Study on Soil Permeability in Unsaturated Zone Based on TST-55 Permeameter

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Keywords: Soil properties; Permeability; Permeability coefficient; Change rule

Abstract: Soil permeability is of great significance to rainfall runoff regulation, water resource conservation, water and soil conservation, water resource evaluation and management, soil remediation, and determination of technical parameters of farmland irrigation. It is closely related to soil properties, vegetation types, soil structure, and soil types. In order to investigate the permeability of unsaturated zone soil in longitudinal section, the permeability and soil physical properties of Duan jiaying unsaturated zone in Chenggong section, Kunming city, Yunnan province were studied. The results showed that there were significant differences in soil properties and permeability between different layers of unsaturated zone in the test area. The results of soil permeability in unsaturated zone based on tst-55 permeameter show that the variation of permeability coefficient is large and tends to increase gradually with the increase of depth. At the depth of 50cm, the water content and permeability coefficient show a significant turning point. After the soil layer, the water content is small but the density is large. According to the screening test and density analysis, the soil contains a lot of broken gravel and gradually increases with the depth. Weathered basalt broken gravel accounts for the main component, resulting in more gaps in the soil layer, so the permeability coefficient gradually increases.

1. Introduction

Soil permeability refers to the permeability of water through soil pores. Soil infiltration process is the central link of precipitation, surface water and groundwater conversion, and is closely related to surface runoff, soil erosion, farmland irrigation, soil level redistribution after rainfall, nutrient migration with water and other issues. Soil permeability, in forestry: affects the water conservation. In agriculture: affects the loss of soil nutrients. Geology: water infiltration affects slope groundwater recharge[1][2].

Soil permeability (permeability) in slope unsaturated zone is an important physical and hydrological parameter of soil, which directly affects soil moisture infiltration[3]. As an important parameter of soil and an indispensable index in soil evaluation, scholars at home and abroad have done a lot of research work on this, put forward the water infiltration theory and infiltration model, and made a lot of research on the influencing factors of soil infiltration[4]. Liu xianzhao (1998) studied the field soil infiltration in wangdonggou watershed of Shaanxi province[5]. Wang (2006) conducted an experimental study on water infiltration, runoff and soil erosion of sloping farmland in arid areas of western Heilongjiang Province[6]. Field experiment with in situ soil infiltration test method, pay attention to the boundary conditions on the influence of soil infiltration test, the test used in the field of in situ monitoring device for double ring infiltration apparatus, the instrument for two concentric rings, the inner ring control test area, outer ring guarantee for vertical infiltration and soil water infiltration under the inner ring to reduce lateral seepage, with the inner ring in unit time (via markov bottle) supply water amount divided by the area of the inner ring, infiltration rate, selection of WM-1 type pressure gauge system to detect the water on the soil profile. In addition, rainfall simulation was used to study soil permeability test. In 2005, Chen conducted an experimental study on rainfall infiltration of slope under simulated rainfall conditions in the field [7]. In 2006, Gao

  DOI: 10.25236/isafb.2019.031

studied the infiltration of rainfall intensity on different land use types in loess areas[8]. Belongs to the soil infiltration test to determine part of boundary conditions; Odgen[9] and Peterson[10] (1997) reported the device of infiltration measurement by simulated rainfall method in 1986, simulated the boundary condition of rainfall, and analyzed the infiltration coefficient of soil column, water accumulation process and flow generation process.

In this paper, the permeability and physical properties of the soil in Jiaying unsaturated zone in Chenggong of kunming city, Yunnan Province were studied in order to investigate the permeability and variation characteristics of the longitudinal profile of the slope unsaturated zone.

2. Geographical Survey and Sampling Process of the Test Area

Duan jiaying experimental area was selected as the experimental site in this study. The selected experimental sites were located at maka mountain and Xiaoli mountain, Jiaying village, Duan district, Chenggong city, southeast of Yunnan normal university, about 1.8km away. Experimental zone is located in the Chenggong new area of Yunnan province, the county is located in the southeast of Kunming, the Kunming municipal administrative center station, within the territory of crisscross roads: KunLuo, up, up, two road, Nanning railway KunYu, ashmore two highway, etc. And, since the ancient times is the point to south and southeast Yunnan Kunming, there are provincial "southeast gate". Chenggong is located in east longitude 102 ° 45 ', north latitude of 59 '~ 102 ° 24 ° 21' ~ 24 ° 45 'between. It is bordered by Guandu district in the north, Yiliang county in the east, Chengjiang river and Jinning county in the south, and Dianchi lake and western mountainous area in the west.

In the selected slope area, first of all, the width is 50cm, the length is 100cm, and the depth is 100cm.Then, on the longitudinal section, 20cm depth was taken as one layer, and 5 samples were taken in total. The number of samples from the first four layers was as follows: 1.The number of samples taken from the fifth layer is: two 100cm3 ring cutters, one 150cm3 ring cutters, two 200cm3 ring cutters, one 500cm3 ring cutters and about 2kg sieve soil samples.On the longitudinal section, 10cm was taken as a layer, and 5 small aluminum box soil samples were taken from each layer, and a total of 50 small aluminum box soil samples were taken to determine the moisture content (see table 1 for the sample quantity, and see figure 1a for all the tested soil samples).

Table 1 Sample quantity

Sampling depth /cm	Specification of ring cutter and quantity of soil sample/piece					Screening sample /kg
	$100cm^3$	$150cm^3$	$200cm^3$	$500cm^3$	Aluminum cans	
0~20	2	3	2	2	10	2
20~40	2	3	2	2	10	2
40~60	2	3	2	2	10	2
60~80	2	2	2	2	10	2
80~100	2	2	2	2	10	2

3. Test Process

Before the test on soil sample pretreatment, after screening mashed soil, into the oven, baking under the condition of 105 ℃ for 24 hours until the moisture volatilizes completely. Weigh and record the 100cm3 ring cutter soil sample, then put it into the oven, bake for 24 hours, and take it out after drying. Layer each small aluminum box with soil label and put it into the oven to dry at constant temperature for 24 hours.

The specifications 150 cm^3, 200 cm^3 and 500 cm^3 loops knife soil sample set of bottom cover, into the water tank, the tank with water, after waiting for the water overflow ring knife on the plane, closed to the tank with water, soak for 24 hours, after being fully saturated soil sample out (as shown in figure 1 b) and been used in the determination of permeability coefficient, the experimental apparatus used is TST - 55 soil permeameter (as shown in figure 1 c, d). The ring have done processing knife soil

YangZhuang into TST - 55 permeameter socket, cover the permeable stone, tighten the screw seal, seal to no water no air, after the stay ring knife sample all saturated, will all the outlet of the sample under test instrument pipe clamp is opened entirely, close the outlet of the variable water head tube valve, the variable water head tube to inject pure water, to head to scheduled height 108 cm, then stop water, cut off the water. Then open the outlet valve of the variable pipe and start timing at the same time. Every 1min, time is counted and the number of readings is read at the same time. After the interval measurement is completed, inject the predetermined head of the same height into the variable head pipe, repeat the above operation, and read once within the same total time, as the Δ reading. According to the data obtained from the variable head test, the soil permeability coefficient can be calculated as follows:

$$k = 2.3\frac{aL}{A(t_2 - t_1)}\log\frac{H_1}{H_2}$$

Where a is the fracture area (cm^2) of the variable head pipe;2.3 is the change factor of ln and log; L is the infiltration path, that is, the sample height (cm);A is the sample cross-sectional area (annular cutter area);T1 and t2 are the starting and ending time (min) of the water head.H1 and H2 are the starting and ending water heads (ml) of the reading head, respectively.

Figure. 1 Soil sample and test process

4. Test Results and Analysis

The average value of moisture content of two soil samples on the first floor was obtained to obtain the natural density, dry soil density and moisture content of the soil in the unsaturated zone of Duanjiaying slope in Chenggong county and their variation trend (as shown in Figure 2). It can be seen from the change of moisture content in figure 2 that with the increase of soil depth, the moisture content of soil gradually decreases, with the maximum at the surface 42.34%, and the minimum at the depth of the section, about 25%. The moisture content of soil at the depth of 50cm~70cm has a large change trend, with a difference of 11.12%. According to the change trend of density in fig.2, with the deepening of soil depth, the wet soil density and the dry soil density have an overall increase trend.At the depth of soil layer less than 50cm, the density has a tendency of sudden increase, so the moisture content of the soil layer at this location is small but the density is high. At the same time, it can be seen that the density of the soil at the lowest part of the profile is the highest, because the rock debris gradually increases with the depth.

According to try and graphic analysis (Figure 3), you can see that some change law: 1, in deep soil layer 0 ~ 50 cm, with the increase of soil layer increases gradually, the coefficient of permeability of gradual change trend, but when the soil depth 50 cm, seepage coefficient reduced to the minimum change happen only 2.46×10^{-4}, below 70 cm soil layer depth, coefficient of permeability suddenly increases to a maximum, 5.18× 10^{-4}.Combined screening test, density and moisture content of soil analysis shows that the soil contains a lot of debris and increased with the increase of depth, soil stone phenomenon is prominent, weathering basalt as main ingredients, debris increase lead to soil and gravel to appear the interface for seepage advantage interface, which resulted in increased permeability coefficient with depth increases with the overall trend.

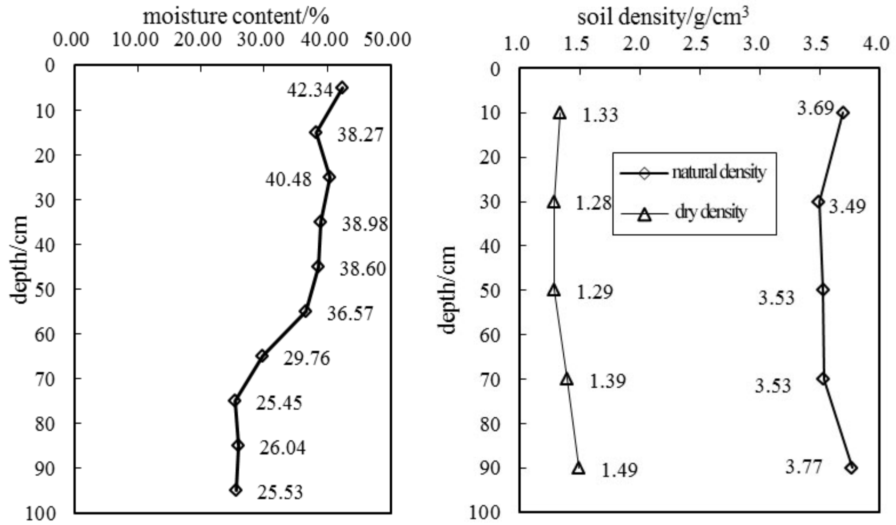

Figure 2. Changes of moisture content and density with depth

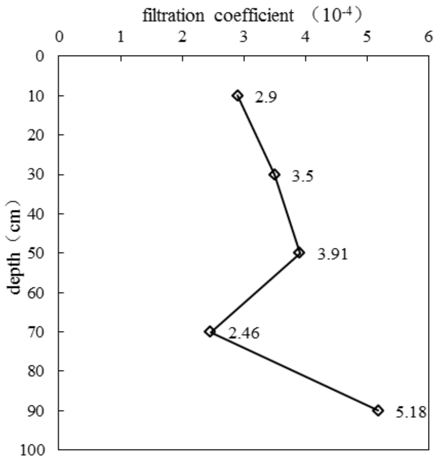

Figure. 3 Permeability coefficient with depths

5. Conclusion

Chenggong section at camp vadose zone in Kunming, Yunnan province based on the layered soil as the research object, through to the soil physical properties and hydraulic properties of research shows that: test different levels of unsaturated zone soil properties, and permeability has obvious differences between the moisture content is between 25% ~ 45%, the soil moisture content of deepening gradually decreases, wet soil density and dry density of soil has a tendency to increase overall; The results of soil permeability in unsaturated zone based on tst-55 permeameter show that the variation of permeability coefficient is large and tends to increase with the increase of depth. At the depth of 50cm, the water content and permeability coefficient show a significant turning point. Combined with screening test, density and moisture content analysis, it can be seen that the soil contains a lot of broken gravel and gradually increases with the depth. Weathered basalt broken gravel is the main component, resulting in more gaps in the soil layer, and the permeability coefficient gradually increases.

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