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Research Article

Mechanism of Action Slope Vegetation

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Abstract: Vegetation protection technology is a kind of engineering slope protection technology and its theoretical research lags behind engineering practice. In order to better reveal the anchoring mechanism of vegetation slope protection, provide guidance for engineering practice, this study establishes the mechanical model of plant roots from the microscopic angle and analyzes their mechanical anchoring mechanism. Analysis showed that the herb roots on slope reinforcement effect of rock and soil reinforcement can be seen as a three-dimensional effect, the effect of strengthening the vertical roots of woody plants can be simplified to the main root of the axial, lateral branch of the grouted type "bolt "to simulate the friction reinforcement effect, through the friction resistance level of lateral roots and rock mass to balance surplus fell thrust slope surface soil.

Keywords: Ecological slope protections, finite element analysis, greening protection layer

INTRODUCTION

Ecological slope protections as an engineering technology, many countries has studied it's reinforcement mechanism and technology applications. Overall, Japan is a leader in the study of ecological slope protection engineering technology, the development of hydroseeding method, fiber green chemical method of soil, vegetation, porous concrete and other construction method has been widely used in ecological highway slope protection works; Europe and America around the country's main highway slope and embankment revetment to prevent rainwater from erosion and development of cuttings, layering, hedges, hydraulic gushing, three-dimensional grass slope ecological protection technology.

China in the early 1990s with Japan for the first time in the Loess Plateau were studied hydroseeding, after a decade of development, the technology has been widely used in highway warm and humid areas of South China, Central China, East China, railways and dams ecological Protection Engineering, then, China imported geonet slope Stabilization technology and the development of three-dimensional vegetation net, geo grid, Geo network, Geo cell and other ecological slope protection technology, slope protection highway, railway, water conservancy projects in the have access to extension application. Research on reinforcement mechanism inferior slope and rock slope of ecology and engineering applications to carry out less accumulated experience relatively plaque lack and its theoretical research lags behind engineering practice. In order to better reveal the anchoring mechanism of vegetation slope protection, provide guidance for engineering practice, this study start from the microscopic mechanical model of vegetation roots rock interaction to explain the mechanism of ecological slope protection and look forward to an accumulation of some ecological protection experiences.

HERB ROOTS ROCK INTERACTION MECHANISM

Since the density of plant roots in the soil from the surface down decreases gradually thin, in the range of roots twine, slope rock mass can be seen as the root of a composite soil and roots from the soil composition. Herb root as the role of reinforcement fibers, as the number per unit volume in the roots, rock and soil shear capacity also will increase, so can the principle of reinforced soil slope rock mass stress state analysis, namely, the distribution of the roots of rock and soil reinforcement fibers treated as distributions and for three-dimensional reinforcement. This reinforced the rock layers provide additional "cohesion", which on the one hand the shear strength of the original rock mass goes up because of the distance and on the other hand limits the lateral expansion of leaving the soil increases to. In the lateral stress unchanged the maximum shear stress is reduced, so that the carrying capacity of these two effects the slope of rock and soil improvement (Zhang *et al*., 2001).

Front part qualitatively analyzed Mohr Have reinforced soil by plant roots at failure. The following

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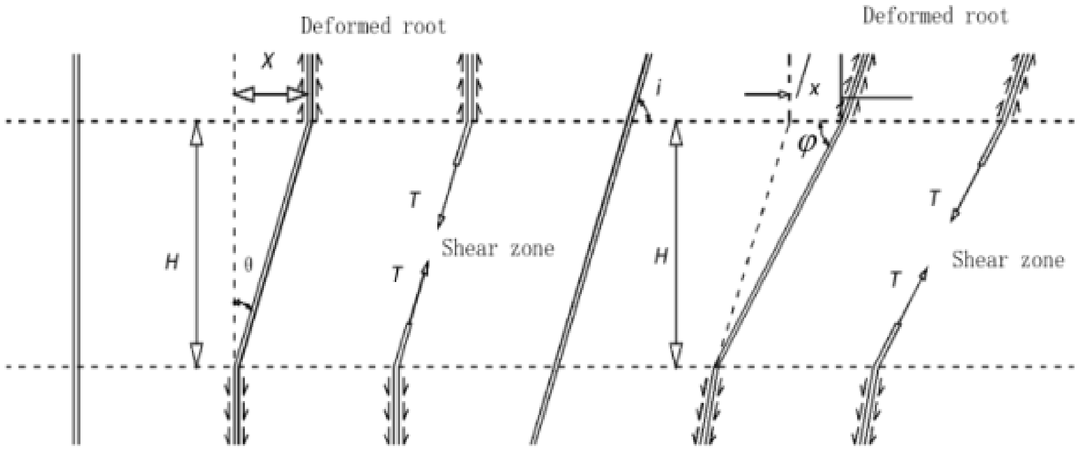

Fig. 1: Rock roots mechanical model interaction

analyze the reinforcement effect by establishing a quantitative mechanics herb root-soil interaction model of plant roots.

Figure 1 is a single herb mechanical model of reinforced soil, Fig. 1a the shear zone extending direction of the root and soil orthogonal case, Fig. 1b indicate the direction of extension of the root and soil oblique shear zone scenario.

According to Fig. 1 shows that, when orthogonal:

$$\tau_{R1} = \frac{T}{\alpha}\sin\theta + \frac{T}{\alpha}\cos\theta\tan\varphi \tag{1}$$

When skew:

$$\tau_{R2} = \frac{T}{\alpha}\sin(90^0 - \varphi) + \frac{T}{\alpha}\cos(90^0 - \varphi)\tan\varphi \tag{2}$$

$$\varphi = \tan^{-1}[\frac{1}{k + (\tan^{-1} i)^{-1}}] \tag{3}$$

where: is due to the reinforcement effect of the increased root soil shear strength, T is a single tensile strength (N), is single soil area, is shear angle degeneration, is the internal friction angle of the soil, .i is the extending direction of the initial shear plane angle, k is the shear deformation ratio, k = x/H, H is the thickness of the shear zone (Zhou and Zhang, 2013).

If the soil in the area of in vivo A total of n root, root pull stress are , ..., shear deformation angles are ,…, and the angle between the direction of extension of the initial shear surface roots are ,…, shear deformation ratios of ,..., then the formula (1), (2) and (3), are respectively:

$$\tau_{R1} = \frac{\sum_{j=1}^{n} T_j \sin\theta_j}{A} + \frac{\sum_{j=1}^{n} T_j \cos\theta_j}{A}\tan\varphi \tag{4}$$

$$\tau_{R2} = \frac{\sum_{j=1}^{n} T_j \sin(90^0 - \varphi_j)}{A} + \frac{\sum_{j=1}^{n} T_j \cos(90^0 - \varphi_j)}{A}\tan\varphi \tag{5}$$

$$\varphi_j = \tan^{-1}[\frac{1}{k_j + \tan^{-1} i_j}](j = 1,2,....n) \tag{6}$$

If there are n roots soil body area A, in which are m orthogonal roots, n- m bias roots, root stress are ,…, orthogonal shear deformation angles are , …, the angle between the initial direction of the shear plane extending skew roots are , …, then the shear deformation are, by the shear strength of roots into soil reinforcement effect become:

$$\tau_R = \tau_{R1} + \tau_{R2} \tag{7}$$

From the above equation, determination the size of need m, n and. Among them, through the direct shear test, parameters can be obtained, the parameter m, n and, can be obtained by intercepting a longitudinal section containing the roots and by the wild root obtained direct shear tests (Xie, 1990). For the parameter, because the root of most herbs withdrawn from the soil, when it are pulled off, we can see the root tensile strength less than roots and soil Mount.

Rub force, therefore T, available from the root of the laboratory to determine the tensile test.

From the above analysis, by the herb roots reinforced, the soil shear strength can be written as:

$$\tau = c + \sigma\tan\varphi + \tau_R = [c + \frac{\sum_{j=1}^{n} T_j \sin\theta_j}{A}] + [\sigma + \frac{\sum_{j=1}^{n} T_j \cos\ \theta_j}{A} + \frac{\sum_{j=m+1}^{n} T_j \cos(90^0 - \varphi_j)}{A}]\tan\varphi \tag{8}$$

EXPERIMENTAL STUDY ON STRENGTHENING THE ROLE OF VEGETATION ROOT

In order to study the effect of root growth herb in slope surface, we take undisturbed soil from Zhang Shi Expressway two work sites, respectively completed the

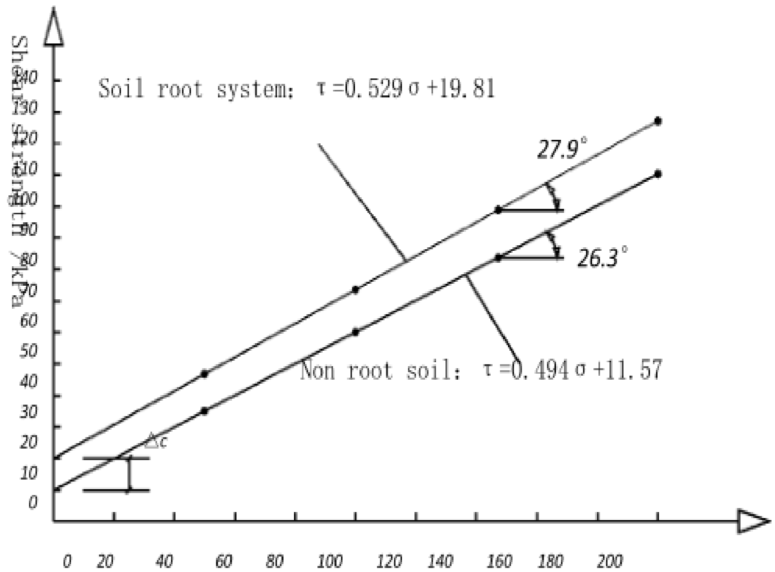

Fig. 2: Comparison of shear strength for the soil with and without roots respectively

natural soil density, moisture content, different amount of soil containing roots shear strength test.

The soil density, water content similarly, the comparison of no root soil shear strength are shown in Fig. 2.

Figure 2 shows, there is the shear strength of the root surface soil slope was significantly greater than the slope without the shear strength of the root surface soil. The test results demonstrated strong roots on slope surface vegetation significantly reinforcing effect.

Strengthening the role of plant roots on slope surface soil can be used to explain the principles of reinforced soil (Fig. 3): root causes soil vegetation within the scope of the extension of secondary roots to form a whole. Root density distribution in the soil, white surface downwards gradually reduced, gradually thin. According to various roots dig deep surface inspection deepest 0.6-0.8 m. The actual range in the roots twine, slope soil is a composite material consisting of the soil and roots. Therefore, when considering Slope Shallow soil strength, should be soil-root strength of the composite material as the basis, namely the distribution of the soil is considered grassroots reinforced material distribution and is a multidimensional ribs, which provide additional reinforcement for the soil " cohesion" and it’s size is related to the grass-roots density, intensity and nature of the soil particles. It makes the shear strength of the original soil line goes up a distance, which makes it the root of soil shear strength is greatly increased (Wang and Lee, 1998).

Shear strength is the internal friction and the cohesive force, the sum of the roots of the vegetation, especially the root in the soil around and growth, penetration depth, intertwined and make the soil particles together tightly connection, form a solid empty asked as a whole.

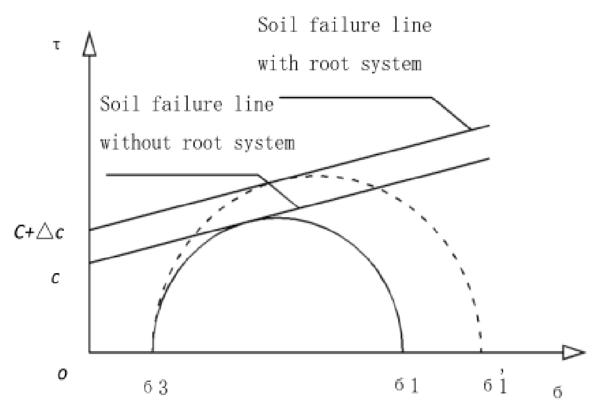

Fig. 3: Mechanical improvement of roots to the soil

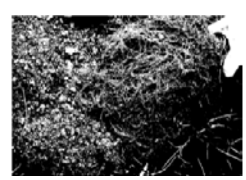

Fig. 4: Plant root net

Within 10 to 50 cm in deeply, the slope is composed of soil and plant roots composites, the properties of reinforced soil is similar. According to the principle of reinforced soil, add reinforced soil to improve strength of soil mass. Of plant roots and soil "reinforced", its strength is also increased. His body shear strength can better reflect its stability.

Should be, due to the vegetation root the intertwining, on-site sampling is very difficult (Fig. 4) and to make test sample, will be for some root resection, actually has a root of the reinforced soil cohesive force value is much larger than the test results, the reinforcement of the slope surface is very beneficial.

Table 1: Shear strength of the greening protecting layer under different average water contents

Experimental group	Average moisture content/%	Shear stress /(10^{-2}kPa)	Vertical load /kPa
1	23.526	21.42	50
2	16.006	40.46	50
3	13.660	40.46	50
4	17.454	35.70	50
5	9.2090	47.60	50
6	13.848	38.08	50

Table 2: Physico-mechanical parameters of the greening protection layer

Status	Deformation modulus E/kPa	Poisson's ratio/μ	Density ρ(g/cm^3)	Cohesion c/kPa
No root system	3.5	0.35	1.56	11.57
Root system	3.5	0.30	1.67	19.81
Status	Internal friction angle ψ/(°)	Expansion angle ψ_f/(°)	Gravity acceleration /(m/g^2)	
No root system	26.3	0	9.8	
Root system	27.9	0	9.8	

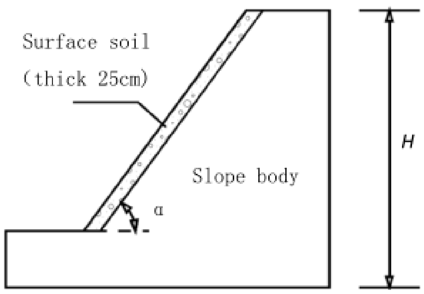

Fig. 5: Geometry model of greening protection layer

For the study of water on the green protective layer shear strength, the effect of experiment under the different moisture content tested green protective layer, shear strength and test data are shown in Table 1.

The average moisture content and protective layer shear strength curve is shown in Fig. 5.

Figure 5 shows that the soil's shear stress decreases gradually along with the increase of moisture content and the quadratic parabola form of downwards. Too little soil moisture will directly affect the survival of vegetation. When too much water also affects soil root growth and root functions. First of all, when the soil moisture content is higher, experience hypoxia resulting in a decline in the root respiration rate and soil anaerobic respiration can also lead to the root of the accumulation of toxic products such as ethanol, led to the deaths of root tip, on the slope surface soil ability are significantly reduced. Second, at high soil moisture, soil particles and greatly reduce the friction root asked, prompting a sharp drop in the shearing strength of the herbaceous plant roots.

Rainfall is one of the important factors of the slope instability, so when factors such as rainfall led to increased soil moisture, often occur slope slide. Green barriers, through the absorption and transpiration of vegetation slope body moisture, reduce the pore water pressure of soil, increase soil cohesive force, improve the soil shear strength are conducive to the stability of the slope body. Of course, when the moisture content is low to a certain extent, the shear strength of soil will reach a constant value, not increases indefinitely.

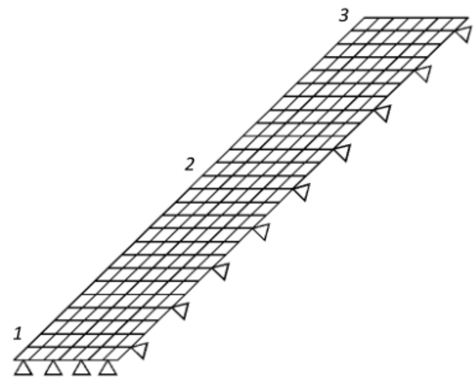

Fig. 6: Finite element model of greening protection layer

GREEN PROTECTIVE LAYER DEFORMATION FINITE ELEMENT ANALYSIS

There is a certain thickness of the soil slope surface, is a prerequisite for green slope protection. The traditional limit equilibrium method in slope stability analysis of surface soil, can't analyze green slope protection layer under the action of gravity deformation condition. This part uses the general finite element program to simulate the deformation of slope surface soil in order to determine the slope surface deformation of soil mass under the action of gravity and the relationship between the slope heights, slope (Zheng *et al*., 2003). Mechanics parameter values are shown in Table 2.

In order to study the slope green protective layer in the presence of root system under the condition of deformation and the relationship between slope height, slope ratio. This study uses the finite element method to analyze the deformation of slope green protection layer, calculate what model shown in Fig. 6 and finite element calculation model is shown in Fig. 6.

Respectively in the calculation of deformation of bottom, middle and upper 3 point comparison found that presence of plant root system, the biggest deformation points now central slope protection layer ("2" point in Fig. 6) Protective layer for the destruction of the main"

Table 3: Deformation of greening protecting layer with thickness of 25 cm for different slope heights and slope ratios

	Mm					
	High slope 5m		High slope 8m		High slope 10m	
Slope	No root system	Root system	No root system	Root system	No root system	Root system
1:1	-15.5	-14.60	-24.50	-16.30	-27.80	-20.90
1:0.75	-20.2	-15.90	-24.80	-17.40	-27.60	-21.11
1:0.5	-23.0	-19.90	-27.90	-19.30	-32.60	-23.40

Table 4: Deformation of greening protecting layer with thickness of 10 cm for different slope heights and slope ratios

	Mm		
Slope	High slope 8m	High slope 10m	High slope 12m
1:1	-1.68	-3.74	-4.01
1:0.75	-2.00	-4.10	-8.80
1:0.5	-7.03	-7.51	-9.26

ballooning "in the middle of slope failure. Different slope height and slope ratio of green protective layer (25 cm thick) deformation are shown in Table 3.

Table 3 shows that there are deformation of root growth of vegetation slope protection layer is smaller than without root deformation of slope protection layer.

In combination with YuHuaiXian worksite, in this study, the protective layer of 10 cm thick, with barbed wire protection when green protective layer deformation finite element analysis.
The results are shown in Table 4.

Contrast Table 3 and 4, with the decrease of the thickness of protection layer, green protective layer is less deformation values. When the protective layer of 10 cm thick, with barbed wire protection, green protective layer in the slope ratio is 1:0.5, the maximum when the slope is 12 m high slope deformation points ("3" position shown in Fig. 6) deformation is 9.26 mm. Such a case, the main factors that affect the growth of vegetation for slope green protective layer are water supply and maintain. Field investigation found that green protective layer 10 cm thick, with barbed wire protection slope surface destruction mainly is the vegetation growth in the early rain wash (ANSYS China, 2010a, 2010b).

THE CONCLUSION

According to above analysis can draw the following conclusion:

- Slope surface growth of vegetation roots can effectively improve slope surface soil shear strength.
- The deformation of slope green protection layer was mainly affected by the following aspects: with the increase of the upper soil pressure, shear deformation is generated in soil makes the soil in the slope direction (x direction) displacement increases gradually, if the heap to the deformation of the soil on slope surface, is on the soil below the larger pressure, make the distance under the slope soil also produces lateral deformation and failure.
- With root slope, the slope of its deformation is small, the influence of the high slope on its deformation. In engineering design of slope can be reduced for each level of the slope height, can effectively increase the stability of the protective layer.
- Green protective layer thickness had a great influence on the deformation, when the green protection layer 10 cm thick, with barbed wire protection, protective layer deformation value is small, when the slope ratio of 1:0.5 and the slope is 12 m high, at the top X direction's maximum deformation is 9.26 mm, protective layer can be stable, under the condition of the vegetation growth is the key to smoothly according to the protective layer can provide sufficient moisture.

It is important to note that in the early to green slope protection and vegetation root system network has not yet formed, the slope protection layer influenced by rainfall and so on, are mainly composed of erosion damage. So in the early to green slope protection should also be combined with other engineering protection measures to prevent the slope green protective layer at the beginning of the vegetation growth is not destroyed.

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