width of 150cm. The steel wire mesh (see Figure 1) is buckled on the slope surface, and it is fixed on the slope surface through the construction auxiliary material anchors or anchor rods. Both the structure of plant and plant seedlings in this method can be customized and cultivated in the factory, so when ecological protection is needed for a rock slope, the structure of plant can be directly assembled on site for anchoring. Realize rapid ecological protection of rocky slopes.

3.1.1 The structure of plant design

Perature of the factory processing and the different polymer products of additives, products with different densities and hardness can be made. This structure uses this feature to process it into a finished plant-based structure. The appearance of this structure is a rectangular parallelepiped with dimensions of length × width × height = 540mm × 200mm × 890mm. There are 8 planting holes in a finished product, and the planting holes are the plant substrate provides space for placement and also protects the growth space of nutrients, water and roots needed for plant growth. The planting hole is roughly in the shape of parallelograms, and the opening direction and structure reach an angle of 50 degrees. When the product is placed perpendicular to the ground, the minimum effective height for the plant substrate in the planting hole is 10 cm, and the angle between the plant and the horizontal plane is 40. When the structural product decreases with the slope angle, the angle between the planting hole and the ground and the height of the plant substrate in the planting hole will increase, which will be beneficial to the growth of plants.

Figure 1. Schematic diagram of reinforcing mesh

Note: the reinforcing mesh is composed of horizontal and vertical reinforcing bars; 1-reinforcing bars; 2-location of irrigation branch pipes; 3-location of corner branch pipes on both sides is movable connection; 4-location of anchor bolts or anchor nails fixed to the slope surface.
Figure 2. Basic unit of top structure.  
Figure 3. Basic unit of top structure.  

Figure 4. Basic unit of middle structure.  
Figure 5. Basic unit of middle structure.  

Figure 6. Basic unit of underlying structure.  
Figure 7. Basic unit of underlying structure.  

Description of the illustrated serial number: 1- polyurethane material product; 2- planting hole; 3-permeable hole; 4- placement drip irrigation water supply pipe; 5- protruding part engaged with the lower structure product; 6- recessed biting with the upper structure product Part; 7-recessed portion engaged with the left structure; 8-protruded portion engaged with the right structure; 9-structure support.  
The support part is because the rock slope is exposed to wind and rain all the year round. The weathering
degree of the slope surface will not be as smooth as the engineering slope. In order to have a good adhesion between the structure and the slope, to avoid the infiltration of rainwater, set the two ends of the structure.

3.1.2 Applicable conditions for ecological protection technology of prefabricated rock face slope

① Applicable area
It can be used in all areas, but in arid and semi-arid areas, a continuous supply of conservation water should be guaranteed.

② Applicable slope condition
Rock face slopes with low weathering degree and slightly flat slopes, such as: embankments, cuts, abandoned quarries or mine slopes along roads and railways. The suitable slope rate is 1: 0.2-1: 2, and the slope of each grade is not higher than 10m.

③ Construction season
In the south, it is not subject to seasonal restrictions, and in the north, construction can be carried out in spring, summer, and autumn, but it is best to avoid heavy rain and other bad weather construction.

3.1.3 Construction method

① Preparatory work
In the factory, structure of the plant is cast and molded, the construction auxiliary materials are processed, and the native plants are surveyed on the slopes to be ecologically protected. After selecting the plant seeds, the factory pre-cultivates into plant seedlings. Set the interception ditch at the top of the rock face slope (a layer of degradable plastic mesh is placed on the top of the interception ditch to avoid falling stones and other debris on the slope top, and a layer of gravel is placed at the bottom to avoid rain seepage, it also serves as a reservoir for the water supply system), and a drainage ditch is provided at the foot of the slope to perform concentrated and rapid drainage for the slope.

② Level the slope
Brush along the slope according to the slope of the rock slope, and clean up the loose layers of debris, debris, etc. on the slope, requiring the slope to be relatively flat.

③ Transplanting plant seedlings
The plant seedlings cultivated in advance in the greenhouse are transplanted into the structure of the plant.

④ On-site installation
Transport the structure of plant that has been prefabricated in the factory to the slope site for installation and anchoring, install the complete set of reinforced mesh at 180mm from the top of each row of the structure of the plant, and arrange it according to the actual situation of the slope with 3 × n. The structure is installed, and the anchors are replaced with anchor rods on the slope with potential deep landslides, which has the effect of strengthening the slope.

⑤ Install water supply system
The water supply system is mainly composed of three parts: the water source part (slope-top reservoir), the configuration pipeline, and the hub part, which mainly include the submersible pump, dripping arrow and hose, steady flow dripper and joint, water supply main pipe and pipe top plug. The first four parts are composed, and each part can determine its size according to the area of the ecological slope protection of the rock slope. According to the specific conditions of the slope height and topography, the water supply system is designed in layers, and pressure stabilizers are installed on the slopes with higher slopes. After completion, conduct drip irrigation test operation of the pipeline. There is no water supply system in areas with particularly abundant rain in the south.

⑥ Early maintenance
The pre-maintenance of plants is mainly drip irrigation water supply on sunny days, and fertilization half a year later (place the fertilizers or nutrient solutions required by the plants into the water source that is usually irrigated, which can accurately transport plant nutrients to the foundation of each plant).
7 Replanting

Check the growth of plant seedlings in time, and replace withered or diseased seedlings.

3.2 Cast-in-place ecological protection technology

The cast-in-situ slope protection technology is based on polyurethane as the raw material, designed to reserve the required position of the plant substrate on the slope, and then is sprayed on the slope by a complete set of spraying machinery. Two different construction schemes are designed for the geographical location.

3.2.1 Applicable conditions for ecological protection technology of cast-in-place rock face slope

① Applicable area:
It can be used in the north and south areas, and the rain in the south is abundant, and there is no need to configure a drip irrigation system.

② Applicable slope condition
The rock face slopes suitable for various weathering degrees include embankments and cutting slopes. The flatness, slope rate and slope stability of the slopes are not required.

③ Construction season
In the south, it is not subject to seasonal restrictions, and in the north, construction can be carried out in spring, summer, and autumn, but it is best to avoid heavy rain and other bad weather construction.

3.2.2 Construction method

Construction process of cast-in-place rock face ecological protection technology

① Preparation
Clean up rubble and obstacles such as floating soil, broken stones, tree roots, etc. In order to ensure that the slope repair is an overall effect, artificially level up the slope surface especially in depressions or protrusions and build intercepting trenches on the slope top.

② Pouring on site

On-site pouring scheme one: After the preparation of the preliminary work is completed, the flower pots are arranged on the slope, a layer of fixed flower pots is poured first, and the drainage pipes between the flower pots are installed, and then a second layer of polyurethane material is poured for fixing.

Scheme 2: The first stage of work is to directly pour a layer of material on the slope surface, design the drainage pipe between the plant holes on the slope surface, and then place the second layer to fix it. According to the position of the drainage pipe, excavate planting holes on the material, this The biggest difference between the two schemes is that the bottom of the former planting hole does not directly contact the slope, the root system of the plant will not affect the stability of the original slope, and it is more suitable for unweathered or weakly weathered rock slope; the latter is a plant The root system can directly contact the slope surface and is suitable for weathered or strongly weathered rock slopes. The root system of plants can also play a mechanical role in increasing the stability of the slope. The common point is that materials can be hooked and filled with more developed structural surfaces when they are poured, which serves as engineering reinforcement measures and also completely isolates the slope from the air to avoid weathering and rain erosion in nature.

③ Install water supply system

The water supply system is mainly composed of three parts: the water source part (slope-top reservoir), the configuration pipeline, and the hub part. The water supply method was selected as the drip irrigation system used in the previous experiment. The branch pipe on the slope surface is fixed to the poured polyurethane material with a slot, and the water supply system is layered according to the specific conditions of the slope height and topography. The pressure stabilizer is installed on the slope with a higher slope. After completion, conduct drip irrigation test operation of the pipeline. It is not necessary to install the water supply system in the southern region.

④ Seedling transplantation
Transplant the plant seedlings cultivated in advance in the greenhouse into the plant holes on the slope.

5 Preliminary maintenance
The pre-maintenance of plants is mainly drip irrigation water supply on sunny days, and fertilization half a year later (place the fertilizers or nutrient solutions required by the plants into the water source that is usually irrigated, which can accurately transport plant nutrients to each planting hole).

6 Replanting
Check the growth of plant seedlings in time, and replace withered or diseased seedlings.

4. Conclusion
In this paper, two kinds of slope ecological protection methods, assembly type and cast-in-place rock slope type, are put forward. Under the condition of not destroying the original slope structure, the engineering protection measures and plant ecological protection are organically combined to achieve the unity of slope greening and stability. Two kinds of ecological protection technologies can use the proposed material polyurethane to isolate the slope and natural air, avoiding the erosion of rainwater on the slope, splashing and natural weathering of the slope, playing a certain protective role in preventing the soil and water loss on the slope, and also preventing the loss of rock debris on the biological damage; as the material has sound absorption, it will also play the role of absorbing road noise. As a result, the green plants on the slope can also purify the air and beautify the road appearance, and have good social and economic benefits for the ecological protection of the rock slope.

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