Experimental Study on Anti-Erosion of Slope Out-Soil Based on ADNB Protection System

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Abstract. To address the stability issue of guest soil in the ecological restoration of high-steep rock slopes, an anchor-double net-baffle (ADNB) slope ecological protection system was proposed. This system formes a three-dimensional flexible structure with anchors, double nets and baffles. Indoor rainfall simulation tests were conducted to study the stability of rock slopes under different slope angles, rainfall intensities, and protection systems. Data on total soil loss and guest soil loss were collected and analyzed. The results demonstrate that the ADNB-based soil consolidation system significantly enhances slope erosion resistance. The anti-erosion performance of the three protection systems follows this order: geogrid-double net-horizontal baffle structure > double net-horizontal baffle structure > guest soil-double net-horizontal baffle structure. This study provides a technical solution for stabilizing guest soil in high-steep slope ecological restoration.

Keywords: anti-scour performance test; soil stablilization; ecological slope protection; high-steep slope

1 Introduction

A large number of exposed slopes will be generated in the process of engineering construction, and these exposed slopes have poor stability and are prone to natural disasters such as landslide and collapse. How to repair these exposed slopes has become an urgent problem to be solved [1-4] . Compared with the traditional reinforced concrete "gray" slope protection technology, ecological slope protection has the advantages of green environmental protection, high efficiency and energy saving, and has gradually become the choice of slope engineering [5] .

About ecological slope protection technology Mingjie Wu [6]designed an ecological slope protection scheme combining three-dimensional network protection technology and mixed sowing, which improved the anti-weathering and anti-erosion ability of slope protection engineering. Xiangyong Zhong et al. [7] put forward the ecological slope protection technology of straw fiber curtain, and conducted an experimental study

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on anti-erosion. Yi Jian, Yubing Fan, [8] realized slope protection and resource reuse by using ecological slope protection technology of dredged sediment recycling. Xiaoke Chen [9]studied the influence of eco-bag slope protection on the stability of river slope through field tests..

In addition, there are many ecological slope protection technologies such as ecological rod slope protection technology and vegetated concrete slope greening technology[10]. Such as Tianbin Li [11] developed a new type of JYC ecological substrate suitable for vegetation restoration of rocky steep slopes in alpine regions, and proved that JYC ecological substrate has good drought and frost resistance and erosion resistance. Tao Sun [12, 13] built a new green protection system applicable to excavated and filled slopes by integrating a series of innovative achievements such as flexible surface slope protection system, multi-layer ecological slope protection system with transverse partition and steel-plastic composite external anchoring system. Based on existing ecological slope protection technologies, Qiaoxue Li [14] proposed a new ecological protection method for high and steep rock slopes, and verified the feasibility of this method through indoor physical model scale tests

In the construction of slope protection project, it is necessary to consider the characteristics of guest soil, slope topography, local climate and other factors. For this reason, many experts and scholars have respectively carried out research on gravity, rain erosion, water infiltration and other factors. Shuijin Shen [15] found that heavy rainfall of a certain duration was the main reason for the instability of the side slope of the gravel earth road embankment by analyzing and investigating the field data and conducting physical model tests. The erosion and infiltration processes of rainwater influenced and promoted each other, and the two combined forces accelerated the failure of the slope. Song Xianghua, Xiao Heng [16] Lin et al. revealed the triggering mechanism of rainfall induced instability failure of soil slope from a microscopic perspective by conducting rainfall slope model tests and combining computational fluid mechanics with discrete element fluid-structure coupling numerical simulation. Xiurong Wang and Bangmin Wang [17] used finite element software to study the instability mechanism of open-pit mine slope under the action of rainfall. Liang Wang [18, 19] studied the influence of surface seepage on the stability of guest soil on ecological slope through laboratory model tests, and concluded that the failure mode of guest soil with seepage was the same as that without seepage, which was a straight sliding surface parallel to the original slope, and also found that seepage could significantly reduce the stability of guest soil.

In the ecological slope protection engineering, in order to ensure the stability of the slope, the erosion resistance of the guest soil under the protection system is a problem that must be considered in the selection of ecological slope protection mode. This paper is based on a multi-layer structural ecological slope protection system with transverse partition proposed by Sun Tao et al. [20, 21], referred to as ADNB. The ADNB soil consolidation system mainly consists of three protection systems, namely, guest soil-double mesh and cross barrier, geoglaret-double mesh and cross barrier, and geobag-double mesh and cross barrier. Through a series of indoor rainfall tests, the stability of rock slopes with different slope angles is studied under different rainfall intensities and protection systems.

2 Test Overview

2.1 Test Materials

(1) Soil

The soil used in this test is provided by Qingdao Ruiyuan Engineering Group Co., LTD. The soil color is yellowish-brown, the texture is uniform, the plasticity index is 11.4, and it belongs to silty clay. The physical properties of soil are shown in Table 1.

Table 1. Physical properties of soil

Specific gravity	Maximum dry density (g/cm^3)	Optimum moisture content (%)	Liquid limit (%)	Plastic limit (%)	Air drying moisture content (%)
2.65	1.64	19.7	32.5	21.1	7.5

(2) Sludge

The sludge compost used in this experiment was treated by Qingdao Loushan River Water Resources Co., Ltd. in accordance with the requirements of "harmless, stable and reduced", and the heavy metal content of the treated sludge met the requirements of the control value of agricultural sludge pollutants in the National standard of the People's Republic of China (GB4284-2018).

(3) Fiber

The plant fiber additive selected in this experiment is rice husk. Adding fiber to soil has two main functions, one is to improve the physical properties of soil, which is because fiber can form a certain pore structure, increase porosity, improve soil consolidation; The second is the bonding effect, fiber can enhance the cohesion and tensile strength of the matrix, improve the strength and durability of the soil. In addition, as a kind of organic matter, plant fiber can provide nutrients for the later growth of plants.

(4) Soil additive

The soil additives used in this test are mainly high-order aggregates and water retaining agents, which are mixed into the soil in a ratio of 1:1. The high order aggregates can react with the mixed mud to make the soil more porous and porous, and form a stable and durable aggregates soil structure with good hydrophobic properties. The water-retaining agent is Sodium Polyacrylate (PAAS), which can improve the water retention of the matrix, slow down the water flow rate, and help to maintain the overall stability of the slope.

(5) Geosynthetics

The geosynthetic materials used in this test include geoglage, geoglage chamber and geoglage bag, which are customized by Shandong Ludian New Materials Co., LTD.

2.2 Test Device

(1) Artificial rainfall device

The artificial rainfall simulation device used in this experiment is composed of four parts: water supply system, spray system, support and soil container. The overall size of the device is 2.5m in height, 1.2m in length and 1.2m in width. By adjusting the pressure of water pipeline and opening and closing different types of sprinkler heads, artificial rainfall scenarios of different rainfall intensification can be simulated. The rainfall device is shown in Fig.1a.

(2) Soil container

The soil container is 800 mm long, 40 mm wide and 150 mm deep, and is placed on the inclined plate. The material of the container is transparent acrylic, which can directly observe the phenomenon of runoff and soil erosion during the test process. The bottom edge of the container is equipped with an overflow trough to ensure smooth discharge of water. In order to simulate the anchor structure, nails with a length of 12cm were fixed at the bottom of the soil container with a row and column spacing of 20cm. In addition, a layer of cement about 1cm thick was laid inside the container and crushed stone was spread on its surface to increase the surface roughness and simulate the slope characteristics of the actual rock slope. The soil container is shown in Fig.1b.

a. Rainfall equipment b. Soil container

Fig. 1. Rainfall equipment and guest soil container

(3) Data measuring instruments

The measuring instruments in this test mainly include a simple rain measuring cylinder used to measure rainfall intensity, a digital display Angle ruler, a stopwatch, a measuring cylinder and a sky level used to measure the inclination Angle of the slope inclined plate model.

3 Test Plan and Process

3.1 Test Scheme

Taking rainfall in the north as a reference, after consulting a large number of meteorological data and combining rainfall intensity in recent ten years, four groups of different rainfall intensities of 60mm/h, 80mm/h, 100mm/h and 120mm/h were finally selected as test conditions, and the rainfall duration of each group was set to one hour. In the study of ADNB protection system, through searching data and combining with the previous experimental research of the research group, three protection systems of guest soil-double mesh-horizontal barrier retaining structure, geoglelab-double mesh-horizontal barrier retaining structure, and soil bag-double mesh-horizontal barrier retaining structure were selected. A total of 36 groups of tests were designed according to different slope conditions and rainfall conditions in different regions. The test conditions are shown in Table 2 to 4.

Table 2. Grouping of 50° slope rainfall scour resistance tests

Number	Slope Angle (°)	Protection Method	Rainfall Intensity (mm/h)
E0	50	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	60
E1	50	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	60
E2	50	Geotextile Bag-Double-Layer Net-Diaphragm	60
F1	50	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	80
F2	50	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	80
F3	50	Geotextile Bag-Double-Layer Net-Diaphragm	80
G0	50	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	100
G1	50	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	100
G2	50	Geotextile Bag-Double-Layer Net-Diaphragm	100
H1	50	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	120
H2	50	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	120
H3	50	Geotextile Bag-Double-Layer Net-Diaphragm	120

Table 3. Grouping of 60° slope rainfall scour

Number	Slope Angle (°)	Protection Method	Rainfall Intensity (mm/h)
I0	60	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	60
I1	60	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	60
I2	60	Geotextile Bag-Double-Layer Net-Diaphragm	60
J0	60	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	80
J1	60	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	80
J2	60	Geotextile Bag-Double-Layer Net-Diaphragm	80

K0	60	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	100
K1	60	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	100
K2	60	Geotextile Bag-Double-Layer Net-Diaphragm	100
L0	60	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	120
L1	60	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	120
L2	60	Geotextile Bag-Double-Layer Net-Diaphragm	120

Table 4. Grouping of 70° slope rainfall scour resistance tests

Number	Slope Angle (°)	Protection Method	Rainfall Intensity (mm/h)
M0	70	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	60
M1	70	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	60
M2	70	Geotextile Bag-Double-Layer Net-Diaphragm	60
N0	70	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	80
N1	70	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	80
N2	70	Geotextile Bag-Double-Layer Net-Diaphragm	80
O0	70	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	100
O1	70	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	100
O2	70	Geotextile Bag-Double-Layer Net-Diaphragm	100
P0	70	Guest Soil-Double-Layer Net-Diaphragm Soil Retaining Structure	120
P1	70	Geocell-Double-Layer Net-Diaphragm Soil Retaining Structure	120
P2	70	Geotextile Bag-Double-Layer Net-Diaphragm	120

3.2 Test Process

First, before starting each rainfall test, the intensity of rainfall must be adjusted and the uniformity of rainfall must be calibrated as required. After the target rainfall intensity is reached, the rainfall uniformity coefficient is calculated. After measurement, the rainfall uniformity coefficient of the rainfall test equipment is calculated to be > 85%, which meets the test requirements and begins the formal rainfall. After the rainfall experiment began, the runoff samples were collected with plastic POTS and the initial runoff production time was recorded. Each runoff sample was weighed and its quality was recorded within the first time after the rainfall test. The sample is then left to rest for 48 hours until the sediment is completely settled. After the precipitation is completed, the sediment is collected and placed in a 105°C oven for 24 hours. Finally, the sediment content in runoff is calculated.

During the preparation of the sample, the passenger soil used in the test is mixed according to the required amount, and the water is evenly sprayed on the soil sample according to a certain moisture content, and then mixed evenly and sealed in the geotechnical box for one day and night to prepare for the anti-erosion test. The steps are as follows:

①Preparation of soil sample
② Lay the bottom geogridc
③ Lay a rail/geobile / 90% full geobile bag
④ Layer the guest soil into the soil container and compact
⑤Lay the top geogrid
⑥ Carry out erosion resistance test
⑦ Clean the broken surface, change the variables according to the requirements, and carry out the next set of tests

4 Test Results and Analysis

(1) Analysis Based on Erosion Resistance Test Of 50° Slope

The slope Angle is fixed at 50°. Through the rainfall model test, the soil flushing volume and rainfall flushing volume of the slope are measured. The relationship between the rainfall intensity of the slope and the total flushing volume is shown in Figure 2.

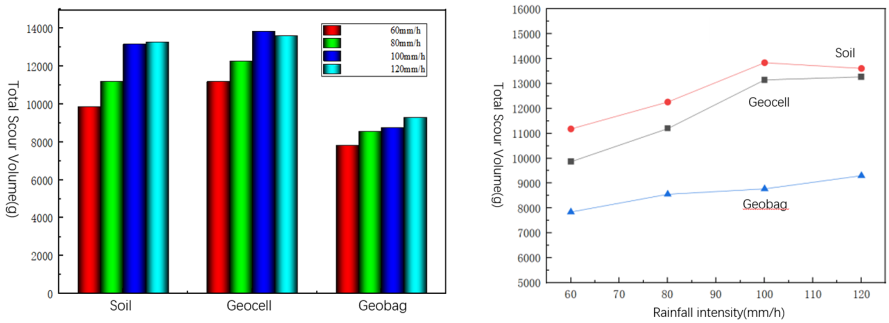

Fig. 2. Plot of rainfall intensity versus total scour on a 50° slope

As can be seen from fig.2., when the slope Angle is 50°, the overall brush volume of the structure increases with the increase of rainfall intensity; when the rainfall intensity is 60~100mm/h, the total brush volume changes rapidly; when the rainfall intensity reaches 100mm/h, the increase rate of the total brush volume decreases significantly and tends to be flat. When the rainfall intensity is 60~100mm/h, the total brush amount of geocell - double mesh - horizontal barrier structure increases with the increase of rainfall intensity, and the change trend is large. When the rainfall intensity reaches 100mm/h, the total brush amount decreases slightly. With the increase of rainfall intensity, the overall flushing amount of soil retaining structure increased, but the overall trend fluctuated little and the change trend tended to be flat. The erosion resistance is as follows: geoback - double mesh - horizontal barrier retaining structure > guest soil - double mesh - horizontal barrier retaining structure > Geoback - double mesh - horizontal barrier retaining structure.

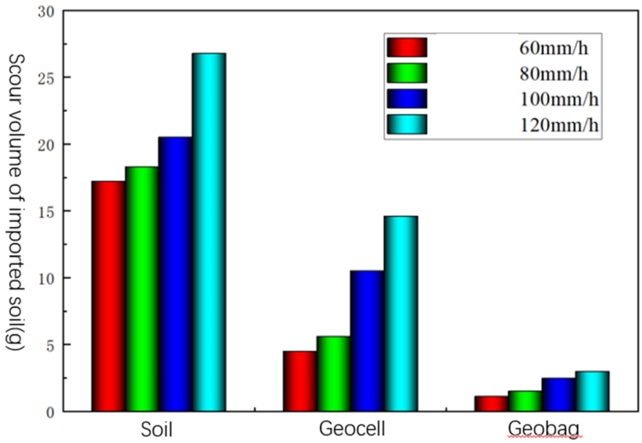

Fig. 3. Trend of rainfall intensity and guest soil scour on 50° slopes

As can be seen from Fig. 3, the passenger soil wash volume of the three slope protection systems increases with the increase of rainfall intensity. When the rainfall intensity is 60~100mm/h, the passenger soil wash volume growth rate is relatively gentle; when the rainfall intensity reaches 100mm/h, the passenger soil wash volume growth rate increases significantly. When the rainfall intensity is 60~80mm/h, the growth rate of the guest soil wash volume is relatively gentle, and when the rainfall intensity reaches 80~100mm/h, the growth rate of the guest soil wash volume is significantly increased. The soil flushing volume of the soil retaining structure of geoback, double layer net and transverse barrier is low and the growth rate is stable, and there is no big fluctuation. The strength of the guest soil flushing is the guest soil - double mesh - horizontal barrier retaining structure > geobytes - double mesh - horizontal barrier retaining structure > Geobags - double mesh - horizontal barrier retaining structure.

(2) Analysis based on 60° slope anti-erosion test

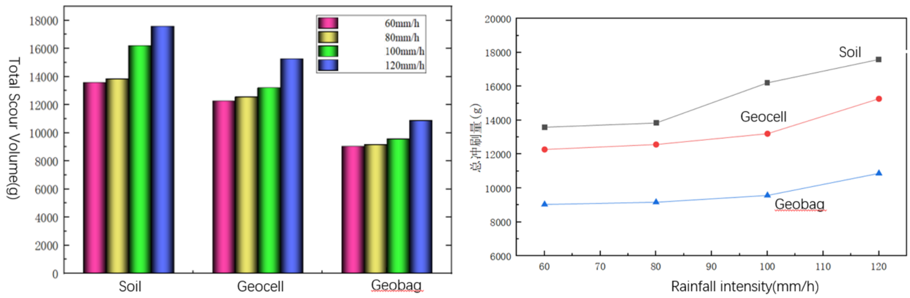

Fig. 4. Plot of rainfall intensity versus total scour on a 60° slope

As can be seen from Fig. 4, when the slope Angle is 60°, the overall flushing amount of the three slope protection systems of guest soil-double mesh - horizontal barrier retaining structure, geoblock - double mesh - horizontal barrier retaining structure, and geoback - double mesh - horizontal barrier retaining structure increases with the increase of rainfall intensity. And the growth rate of geocell - double mesh - horizontal barrier retaining structure and geocell - double mesh - horizontal barrier retaining structure tends to accelerate, while the growth rate of guest soil-double mesh - horizontal barrier retaining structure starts to slow down after the rainfall intensity reaches 100mm/h. The erosion resistance is as follows: geoback - double mesh - horizontal barrier retaining structure > Geoback - double mesh - horizontal barrier retaining structure > guest soil - double mesh - horizontal barrier retaining structure.

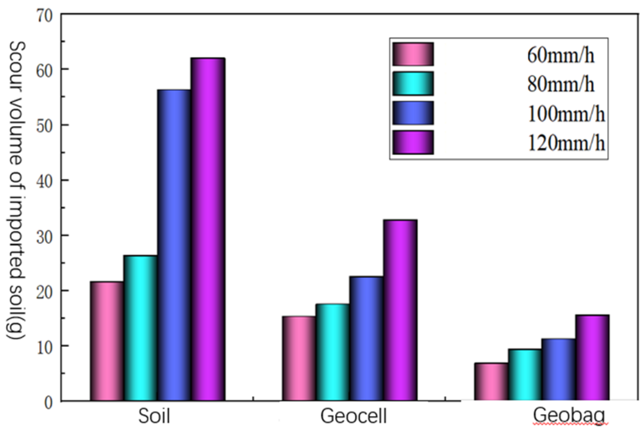

Fig. 5. Trend of rainfall intensity and guest soil scour on 60° slopes

As can be seen from Fig. 5, the passenger soil flushing capacity of the three slope protection systems all increases with the increase of rainfall intensity. When the rainfall intensity is 60~80mm/h, the passenger soil flushing capacity of the passenger-double-layer net - horizontal barrier retaining structure has a relatively gentle growth rate; when the rainfall intensity is greater than 80mm/h, the passenger soil flushing capacity increases significantly. When the rainfall intensity is 60~100mm/h, the growth rate of the visitor soil flushing of the geobial-double-layer grid - horizontal barrier structure is relatively gentle, and the visitor soil flushing gradually increases when the rainfall intensity is 120mm/h. The soil flushing volume of the soil retaining structure of geoback, double layer net and transverse barrier is low and the growth rate is stable, and there is no big fluctuation. The strength of the guest soil flushing is the guest soil - double mesh - horizontal barrier retaining structure > geobytes - double mesh - horizontal barrier retaining structure > Geobags - double mesh - horizontal barrier retaining structure.

(3) Analysis based on erosion resistance test of 70° slope

The slope Angle is fixed at 70°. Through rainfall model test, the guest soil flushing and rainfall flushing of the slope are measured. The relationship between the slope rainfall intensity and the total flushing is shown in Figure 6.

As can be seen from FIG. 6, when the slope Angle is 70°, the overall flushing volume of the three slope protection systems, namely, the guest soil-double mesh - horizontal barrier retaining structure, and the geoblock - double mesh - horizontal barrier retaining structure, all increase with the increase of rainfall intensity.

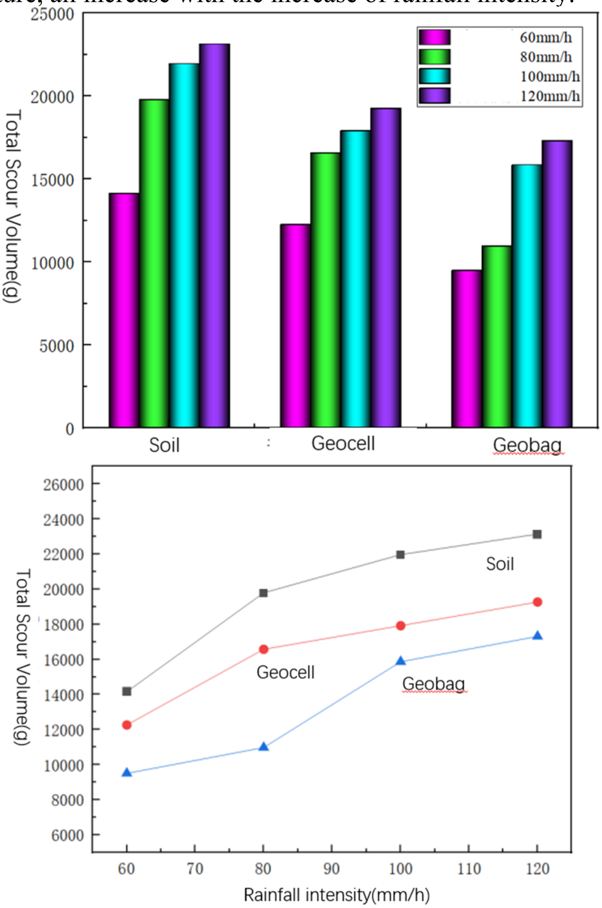

Fig. 6. Plot of rainfall intensity versus total scour on a 70° slope

When the rainfall intensity reaches 80mm/h, the overall flushing volume of the slope protection system increases with the increase of rainfall intensity. The total flushing volume of the soil - double mesh - horizontal barrier retaining structure and geoblock - double mesh - horizontal barrier retaining structure increased significantly, and with the increase of rainfall intensity, the total flushing volume increased slowly and tended to be flat. When the rainfall intensity reaches 100mm/h, the total brush amount of the soil retaining structure of the earth bag, double mesh and horizontal barrier increases significantly, and with the increase of rainfall intensity, the total brush amount increases slowly and tends to be flat. The erosion resistance is as follows: geoback - double mesh - horizontal barrier retaining structure > Geoback - double mesh - horizontal barrier retaining structure > guest soil - double mesh - horizontal barrier retaining structure.

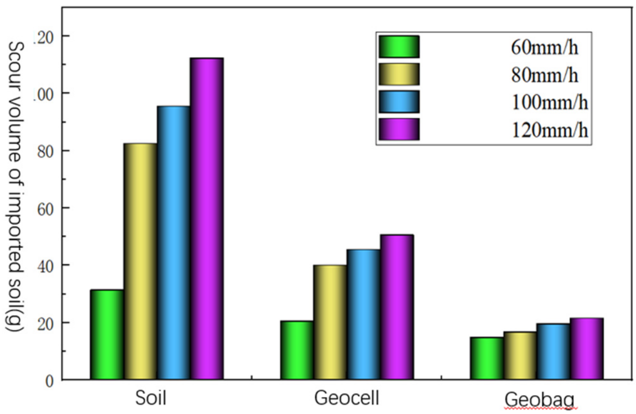

Fig. 7. Trend of rainfall intensity and guest soil scour on 70° slopes

As can be seen from Fig.7, the passenger soil flushing capacity of the three slope protection systems all increases with the increase of rainfall intensity. When the rainfall intensity is 80mm/h, the passenger soil flushing capacity of the passenger-double-mesh - horizontal barrier retaining soil structure and the geofril-double-mesh - horizontal barrier retaining soil structure significantly increases, and then slowly increases with the increase of rainfall intensity and tends to be stable. The flushing amount of soil in the soil retaining structure of geoback - double mesh - horizontal barrier did not fluctuate greatly with the significant increase of the total flushing amount, but still maintained a stable growth rate and slowly increased. The strength of the guest soil flushing is the guest soil - double mesh - horizontal barrier retaining structure > geobytes - double mesh - horizontal barrier retaining structure > Geobags - double mesh - horizontal barrier retaining structure.

5 Conclusion

This study investigates the ADNB soil stabilization system through rainfall simulation tests, yielding the following conclusions:

(1) The anti-scour capacity of rock slopes is jointly determined by three interactive factors: imported soil material properties, rainfall conditions, and slope topography.

(2) For rock slopes with angles 50°, the protective structure based on the ADNB soil stabilization system demonstrates significant enhancement in scour resistance. When the slope angle increases to 60°, all three protective systems remain stable without noticeable collapse under rainfall intensities below 100 mm/h. However, for steeper 70°rock slopes: both the imported soil-double-layer mesh-transverse barrier stabilization structure and geocell-double-layer mesh-transverse barrier stabilization structure experience collapse as rainfall intensity increases. The geotextile bag-double-layer mesh-transverse barrier stabilization structure exhibits localized collapse when rainfall intensity exceeds 80 mm/h.

(3) The scour resistance performance of the ADNB soil stabilization protection system ranks in descending order as follows: geotextile bag-double-layer mesh-transverse barrier > geocell-double-layer mesh-transverse barrier > imported soil-double-layer mesh-transverse barrier. This study provides multiple technical options for ecological slope protection engineering.

Reference

1. Aocun, Y., et al. Study on rapid ecological protection of rock slope. in IOP Conference Series: Earth and Environmental Science. 2020. IOP Publishing.
2. Kang, W. and H. Kang, The Combined Application of New Ecological Slope Control Technologies in the Wuxi Kou Water Conservancy Project. Hunan Water Conservancy and Hydropower, 2021(02): p. 97-99.
3. Liu, Z., Study on ecological restoration of rock slope. Construction technology, 2020(17): p. 27-29.
4. Wei, C., et al. Discussion on ecological protection technology of high and steep slope of expressway. in IOP Conference Series: Earth and Environmental Science. 2021. IOP Publishing.
5. Li, J., Application of ecological slope protection in slope protection of expressway. Traffic world, 2025(Z1): p. 127-129.
6. Wu, M., Design and evaluation of ecological slope protection scheme based on three-dimensional mesh protection technology and mixed sowing. Guangdong Water Resources and Hydropower, 2025(02): p. 66-70.
7. Zhong, X., Experimental study on erosion resistance of straw fiber curtain under rainfall condition. Journal of Railway Science and Engineering, 2025: p. 1-12.
8. Fan, Y., Research on ecological slope protection construction technology of dredged sediment recovery and reuse. Engineering technology research, 2024. **9**(24): p. 224-226.
9. Chen, X., Study on the influence of eco-bag slope protection on the stability of river slope. Water science and engineering technology, 2024(04): p. 61-64.
10. Zheng, W., Vegetation concrete ecological slope protection construction. Sichuan water resources, 2024. **45**(05): p. 171-174.

11. Tianbin, L. and X. Hua, JYC Ecological Substrate Slope Protection Technology for Steep Rock Slopes in Alpine and High-altitude Regions. Chinese Journal of Rock Mechanics and Engineering, 2008(11): p. 2332-2339.
12. Tao, S. and Y. Ningye, Green Slope Protection System Based on Geopolymers. Industrial Construction, 2019. **49**(06): p. 124-129.
13. Tao, S. and L. Qiang, Research on the Slope Support Technology with Flexible Surface Layer and Its Application. Construction Technology, 2017. **46**(17): p. 121-125.
14. Qiaoxue, L. and S. Tao, Experimental Study on the Physical Model Based on the New Ecological Protection Method for High and Steep Rock Slopes. Xinjiang Geology, 2023. **41**(02): p. 256-261.
15. Shuijin, S. and S. Hongyue, Coupled Analysis of Scouring and Infiltration of Embankment Slopes under the Action of Rainfall. Chinese Journal of Rock Mechanics and Engineering, 2011. **30**(12): p. 2456-2462.
16. Song, X. and H. Xiao, Macro and micro study on the trigger mechanism of sand slope instability failure under the action of rainfall. Rock and soil mechanics, 2025. **46**(03): p. 969-979.
17. Xiurong, W. and W. Bangmin, Study on the instability mechanism of open-pit mine slope under the action of rainfall. Mineral exploration, 2025: p. 1-10.
18. Liang, W. and X. Jian, Study on the Influence of Surface Seepage Parallel to the Horizontal Plane on the Stability of Borrowed Soil in Ecological Slopes. Rock and Soil Mechanics, 2009. **30**(08): p. 2271-2275.
19. Liang, W. and L. Qiang, Study on the Influence of Surface Seepage on the Stability of Borrowed Soil in Ecological Slopes. Rock and Soil Mechanics, 2008(06): p. 1440-1445+1450.
20. Tao, S. and S. Chong, An Ecological Slope Protection System with a Multilayer Structure with Diaphragms and Its Construction Method. p. 12.
21. Tao, S. and S. Yanfeng, An ecological slope protection system with a multi-layer structure equipped with transverse diaphragms. p. 8.