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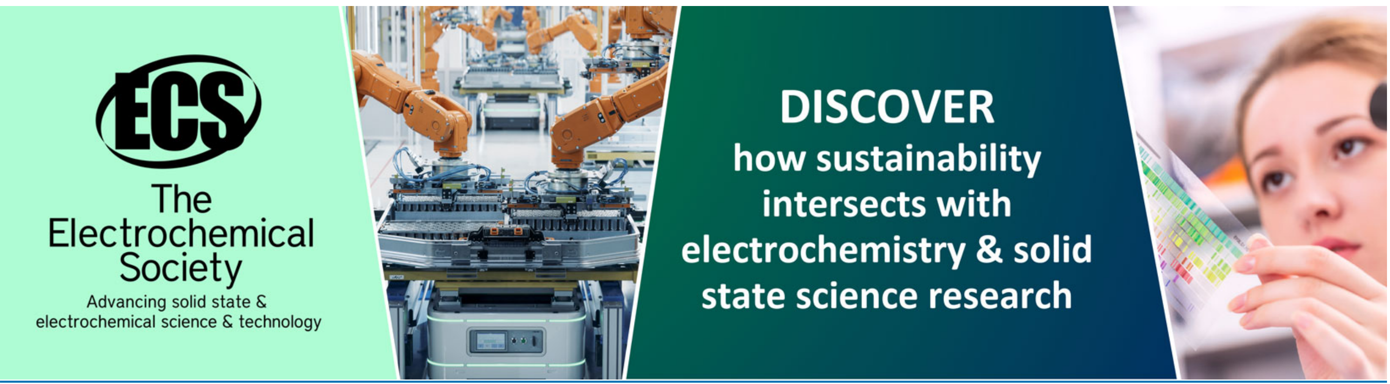

Research on Vegetation Community Restoration Technology of Engineering Destruction Surface Based on Real-Time Fusion of Environmental Background

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Abstract. Vegetation community restoration is an important means for background matching modelling of destructive surface in disturbed area of engineering and real-time fusion of environmental background. Aiming at the problems of large-scale reconstruction or new construction, changing topography and landform, difficult ecological restoration and poor natural similarity of existing vegetation restoration. Through investigation of plant communities around the engineering area, methods such as stable base materials, rapid and sustained nutrient supply, plant screening and cultivation and functional testing were adopted. Three-dimensional construction of plant communities on the destructive surface of engineering disturbance area was carried out, promoting the succession of vegetation communities to surrounding vegetation types. Finally, the effect of vegetation community restoration was characterized. Experiments show that the vegetation coverage rate is 89.4%; the replanting rate is high, which reduces the difference between the restored vegetation and the surrounding background. After a certain period of vegetation community restoration, it can naturally and continuously merge into the background vegetation, destroying the characteristics of target detection and recognition, and realizing dynamic real-time fusion , and improving the natural similarity of the vegetation ecological restoration system.

1. Introduction

The excavation and disturbance of the project forms a large number of bare side-slopes, and the healthy growth of artificially reconstructed vegetation is inhibited, which makes the ecological restoration of disturbed side-slopes face great challenges [1-3]. In this case, domestic and foreign experts and scholars have developed a series of ecological restoration techniques for slopes, which are widely used in slope ecological management, such as soil-spraying, thick-layer substrate spraying, the ecological protection of vegetation concrete, soil bacteria greening method and vegetation strip greening method, etc. [4-5]. Among them, the ecological protection technology of vegetation uses the dry-spray cement-based ecological slope protection substrate to create the vegetation habitat, which makes the adhesion between the substrate and the slope surface stronger, and can stably adhere to the steep slope above 45°, and has many applications. However, the key factor limiting its extension to the ecological restoration of steep slopes is that the substrate has weak erosion resistance, and soil erosion is highly prone to occur under heavy rainfall or runoff conditions, resulting in a continuous reduction in substrate thickness. Therefore, this project has the problems of poor durability, low coverage and poor integration with background features for the restoration of existing vegetation communities on the failure surface of the engineering disturbance area [6-9]. Combining the technical advantages above, referring to the vegetation concrete formula and the construction process of the soil-spraying and thick-layer substrate, selecting the vegetation suitable for the fusion of the slope on the destructive surface of the engineering gateway and the surrounding feature background. Through experimental research, the thickness, density and growth period of the growing vegetation can be well integrated with the optical characteristics of the surrounding background.

2. Research on Vegetation Community Restoration Technology

Based on the collection and investigation of the basic data such as landform, soil and vegetation in the study area, the project carried out the selection of key materials for the side-slope ecological restoration substrate and clearly used the parameters. For the steep slope, develop the dry-spray formula and construction process of the ecological repair substrate. Simultaneously analyse the characteristics of native vegetation communities in the study area, select the artificially constructed target plants based on the constructive and dominant species, and propose a vegetation community allocation scheme with high natural similarity.

2.1. Actual Investigation of Engineering Disturbance Area

Investigate the local and oral plant species and community status of the project, as shown in figure 1. Select a certain area of homogeneous sample, record the sample environmental information, such as slope direction, soil type, thickness of leaf layer, etc.; investigate vegetation type, species composition, community type, main species composition, number of individuals, etc. within the sample; Record the plant species, average height, distribution, etc. in the sample. The plant community is divided in accordance with habitat characteristics, community structure and appearance, species dominance and species composition. According to the height, density and frequency of the individual plants in the sample, the dominant species and the constructive species are identified.

Figure 1. Wlid vegetation community investigation.

2.2. The Repair of Key Materials and the Selection of their Parameters

The main reasons for the failure of vegetation growth on the disturbed surface of the engineering disturbed area are that: (1) No soil environment for vegetation growth, due to the large slope of the rock, even if there is a small amount of soil parent material due to weathering of the rock, it will be washed away by rain. (2) It is impossible to provide the moisture required for vegetation growth. (3) It is impossible to provide the nutrients needed for vegetation growth. Therefore, the key to vegetation restoration and fusion on the steep slope surface of the engineering disturbed area is to preserve a certain thickness of the matrix soil on the slope to provide a growing environment for vegetation restoration.

At present, the organic materials used in the formulation of the damaged surface vegetation restoration substrate are often rice husk or sawdust [10-11], while the organic material types in the side-slope ecological restoration materials in the northern region should be adjusted accordingly, as shown in figure 2. Therefore, the first step is to select suitable organic material types from straw,

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peanut shell, distiller's grains and other common materials in the northern region from the perspectives of difficulty in obtaining, availability, and cost of access, And through experiments to study the influence of organic material type, addition amount and particle size on physical and mechanical parameters such as strength, shrinkage characteristics and porosity of ecological restoration substrate, then, determine the suitable organic material type, addition amount and particle size, and the processing method of the selected organic material is further determined based on the appropriate particle size. Starting from strengthening the structural stability of the substrate, it is considered to use the fiber reinforcement effect to suppress the structural change of the substrate under the freeze-thaw cycle. In this study, 3 to 4 plant fibers such as brown leaf sheath fiber, jute fiber and cellulose fiber with a fiber diameter of less 0.2 mm and high breaking strength were used as alternative materials, as shown in figure 3. The matrix soil ratio is shown in table 1.

(a) corn distillers (b) straw

Figure 2. Materials required for substrate formulation.

(a) brown leaf sheath fiber (b) cellulose fiber

Figure 3. Alternative fiber.

Table 1. Matrix soil ratio.

Name	Ratio	Remark
cultivated soil	100	Main material
corn distillers	2	Improve matrix pore structure
adhesive	10	Enhance soil and matrix adhesion
PH regulator	1	PH is about 7
aqua orb	5	500 times
granule	5	Form agglomerate structure
brown leaf sheath fiber	2	Reducing the expansion and contraction of soil under the driving force of environmental factors
cellulose fiber	2	Strengthen the structural stability of the substrate
straw	3	Enhanced interconnection

2.3. Plant Community Modeling on the Destructive Surface of Engineering Disturbed Area

The restoration of hidden plant communities modelling in the steep slopes of the project needs to be based on the local background, take the surrounding typical plant communities as a reference, the characteristics of community formation were simulated to the maximum extent. Taking the typical mountain-forest background in North China as an example, the restoration of background fusion vegetation community carried out on steep slope surface of engineering disturbed area is mainly realized from the two following aspects: one is to avoid the number of vegetation species to be monochrome; the other is the vegetation types are close.

2.3.1. Number of Vegetation Species. The number of vegetation species should take two factors into consideration: one is the number of main species in the surrounding background plant community; the other is that the vegetation species should meet the requirements for establishing plant communities. According to the experience of many years in Japan, it is considered that the reasonable selection of 4 to 8 plant species can meet the requirements for establishing plant communities. The reason is that the vegetation restoration and fusion area is part of the background large community, and the species mainly refer to the background vegetation community will facilitate the fusion with the background. In addition, the vegetation restoration and fusion area generally uses pioneer plants to establish the vegetation community. After initial maintenance, the surrounding background species will invade the camouflage area for succession. The test site is located in the mountainous area of the suburbs of Luoyang. The surrounding plant community characteristics are shown in figures 4 and 5.

Figure 4. Ground map of a test site background.

Figure 5. Low-altitude map of a test site background.

2.3.2. Vegetation Types. The Luoyang area is the northern transitional climatic zone. The grass species that can be planted include tall fescue, Bermuda grass, white clover, foxtail and ryegrass. The suitable shrubs are torches, skunks, and amorpha. According to the onsite situation, the shrubs and bushes choose torches, hedgehogs and skunks, and the grass species choose Bermuda grass, tall fescue and perennial ryegrass.

2.4. The Boundary Cross Modeling of Vegetation Restoration Background Fusion Area

One of the main reasons for the obvious bare characteristics of the steep slope on the destructive surface of the tunnel engineering disturbed area is that the steep slope has a clear boundary with the surrounding background, so that the human eye can quickly capture the shape of the steep slope. The boundary is the contour mentioned in the shape perception. Contours have an important place in shape perception. The contour is produced by a sudden change in brightness, and the gradient of lightness cannot produce a contour. The vegetation on steep slope of the tunnel project gateway needs a cross modelling while restoring the boundary contour of background fusion area. The principle is as follows: a. Try to destroy the continuity of the original boundary contour. Especially in the feature parts that best reflect the nature of the target, the original outline of the target cannot be repeated, and the original outline of the area is distorted and destroyed as much as possible. b. Coordinate with the natural contours of the vegetation community in the background. In the staggered shape, the same species as the surrounding vegetation community can be planted through the boundary contour, making it a natural extension of the surrounding vegetation community, which can not only destroy the inherent boundary contour of the region but also blend into the natural contour. c. The colour and brightness of the vegetation planted on the boundary contour are close to the adjacent background and merge with each other to achieve the purpose of the inherent boundary contour of the fuzzy region.

2.5. Background Fusion Technology Rapidly Constructed by Grass Seeding Amount and Vegetation Community

For the lawn, there is a grass seedling every 0.5 to 1.0 cm^2. However, the expected number of plants used for the fusion of the background characteristics of the engineering steep slope vegetation cannot be the same as that of the urban lawn. The vegetation with merged background characteristics of the steep slopes are extensive management after the initial stage of conservation, and basically rely on themselves and the environment to achieve the required water and nutrient balance. If the plant density is too large, plants are easily degraded due to lack of water or nutrients. Therefore, the density of plant species must follow the principle of population density constraints, that is, not too high and not too low.

According to the principle of “biodiversity, adapting to local conditions, selecting materials locally, reducing costs, respecting the surrounding environment, and symbiosis”, the vegetation suitable for the integration of the slope of the engineering damaged area and the surrounding characteristic background is screened out. Designing plant density and allocation model of vegetation combined with a reciprocal vegetation allocation method among species, which mainly based on native species and supplemented by pioneer species, and through the combination of direct seeding of herb seeds and transplanting of arbour, to achieve the quickly construction of plant communities, the surrounding environment of the project is fully considered, and the layer stacking method is adopted to perform surface disturbance and fusion modelling. Through experimental research, the thickness, density and growth period of the growing vegetation can be well integrated with the optical characteristics of the surrounding background. Through laboratory experiments of seed germination and seedling growth (see figure 6), the relationship between conventional herbaceous plants, pioneer species and native species was studied to provide a basis for the target species to be used as the middle layer and ground cover plant configuration of the new silver wood forest. Plant root morphology monitoring: Plant root morphology was respectively monitored in three months, one year and one and a half years, as shown in figure 7. Finally, according to the height and topographical conditions of the slope, transplanting, cutting the native plants, and properly planting the small shrub seedlings to construct the intermediate layer, to quickly form the artificial slope restoration community similar to the vegetation community in the engineering disturbance area, as shown in figure 8.

2.6. Test Methods

The optical band performance test uses aerial visible light photography for direct interpretation, determining the optical fusion effect after vegetation restoration [12-13], the degree of fusion with the surrounding background and target edge detection. The aerial visible light photograph is also used to calculate the vegetation coverage of the damaged surface in the disturbance area. The spectral reflectance curve is used to calculate the contrast between the camouflage area and the surrounding background brightness [14-16].

Figure 6. Seed germination experiment.

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(a) Half year (b) One year (c) One and a half years

Figure 7. Plant root morphology monitoring.

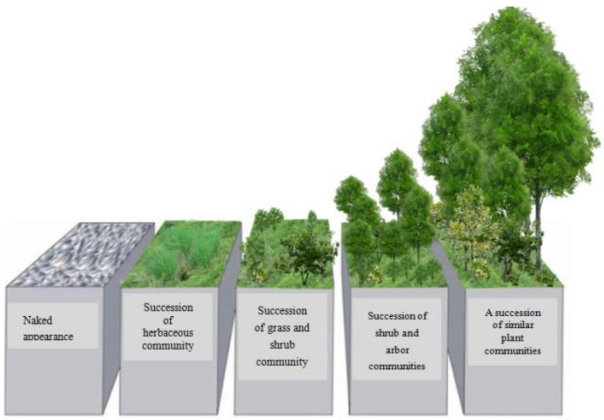

Figure 8. Schematic representation of vegetation community succession process (reference).

3. The Fusion Matching Test of Restored Vegetation Community and Environmental Background

3.1. Test Equipment
The optical test is mainly based on optical photographs, supplemented by spectral reflectance curves. Low-altitude optical photos are mainly acquired by drones, as shown in figure 9.

Figure 9. Drone.

3.2. Test Results
It can be seen from figures 10 to 11 that as time goes by and the season changes, the vegetation in the steep slopes of C and D areas grows more and more lush, and the vegetation coverage rate is larger and larger, and these changes are synchronized with the surrounding background plants. The exposed characteristics of the steep slope gradually decreased with the increase of vegetation coverage. The exposed rocks of the steep slopes in the C and D areas of the early summer were all covered by vegetation and integrated with the surrounding vegetation. The camouflage effect was very significant.

It can be seen from figure 12 that the coverage of the C, D and E areas is relatively high, the vegetation growth area can cover the exposed characteristics of the exposed rock, the vegetation edge of the C area is highly integrated with the surrounding background, and the middle and upper parts of the D area are well merged with the surrounding vegetation. Because the E area is planted with grass, it is not as patchy as the surrounding background. It is relatively "flat" and less integrated with surrounding than an area and C area. According to the relevant formula, calculate the colour coordinates and brightness contrast of the vegetation of the steep slope in engineering project area and the surrounding typical vegetation. (See table 2) As is shown from the table, its visible light brightness contrast is 0.05.

(a) Before vegetation restoration (b) After vegetation restoration (8 months)

Figure 10. Visible image in C area.

(a) Before vegetation restoration (b) After vegetation restoration (8 months)

Figure 11. Visible image in D area.

Low-altitude visible light images in areas C, D, and E

C area D area E area

Figure 12. Low-altitude visible image.

Table 2. Comparison of color difference and brightness between experimental vegetation and background vegetation.

Testing object	Ratio			visible light contrast
	L*	a*	b*	
Test area	37.90	-11.10	19.30	0.05
Background vegetation community area	41.00	-12.50	18.40	

By measuring the vegetation coverage rate in the experimental project area, the sustainability of the vegetation restoration camouflage technology on the steep slope is known. Photographs were taken perpendicular to the test project area, and image processing software was used to count the pixel percentage in the vegetation coverage area of the photograph, and the vegetation coverage rate in the test project area was calculated. A photograph of the test project area is shown in figure 13. Performed by image processing software, and a screenshot of the running result is shown in figure 14. After calculating the white area, the bare area occupies 10.6%, that is, the vegetation coverage rate reaches 89.4%.

(a) Overall photo of the test project area. (b) The photo of steep slope vegetation restoration.

Figure 13. Experimental project area photo.

Figure 14. Calculation results screen capture.

4. Conclusion

Based on the environmental target visible light fusion indicators, this paper studies the vegetation community restoration technology on the failure surface of the engineering disturbance zone, and main results as follow:

(1) Using the techniques of substrate stabilization, rapid and continuous nutrient supply, plant screening and cultivation as well as performance testing, the rapid three-dimensional construction of plant community on the destructive surface in the engineering disturbance area is carried out, promoting the succession from constructed vegetation community to the surrounding vegetation community type.

(2) The restoration effect of the vegetation community on the failure surface of the engineering disturbance area is obvious, the coverage rate is 89.4% and the multiple cropping rate is high; the restoration area enables the engineering area to naturally and continuously blend into the background vegetation, realizing dynamic real-time fusion degree;

(3) The visible light brightness contrast between the vegetation in the steep slope test area and the surrounding background typical vegetation is 0.05, and the natural similarity of ecological restoration is high.

The research results of this paper have a guiding role in the construction of vegetation communities on the steep slope of the engineering disturbance area.

Notes

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