Research Article

Impact of Plant Root Morphology on Rooted-Soil Shear Resistance Using Triaxial Testing

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Received 12 August 2020; Revised 7 October 2020; Accepted 21 October 2020; Published 6 November 2020

Academic Editor: Xinyu Ye

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Mechanical reinforcement by plant roots increases the soil shearing strength. The geometric and distribution characteristics of plant roots affect the soil shearing strength. Current research on the shear strength of rooted-soil is mostly based on direct shear tests with a fixed shear surface and thus cannot reflect the actual failure state of the rooted-soil. In this study, Golden Vicary Privet was used to create a rooted-soil, and a triaxial test method was used for soil mechanical property analysis. The influence of the root geometry (root diameter and individual root length) and distribution characteristics (root density and root distribution angle) on the rooted-soil shearing strength was studied by controlling the root morphology in the specimens. According to the results, both the root geometry and distribution characteristics affect the rooted-soil shearing strength. For a fixed total length of the roots, the longer the individual root length is, the better the soil shearing strength is. In addition, the reinforcement effect of the root system increases as the angle between the root and the potential failure surface increases. The results also show that the root system significantly enhances the soil cohesion while only minimally affecting the internal friction angle. The maximum rooted-soil cohesion is 2.39 times that of the plain soil cohesion, and the maximum internal friction angle of rooted-soil is 1.24 times that of plain soil. This paper provides an approach for the determination of the rooted-soil strength and a rationale for vegetation selection in ecological slope reinforcement applications.

1. Introduction

In highway slope engineering, reinforcement materials with a good tensile strength are usually added to the soil to improve the shear strength of the soil that forms the slope [1–3]. Increasing the soil shear strength simultaneously increases the stability of the slope. Therefore, the study of the shearing strength of reinforced soil is very important for the stability analysis of highway slopes. The root system of a plant has a high tensile strength [4, 5] and can enhance the soil shearing strength [6–8].

The strengthening effect of plant roots on soil strength is affected by the root morphology. Mickovski and Van Beek [9] showed that *Vetiveria zizanioides* was mainly distributed in the topsoil near the stem in a semiarid climate, and the root diameter was roughly the same. A large number of *Vetiveria* root systems could improve the stability of terraced

slopes. Temgoua et al. [10] studied the influence of the structure and 3D root morphology of a forest stand on slope stability using the 3D finite element method. The results show that the overall slope stability mainly depends on the depth of the root system and the additional cohesion provided by the root system. In addition to root morphological characteristics such as the root length and root depth, the root spacing and root bundle geometry also affect the root-soil mechanical interactions [11]. The pull-out force of cross distributed roots is greater than that of roots distributed in parallel. In addition, the root systems of different types of plants have different morphological characteristics and different mechanical effects. Stokes et al. [12] studied the mechanical resistance of Silver fir, European beech, and Norwegian spruce to rockfall through static winching tests, and the results indicated that European beech had the highest root number; its roots were highly branched, and

they could better prevent falling rocks. The high tensile strength results of graminoid and a dwarf shrub species combined with a dense elaborate root morphology provide many anchoring points and enhanced plant resilience to solifluction in periglacial environments [13].

To evaluate the strengthening effect of the root system on the soil, some scholars have carried out experiments on the mechanical properties of the root-soil complex. Endo and Tsuruta [14] studied the mechanical action of rooted-soil using the shear test. Ziemer [15] developed a two-walled box to measure the contribution of roots to the rooted-soil strength. Field shear tests have been widely used to study the mechanical properties of rooted-soils [16–18]. Van Beek et al. [6] and Cammeraat et al. [19] studied the effect of plant roots on the rooted-soil shearing strength using a direct shear field test. In addition to field shear tests, laboratory shear tests are also a common method to study the properties of rooted-soil [20, 21]. Ghestem et al. [22] studied the influence of root geometric characteristics on the soil shearing strength using a laboratory shear test. The results showed that the root density, branch, volume, and direction affect the rooted-soil shearing strength increment. Zhang et al. [23] studied the effects of the root distribution of *Robinia pseudoacacia* on the rooted-soil strength using a consolidated drained (CD) triaxial test. The results showed that the reinforcing effect of a vertical-horizontal (cross) root distribution was the most effective. Negadi et al. [24] carried out both CD- and UD-triaxial tests on pure soil and with *Acacia pycnantha* roots, and the results indicated a clear increase in the soil shear strength with the presence of roots. In the triaxial test, normal stress is applied in three directions, and the shear area remains unchanged during the test. The failure surface of the triaxial test is the weakest surface of a specimen, which is neither fixed nor assumed. Compared with the direct shear test, the triaxial test can reflect the real stress-strain relationship of a specimen [23].

In this paper, the roots of Golden Vicary Privet (*Ligustrum x vicaryi*), which is an annual in the region of Mentougou, were used. The rooted-soil was simulated by forming laboratory remolded specimens, and the consolidated undrained (CU) triaxial shear test was carried out. This study aimed to study the effects of the root geometry (root diameter and individual root length) and distribution characteristics (root density and root angle) on the shearing strength of rooted-soil by controlling the root morphology of the specimen. This study provides an approach for the determination of the rooted-soil strength and a rationale for vegetation selection in ecological slope reinforcement applications.

2. Materials and Methods

2.1. Rooted-Soil Specimen. The test soil and plant roots were collected from a highway slope in Beijing, China. The soil used in the test was silty clay. The physical parameters of the soil were obtained from laboratory geotechnical tests, as shown in Table 1. Figure 1 shows the particle size distribution of the tested soil.

The plant root system of Golden Vicary Privet was added to the triaxial test specimen. The height of the Golden Vicary Privet adopted in the experiment was approximately 40 cm. The maximum root depth in the soil was 15 cm, and the maximum root diameter was between 4 and 5 mm. The morphology of the root systems was that of a taproot. An example of the plant root system is shown in Figure 2. A number of Golden Vicary Privet plants were taken from the research area and transplanted to pots in the laboratory. The size of the pots was $100 \times 50 \times 50 \text{ cm}^3$. Care was given not to damage the soil around the roots. Before each experiment, fresh roots with a specific diameter and length were selected for testing.

2.2. Test Methods. The test instrument was a British GDS triaxial tester. Each remolded specimen had a diameter of 39.1 mm and a height of 80 mm. Remolded soil was adopted for this experimental study, with the parameters of the soil shown in Table 1. The dry density of the test soil was 1.68 g/cm^3 , and the water content was 17.50%. The mass of soil required for each specimen was calculated to be 189.52 g. The remolded soil had the same dry density as the in situ soil.

In the compaction mold, the complete remolded specimen was prepared by compacting three layers of soil in sequence. The mass of soil used for each layer was 63.18 g. From multiple tests, the height of each specimen layer before compaction was approximately 46 mm. Fresh roots were added to the specimen during each specimen preparation process. The root diameters were measured by using Vernier calipers with an accuracy of 0.05 mm, and the root lengths were measured by using a steel ruler with an accuracy of 1 mm.

Controlling the morphological parameters of the roots added to the remolded specimen allowed these parameters to be varied to establish 15 sets of experiments. The geometric characteristics and distribution characteristics of the roots added in each group are shown in Table 2. Three root numbers (Group I), four root diameters (Group II), three individual root lengths (Group III), and four initial root distribution angles (Group IV) were used to study the influence of the root morphology on the rooted-soil shearing strength. In addition, a group of control experiments without the addition of roots to the remolded soil specimens (Group V) was tested.

CU triaxial tests were carried out on the specimens. Each group of specimens was tested under four confining pressures of 50 kPa, 100 kPa, 150 kPa, and 200 kPa. A total of 56 rooted specimens and 4 plain soil specimens were tested. The shear rate was 0.08 mm/min. The stress point was automatically recorded for every 0.1% increment of the axial strain. The test was completed when the axis of the specimen reached a strain of 20%. Relational curves of the deviatoric stress ($\sigma_1 - \sigma_3$) and the axial strain were created. The peak of the deviatoric stress was taken as the failure point. When there was no peak in the deviatoric stress, the deviatoric stress corresponding to an axial strain of 15% was considered to be the failure point.

TABLE 1: Physical properties of the test soil.

Index	Soil dry density (g/cm^3)	Water content (%)	Liquid limit (%)	Plastic limit (%)	Plasticity index
Value	1.68	17.50	27	12.2	14.8

FIGURE 1: Particle size distribution curve of the test soil.

FIGURE 2: Root of the Golden Vicary Privet.

2.3. Specimen Preparation. To study the effect of root density on the rooted-soil shearing strength, different numbers of roots (4, 8, and 12) were placed in the three specimens. The diameter of each root was 1 mm, and the length of each root was 30 mm. The distribution of the different numbers of roots is shown in Figure 3. The greater the number, the greater the root density. Figure 3(a) shows the distribution when 4 roots were added to the specimen. When the second layer of soil was to be compacted, first, 31.59 g of soil was added for trimming and leveling, and then 4 fresh roots were placed horizontally with tweezers.

Finally, the remaining 31.59 g of soil was added, and the surface was once more trimmed and leveled before compaction. In Figure 3(b), 8 roots were added to the specimen, and similarly, in Figure 3(c), 12 roots were added to the specimen. The root placement method for each was similar to that shown in Figure 3(a).

To study the effect of the root diameter on the rooted-soil shearing strength, four groups of roots with diameters of 0.5 mm, 1 mm, 2 mm, and 3 mm were placed in each of the four specimens for successive tests. The number of roots was 12 in each specimen, and the length of each root was 30 mm. The distribution of roots in the four specimens with different root diameters is shown in Figure 3(c).

To study the effect of the root length on the rooted-soil shearing strength, four roots with a length of 72 mm, eight roots with a length of 36 mm, and twelve roots with a length of 24 mm were placed in the three respective specimens. The diameter of the root was approximately 1 mm, and the total length of roots in each specimen was the same. The distribution of roots in the three specimens with different individual root lengths is shown in Figure 4. Taking the specimens shown in Figure 4(a) as an example, the specimen preparation process can be introduced. First, after placing the first layer of soil (63.18 g) into the compaction cylinder, the intended root position was poked into the soil by using tweezers before compaction, and the fresh roots were placed. Second, the soil around the roots was gently compacted by using a small rubber hammer with a diameter of 10 mm, and then the first compaction was carried out with the compaction hammer. Third, after the first layer of soil compaction was completed, the exposed roots were gently straightened with the tweezers, the second layer of soil was added into the compaction cylinder, and the soil was gently compacted around the roots for the second compaction. The third layer of soil was compacted using the same method as for the second layer.

To study the effect of the root distribution angle on the rooted-soil shearing strength, four groups of roots with initial angles of 0° , 15° , 30° , and 65° to the horizontal were placed in the four specimens. The diameter of the root was approximately 1 mm with a length of 30 mm, and the number of roots was 12 in each specimen. The distribution of the roots in the five specimens, each with a different initial distribution angle, is shown in Figure 5.

Before the specimens with the different initial distribution angles were made, scale marks were drawn on the inner wall of the compaction cylinder, as shown in Figure 6. Through formula conversion, the placement angle of the roots was calculated before the soil was compacted. Assuming that the root distribution angle before compaction

TABLE 2: Specimen parameters used in the triaxial tests.

Groups	Geometric characteristics of the roots		Distribution characteristics of the roots	
	Root diameter (mm)	Individual root length (mm)	Root number	Root angle (°)
I	1	30	4/8/12	Horizontal cross
II	0.5/1/2/3	30	12	Horizontal cross
III	1	24/36/72	12	90° (vertical)
IV	1	30	12	0° (horizontal)/15°/30°/65°
V	/	/	/	/

FIGURE 3: The distribution of different numbers of roots: (a) 4 roots in the specimen; (b) 8 roots in the specimen; (c) 12 roots in the specimen.

was α , then the root distribution angle in the sample after compaction was β (where β corresponded to 0° , 15° , 30° , and 65°), and the soil compression coefficient after compaction was C . Thus,

$$C = \frac{h_0}{H_0} = \frac{h_1}{H_1} = \frac{h_2}{H_2}, \quad (1)$$

$$h_1 = O'A' \sin \beta, \quad (2)$$

$$h_2 = \frac{h_0 - 2h_1}{2}. \quad (3)$$

Formulae (1)–(3) were used simultaneously to calculate the distribution angle and specific position of the roots in the specimens before compaction.

To evaluate the degree of increase in the root morphology relative to the failure load, the shear strength ratio (F) is introduced [25]. F is the ratio of the failure load of the rooted-soil to that of the plain soil. The larger F is, the more significant the effect of the roots on the soil shearing strength will be. The shear strength ratio (F) can be expressed as follows:

$$F = \frac{(\sigma_1 - \sigma_3)_f^r}{(\sigma_1 - \sigma_3)_f}, \quad (4)$$

FIGURE 4: The distribution of roots with different root lengths: (a) roots with a length of 72 mm; (b) roots with a length of 36 mm; (c) roots with a length of 24 mm.

FIGURE 5: The distribution of roots with different initial distribution angles: (a), (b), (c), and (d) correspond to root distribution angles of 0°, 15°, 30°, and 65°, respectively.

FIGURE 6: The distribution angle and position of the roots in the specimens: (a) before compaction; (b) after compaction.

where $(\sigma_1 - \sigma_3)_f$ is the failure load of plain soil, and $(\sigma_1 - \sigma_3)_f^r$ is the failure load of rooted-soil.

3. Results

3.1. Stress-Strain Behavior. Figure 7 shows the relationship between the deviatoric stress ($\sigma_1 - \sigma_3$) and the axial strain (ϵ) of the rooted-soil with different root morphologies under different confining pressures.

As shown in Figure 7, the stress-strain curves of the plain soil and the rooted-soil have the same shape, and both exhibit strain hardening. The deviatoric stress of the rooted-soil is significantly larger than that of the plain soil under the same axial strain. The stress-strain curve distance between the rooted-soil and the plain soil gradually expands as the axial strain increases.

As mentioned above, the deviatoric stress at 15% axial strain is defined as the failure load $(\sigma_1 - \sigma_3)_f$ when there is no peak. Figures 8(a)–8(d) show the failure load curves corresponding to different root numbers, root diameters, individual root lengths, and root angles under the four confining pressures. It can be seen from Figure 8 that as the confining pressure increases, the soil failure load is gradually increased.

Figure 9 shows the variation in F with confining pressure for reinforced soils with different root morphologies. It can be seen from Figure 9 that the F value of reinforced soil is greater than 1. The value of F decreases as the confining pressure increases.

It can be seen from Figures 8 and 9 that the failure load and F value of the rooted-soil are larger than those of the plain soil under the same confining pressure. The failure load and F value of the rooted-soil increase as the root diameter increases. The greater the number of roots and the length of individual roots, the greater the failure load and F value of the rooted-soil. The failure load and F value range from large to small according to the following order of the root angle: $0^\circ > 15^\circ > 30^\circ > 65^\circ$.

3.2. Parameters of Shear Strength. Figure 10 shows that the rooted-soil shearing strength changes with the root morphology. It can be seen from Figure 10 that the rooted-soil cohesion increases significantly compared with the plain soil. The angle of internal friction also increases compared with that of the plain soil. The cohesion increases significantly, whereas the angle of internal friction increases slightly. The shear strength of rooted-soil is higher than that of plain soil under the same stress condition.

Table 3 shows the increases of the cohesion and internal friction angle of the rooted-soil for the different root morphologies. According to Figure 10 and Table 3, for the roots with a diameter of 0.5 mm–3 mm, the rooted-soil with a diameter of 3 mm has the highest shear strength. The increment of the cohesion is 14.3 kPa, and the increment of the angle of internal friction is 5.54° . The rooted-soil cohesion with a diameter of 3 mm is 2.39 times that of the plain soil, and the angle of internal friction of the rooted-soil with a diameter

FIGURE 7: Relationship between the deviatoric stress and the axial strain of reinforced soil under different root morphologies with a confining pressure of 100 kPa: (a) different root numbers, (b) different root diameters, (c) different individual root lengths, and (d) different root distribution angles.

of 3 mm is 1.24 times that of the plain soil. The shear strength of the rooted-soil with a diameter of 0.5 mm is the smallest. The increment of the cohesion is 6.4 kPa, and the increment of the angle of internal friction is 1.53° . The rooted-soil cohesion with a diameter of 0.5 mm is 1.62 times that of the plain soil, and the angle of internal friction of the rooted-soil with a diameter of 0.5 mm is 1.07 times that of the plain soil.

The greater the root number and the individual root length, the greater the increment of the cohesion and the angle of internal friction, and the greater the shear strength of the rooted-soil.

The rooted-soil has the largest shear strength when the root angle is 0° to the horizontal direction. When the root angle is 0° , the cohesion increment of the rooted-soil is 14.2 kPa compared with the plain soil, and the angle of internal friction increment is 1.67° compared with the plain soil. The rooted-soil cohesion with a root angle of 0° to the horizontal is 2.38 times that of the plain soil, and the angle of

internal friction is 1.07 times that of plain soil. The rooted-soil has the smallest shear strength when the root angle is 65° . The rooted-soil with a root angle of 65° to the horizontal has a cohesion increment of 2.9 kPa and an internal friction angle increment of 0.73° . The rooted-soil cohesion with a root angle of 65° to the horizontal is 1.28 times that of the plain soil, and the angle of internal friction is 1.03 times that of plain soil.

4. Discussion

The failure load $(\sigma_1 - \sigma_3)_f$ can characterize the ability of a specimen to resist shear failure. From Figure 8, it can be seen that the rooted-soil is more resistant to failure than the plain soil. According to Figure 9, the shear strength ratio (F) under a low confining pressure is greater than that under a high confining pressure. Accordingly, the roots under low confining pressures can play a greater role in resisting the failure

FIGURE 8: The failure load of rooted-soil with different root morphologies: (a) different root numbers, (b) different root diameters, (c) different individual root lengths, and (d) different root distribution angles.

of reinforced soils. The ability of a rooted-soil to resist failure is affected by the root geometry and distribution characteristics.

The root system has a higher tensile strength than the soil. In the loading process of soil, the shear stress of soil is gradually transferred to the root through the interaction between the root and the soil, which makes the root system tensile and thus increases the soil shearing strength [16, 20, 26]. Root reinforcement can improve the soil cohesion and soil internal friction angle, and the cohesion is increased significantly. The main reason is that in addition to the interaction of soil particles, the cohesion between soil particles and the root system, as well as the tensile strength of the root system, will increase the rooted-soil cohesion [4, 27–29]. During the shearing process, the sliding of roots between soil particles

increases the rooted-soil internal friction angle. Tang et al. [30] studied the shear strength of fiber-reinforced soil and came to a similar conclusion that the reinforcement of fibers will increase the soil cohesion and the soil internal friction angle. However, Graf et al. [31] showed that the influence of plant roots on the shear strength of moraine soil is mainly reflected in the increase in the internal friction angle, and no difference was found in the cohesion of moraine soil under the action of roots. The cohesion of moraine soil under the action of a root system does not change, which is different from our research results. The main reason is that the proportion of coarse particles in the moraine soil is large, the cohesive strength between moraine soil particles is small, and the adhesion between roots and coarse particles is weak, resulting in no difference in the cohesion of moraine soil.

FIGURE 9: Shear strength ratio (F) of different root morphologies: (a) root number, (b) root diameter, (c) single root length, and (d) root angle.

The ability of rooted-soil to resist failure is affected by the root diameter and root number. Schmidt et al. [32] found that in the process of slope sliding, roots with smaller diameters will rupture first. At this time, the soil may slide along the roots with larger diameters, and the roots with larger diameters tend to slide across the soil matrix without fracture. This is consistent with our results. The greater the root diameter, the greater the rooted-soil shearing strength, and the stronger the reinforcement of the root system on the soil shearing strength. Large diameter roots can play a greater role in resisting soil failure. The reason is that the larger the root diameter,

the greater the pulling force required for the root to be broken [33, 34]. Large diameter roots are less likely to be broken and can play a better reinforcement effect. Bischetti [34] found that the greater the root density, the greater the root tensile strength per unit volume of soil, which is consistent with our results. The greater the root density, the greater the rooted-soil shearing strength. Greater root densities in the soil increase the total tensile strength of the root system, thereby improving the root reinforcement in the soil.

When the total length and diameter of the root are held the same, the length of individual roots can affect the

FIGURE 10: Shear strength of rooted-soils with different root morphologies: (a) root number, (b) root diameter, (c) root length, and (d) root angle.

TABLE 3: Increment of the shear strength parameters of the rooted-soil.

Indexes of shear strength	Root diameter (mm)				Root number			Individual root length (mm)			Root angle (°)			
	0.5	1	2	3	4	8	12	24	36	72	0	15	30	65
Δc (kPa)	6.40	12.00	13.80	14.30	2.70	6.30	12.00	6.40	8.40	13.10	14.20	9.70	6.80	2.90
$((c + \Delta c)/c)$	1.62	2.17	2.34	2.39	1.26	1.61	2.17	1.62	1.82	2.27	2.38	1.94	1.66	1.28
$\Delta \phi$ (°)	1.53	2.55	4.44	5.54	2.34	4.03	2.55	0.88	1.86	2.52	1.67	1.57	0.92	0.73
$((\phi + \Delta \phi)/\phi)$	1.07	1.11	1.19	1.24	1.10	1.18	1.11	1.04	1.08	1.11	1.07	1.07	1.04	1.03

* Δc is the cohesion increment of the rooted-soil compared with the plain soil, and c is the plain soil cohesion; $\Delta \phi$ is the internal friction angle increment of the rooted-soil compared with the plain soil, and ϕ is the internal friction angle of the plain soil.

FIGURE 11: Schematic diagram of vegetation selection for a slope.

root reinforcement. When the length of the individual roots is very short, the roots are unable to penetrate the potential failure surface. Short roots act as only fiber reinforcement during the shear process [35]. In the triaxial test conducted in this study, the roots with a length of 72 mm run nearly through the entire specimen, which must pass through the potential failure plane of the specimen. Therefore, when the total length of the roots is constant, longer roots improve the soil shearing strength more than short roots.

The root angle affects the reinforcement effect of the root system. The rooted-soil has the largest shear strength when the root angle is 0° to the horizontal. The rooted-soil has the smallest shear strength when the root angle is 65° to the horizontal. The cohesion increment of the reinforced soil with a root angle of 0° to the horizontal is 4.89 times that of 65° . According to the Mohr–Coulomb law, the angle between the failure surface and the major principal stress plane is $\alpha = 45^\circ + (\varphi/2)$. The internal friction angle of the plain soil is approximately 23° . Thus, it can be calculated that $\alpha = 56.5^\circ$. When the root angle is 65° to the horizontal, it is close to the dip angle of the soil failure surface, which makes the soil more susceptible to damage. This conclusion can guide the rational selection of vegetation for slope protection applications.

The types of available root systems mainly include tap root systems, plate root systems, and heart root systems [36], among which the vertical depth of the plate root system is small, and the growth of roots often occurs parallel to the slope surface. The taproot of the tap root system grows downward perpendicular to the slope. When selecting vegetation for a slope, the angle between the plant root system and the potential sliding surface should be as large as possible. For example, as shown in Figure 11(a), by planting a tap root system at point A, the angle between the potential sliding surface and the taproot is β . The smaller β is, the more parallel the potential sliding surface is to the root system, which does not permit the full reinforcement effect of the root system. As shown in Figure 11(b), by planting a plate root system at point A, the angle between the potential

sliding surface and the taproot is γ . The angle γ is relatively large, and therefore, the plate root system can produce a good reinforcement effect at point A. However, the depth of the plate root reinforcement is small. At point A, the combination of a plate root system and a tap root system will provide a better slope reinforcement. Therefore, in addition to the root distribution, the root depth and root diameter should also be considered when selecting vegetation for a slope.

5. Conclusions

The effects of the root geometry (root diameter and individual root length) and distribution characteristics (root density and root angle) on the rooted-soil shearing strength were studied by triaxial testing. Root reinforcement can improve the soil cohesion and soil internal friction angle, and the cohesion is increased significantly. The results of this study show that root morphology has a significant impact on the root reinforcement effect. When the root number is held constant, within a certain diameter range, the thicker the root, the higher the shear strength of the rooted-soil. The greater the root density in the reinforced soil, the greater the shear strength of the rooted-soil. When the root diameter and total root length are constant, as the individual root length increases, the easier it is for the root to pass through the potential failure surface of the specimen. The root with a distribution angle of 65° has the weakest increase in the rooted-soil shearing strength during this test type.

This paper provides an approach for the determination of the rooted-soil strength and a rationale for vegetation selection in ecological slope reinforcement applications. When choosing vegetation to protect a slope, it is necessary to avoid choosing a plant with a single root morphology; a variety of vegetation with different root shapes should be chosen to enhance the soil strength and maintain slope stability. However, due to the complexity of root growth conditions, the triaxial test conditions require further improvement. For example, the actual growth of plant roots could be simulated during specimen preparation, and a

more effective method for characterizing the mechanical properties of rooted-soil under natural growth conditions should be developed.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgments

The authors thank China University of Geosciences Beijing for the test site and device. This research was funded by the Doctoral Scientific Research Foundation of Liaoning Province, grant numbers 2020-BS-161 and 2020-BS-162.

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