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Research on Scour Resistance based on Ecological Concrete Slope Protection Method

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Abstract

In order to study the anti-scouring performance under the ecological concrete slope protection method, tall fescue was selected for vegetation experiments and anti-scouring experiments to analyze the effect of anti-scouring performance under different slope, different rainfall and different concrete thickness conditions, and concluded that the runoff erosion increases with the increase of slope and rainfall, while the concrete laying thickness has little effect on the runoff erosion. It also provides new research ideas and research directions for engineering applications.

Keywords

Vegetated Slope Protection; Porous Concrete; Scour Resistance Experiment; Ecological Slope Protection.

1. Quotes

Road construction plays an important role in the development of China's economy. In order to ensure the stability of the roadbed, slopes of different slopes are formed during road construction, which in turn form exposed slopes, and the formation of slopes will cover the original vegetation. The formation of slopes will cover the original vegetation. The original vegetation covered by soil slopes will cause serious damage to the ecological balance, and the ecological restoration and sustainable development is a hot topic of global concern, so the research on ecological protection of slopes is extra important.

In recent years for the generation of a large number of slopes, in strong rainfall and other environmental conditions will produce landslides, erosion and other natural disasters, for the traffic safety issues produce a serious threat, ecological concrete slope protection method has better permeability, can be combined with engineering and ecological environmental protection, in recent years is widely used, so for ecological concrete vegetation after the study of the scour resistance is of significant significance.

Ecoconcrete has more pores, which can provide a space for air, soil, water and plant roots to connect, providing good conditions for plant growth.[1] The plant roots can enter the deeper soil through the pores of the porous concrete, which can play a role of soil consolidation and reinforcement for the slope.[2] This paper is based on ecological concrete slope protection. In this paper, based on the ecological concrete slope protection, indoor vegetation test was conducted firstly, followed by the ecological concrete scour resistance test and analysis of the test results, and the plant consolidation mechanism was analyzed to reveal the ecological concrete slope scour resistance law, which can provide reference for similar projects.

2. Experimental Materials and Protocol

Based on the study of ecological concrete in North China, plants suitable for the climate of North China should be used as much as possible for planting. North China is a semi-humid continental monsoon climate in the middle warm zone, with cold winters and hot summers, cold and dry

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winters, hot and rainy summers, and annual precipitation of over 400mm-800mm. In view of the special natural geography of North China, the vegetative porous concrete slope grasses should not only have strong cold tolerance, but also have certain drought tolerance and barrenness resistance, and the root system is well developed and strong to penetrate the soil, and the ecological concrete pores are alkaline, the grasses need certain alkali resistance, so tall fescue is selected as the vegetative experimental grasses, and the soil is selected from the native loess in Hebei.

2.1. Indoor Vegetation Test

The specific test procedure is shown below:

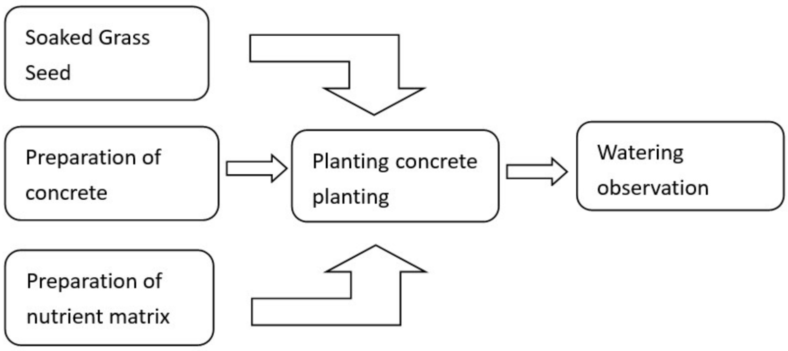

Figure 1. Steps of vegetation test

(1) Porous concrete selection:

By comparing the physical properties such as compressive strength and frost resistance of the planted concrete under different proportion, the proportioning scheme of water-cement ratio of 0.3, silica fume dosage of 10% of cement dosage, water reducer dosage of 1% of cement dosage and cement dosage of 300kg/m3 was selected for the experimental study of planting properties. The compressive strength of the porous concrete specimens prepared under this ratio scheme can reach about 10MPa, which can meet the requirements of slope protection strength. The coarse aggregate size is 16-19mm, the porosity is 25%, and the specimen thickness is set according to Table 3.

(2) Preparation of raw materials:

1) Vegetative seeds: tall fescue seeds as in Figure 2;

2) Vegetation base material formulation as Table 1.

3) Three sets of vegetated concrete specimens;

4) Customized wooden box (101cm x 51cm x 12cm).

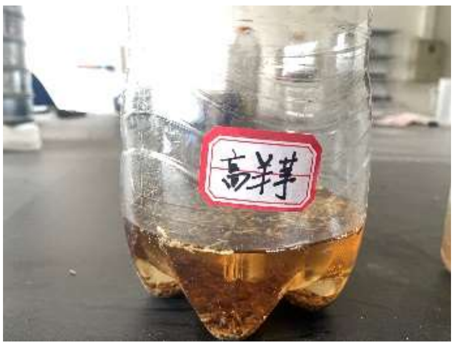

Figure 2. Tall fescue grass species

Table 1. Vegetation base material ratio

Raw Materials	Natural Soil	Peat soil	Vermiculite	Perlite	Humic substances	Organic fertilizer	Water Retention Agent	Ferrous Sulfate
Proportion	48%	18%	5%	8%	15%	5%	1%	1%

(3) Test process

1) The bottom is filled with 8cm of soil to ensure that the vegetation can reach the soil and continue to grow when it passes through the vegetated concrete;

2) Fill the tray with 100cm x 50cm x 5cm porous concrete specimens;

3) Filling the pores of porous concrete with nutrient substrate and grass seeds;

4) Regular watering and observation of plant growth at 3d, 7d and 18d.

2.2. Scouring Resistance Test

2.2.1. Test Setup

In order to study the scouring resistance, the experiment used a homemade test device as shown in Figure 3. the rainfall device consists of a bracket and a rainfall system, the rainfall system consists of a water pipe, a nozzle, a water pressure gauge, a water pump and a regulating valve, there are eight nozzles evenly distributed on the side slope, the bracket is connected by iron pipes, and the porous concrete has an adjustable height wooden board at the bottom, which is used to adjust the angle and height of the side slope to meet the experimental requirements. During the test, the water collection container will be placed under the grinding tool to collect the soil washed down by the rain.

Figure 3. Test setup

2.2.2. Rainfall Intensity Design

The rainfall distribution derived from the review of information is shown in Table 2;

Table 2. Classification of rainfall levels

Rainfall level	Light rain	Medium Rain	Heavy Rain	Rainstorm	Heavy rainstorm	Very heavy rainfall
Mm/24h	<10	10-25	25-50	50-100	100-250	>250

For the annual average rainfall in Hebei area, representative rainfall intensities were selected to start the test. The rainfall intensity is set to 10mm/h, 20mm/h and 50mm/h, and the time will be 60min.

2.2.3. Test Protocol

The test mainly investigates the effects of different thicknesses of vegetated concrete, different slopes and different rainfall on the scour resistance performance. Among them, with reference

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to the requirements for side slope design in the Specification for Design of Highway Road Base[3] The slope of the slope was determined with the parameters shown in Table 3.

Table 3. Experimental protocol

	Concrete thickness/cm	Slope	Rainfall intensity(mm/24h)
1	5	1:1.2	10
2	8	1:1.5	20
3	12	1:2.0	50

The test protocol is shown below:

(1) After the plants are well grown and maintained for three months, observe the growth status, determine whether the plant coverage and survival rate meet the requirements, and carry out the scouring test after determining that the requirements are met.

(2) The test device will be assembled and connected to the inlet and outlet pipes, open the water inlet, and carry out the scouring test according to the designed rainfall intensity, with each rainfall intensity ensuring a scouring time of 60min.

(3) Adjust the concrete thickness and slope, i.e., carry out 9 groups of scouring tests.

(4) After the flushing test, the water collection container of each group is marked and weighed, and left to stand for 10 hours, and then put into the oven after standing, and after drying, the sediment mixture is weighed again, and the weight is recorded as P.

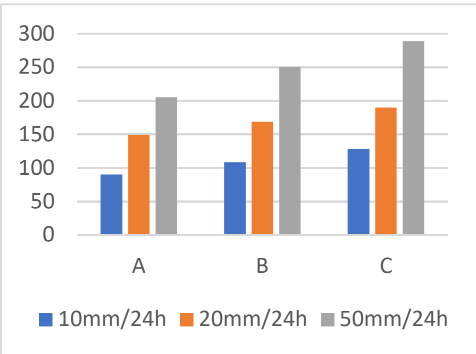
3. Analysis of Experimental Results

Analysis of runoff erosion for nine groups of ecological concrete slopes

3.1. Influence of Slope on the Scour Resistance of Slope

The effect of slope on the scour resistance performance is shown in Table 4. The three slopes are 1:2.0, 1:1.5, and 1:1.2, respectively, and are recorded as A, B, and C. The concrete thickness is selected as 6 mm.

Table 4. Runoff erosion at different slopes (g/m2)



It can be seen from Table 4 that the runoff erosion volume gradually becomes larger with the increase of rainfall. When the slope is 1:2.0, the runoff on the slope surface is slow, and when the slope increases to 1:1.5 and 1:1.2, the runoff on the slope surface becomes more rapid. It can be seen from the graph that as the slope increases, the runoff erosion on the slope surface also increases. When the rainfall intensity is 50 mm/24h, the runoff erosion on the slope surface of 1:1.0 increases by 25% and 45% compared with the other two slope surfaces. With the increase of slope, the infiltration of rainwater into the planted soil body gradually decreases,

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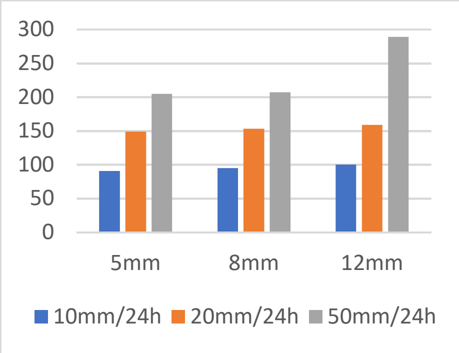
and the runoff on the slope surface gradually increases, which in turn weakens the stability of the soil body and makes the degree of rainwater erosion increase.

3.2. Influence of Porous Concrete Thickness on the Scour Resistance of Slopes

The influence of thickness on slope scour resistance is shown in Table 5. A slope with a slope of 1:1.5 is selected, and three concrete thicknesses of 5mm, 8mm and 12mm are chosen.

Table 5. Runoff erosion for different concrete thicknesses (g/m2)



From Table 5, it can be found that the scour resistance of ecological concrete slope is not much related to its concrete thickness.[4]. To explore the reason, when the runoff on the slope surface is not formed, rainwater infiltration, the pores inside the concrete can effectively reduce the water accumulation on the slope surface, which can play a role in alleviating the erosion of runoff. When the runoff of the slope surface is obvious, the effect of the soil and water conservation ability of plant roots is not obvious, solid its erosion increases, and there is no significant relationship with the thickness of concrete.

4. Conclusion

Through the above test, it can be found that slope and rainfall intensity are the main causes of slope erosion. The erosive effect of rainfall on ecological concrete is more obvious, with the increase of rainfall, erosion also gradually increases, and with the increase of slope, erosion is also obvious due to the effect of gravity, which accelerates the erosion of soil.

And the concrete laying thickness has no significant influence on the scour resistance performance of slope, which can be not considered as a priority research object in the subsequent study. The subsequent study can introduce other slope protection methods for comparison of scour resistance performance to get the optimal slope protection method.

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