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The Study of Test Method Improvement for Organic Matter and Decomposition Degree of Turfy Soil

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The degree of turfy soil decomposition is the relative proportion that animal and plant residues decomposed by soil microbes account for and its special structures also lead to high content of organic matter. The decomposition degree and organic matter content of turfy soil can not only reflect the degree of peatification in the soil forming environment, but also influence the engineering and physical properties of turfy soil. The improved test method for organic matter and decomposition degree of turfy soil were studied and then applied to the samples collected from Dunhua and Jingyu in China. The results showed the simpleness and convenience of the amended method and the organic matter content and decomposition degree varied from different soil layers. The surface and bottom layer shared high decomposition degree but low oragnic matter content which was on the contrary to the middle part. And the comparison showed that there was some differences in organic matter content between the former method and amended method.

1. Introduction

Turfy soil is widely distributed in Changbaishan, Xing'anling, Qingzang plateau, NW Sichuan and Yunan provinces and usually characterized by its special properties including low decomposition degree, high organic content, high void ratio and high compressibility etc (Xu 2008, Susan 2004). Under the special climate, topography and hydrological conditions, the marsh plant residues were decomposed by aerophile bacteria in soil and turned into a new kind of humus soil with high moisture content large amounts of humic acid, which causes the complexities in the physico-chemical properties, hydraulic properties and mechanical properties of turfy soil(Assem, 2003; Cutler, 2010). With the rapid development of economic construction, the engineering projects inevitably need to be constructed in the turfy soil distribution area, which brings many problems in geotechnical engineering design. The objective of this paper is to targetedly study the unique soil composition of turf.

In former studies, Liu(2010, 2011) , Nie(2012, 2014), Lv(2011) defined the degree of decomposition of turfy soil to study the soil microstructure characteristic and physic-mechanical properties, they proposed that the decomposition degree was the relative proportion that animal and plant residues decomposed by soil microbes and lost their original cell structures accounted. It could reflect the degree of peatification in the soil forming environment and may also influence the engineering and physical properties of turfy soil. The measure method was put forward refer to the central Peat Experimental Station that separated the soil and plant residues with running water (Liu, 2013), as seen in following Eq(1):

$$F = (1 - \frac{v'}{v}) \times 100 \quad (1)$$

Where F and v are the decomposition degree of turfy soil and volume of soil before test, respectively, v' is the volume of undecomposed plant residues.

From Eq.(1) we can see that the key of this method is how to accurately determine the volume of undecomposed plant residues. The measuring steps are as follows: first, take out the intact soil samples with

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ring sampler into a 60 mesh sieve, wash it with running water till there are only undecomposed plant residues in the sieve, air drying. Then measure the volume of undecomposed plant residues by draining kerosene instead of draining distilled water. However, if a large number of soil samples need testing, some shortages arise with this measurement process: First of all, plant residues and soil particles are cemented together through a large amount of cementation. It is hard to completely separate plant residues and soil particles with mechanical flush of the running water; second, it is impossible to keep the air-drying sample the same original moisture content as before. In view of this, two typical turfy soil samples from northeast China were selected in this study and the separation methods of plant residues and the calculation of degree of decomposition process were improved, respectively.

2. Test for decomposition degree of turfy soil

2.1 The separation of plant residues

The intact turfy soil samples were cut into two parts, then test specimens were took out with 60 cm3 ring sampler at upper and lower section, which were used for parallel tests. Cut the test specimen into four equal parts as seen in Fig.1, chose two at random then sealed it in a numbered vacuum bag for the determination of organic matter content. The remaining two parts were numbered for plant residues separation test as shown in Figure1.

Figure 1: The quartering preparation of turfy soil specimens

NaOH solution was applied in separation test (Lang, 1984), cut the soil specimen into many small pieces and put them in a beaker, then boiling the turfy soil in 3% NaOH solution for 2 h to separate plant residues from cementing substance completely. Poured the soil suspensions in a 0.25mm-mesh and washed them with running water to rinse and remove humus and minerals. Collected all the plant residues in ceramic bowls the mesh into and dried them in an oven at 65°C for 24 h, sealed one for testing the organic matter content in plant residues and another was used for measuring the volume of undecomposed plant residues by draining kerosene. As shown in Figure 2.

Figure 2: The separation process of plant residues and soil particles

2.2 The Calculation of Decomposition Degree

Soil is usually composed of solid phase, liquid phase and gas phase. The main composition of soil is solid particles which were composed of countless mineral particles in many sizes and shapes. With the random permutation and combination of these mineral particles, the skeleton of soil body is constituted, which also known as the soil particles(Tang, 1999).

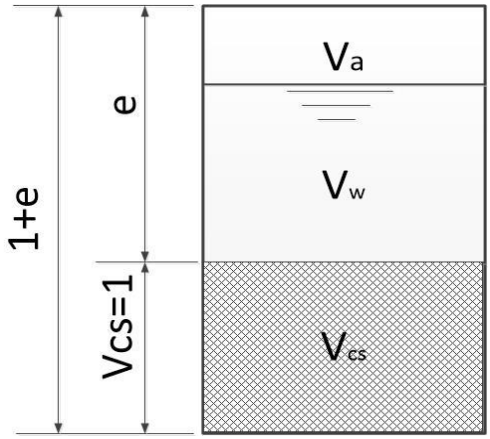

Figure 3: Three-phase sketch of turfy soil

But the turfy soil contains a lot of plant residues, organic matter and mineral particles, which constitute the skeleton of soil body, as seen in Fig. 3. and are the volume of gas and liquid in turfy soil respectively, the volume of plant residues, organic matter content and mineral particles and it can be calculate from Eq. 2. Then the Eq. 3 can be deduced, as seen in below.

$$V_{cs} = V_c \Big/ (1+e) \tag{2}$$

$$F = \left(1 - \frac{V_c^{'}(1+e)}{V_c}\right) \times 100 \tag{3}$$

Where, F(%) is the decomposition degree (DEC) of turfy soil and $V_c^{'}$ (cm3) volume of dried undecomposed plant residues; *e* is the void ratio of turfy soil and the volume of soil before test which is 15 cm^3 in this study, the results of decomposition degree calculated by Eq. 3 are shown in Table 1.

Table 1: Decomposition degree of Turfy soil samples

Sampling site	Sample name	void ratio *e*	V_{cs} (cm^3) [a]	$V_c^{'}$ (cm^3) [b]	Decomposition Degree F (%)
Dunhua Jiangyuan	1#	2.69	4.07	1.15	71.71
	2#	7.32	1.80	1.10	38.99
	3#	5.82	2.20	1.02	53.62
	4#	5.72	2.23	0.84	62.37
	5#	4.18	2.90	0.95	67.19
	6#	3.39	3.42	0.40	88.29
Jingyu Longquan	1#	4.24	2.86	0.95	66.81
	2#	5.91	2.17	0.85	60.84
	3#	4.31	2.82	0.90	68.14
	4#	1.79	5.38	0.64	88.10

[a]The volume of plant residues, organic matter content and mineral particles.

[b]The volume of dried undecomposed plant residues.

The results show that the decomposition degree of turfy soil varies from different depths, usually the surface and bottom layer exhibit higher degree than the middle parts where the degree could reach to as low as 38.99%.

3. The organic matter content test

Former studies indicated that the organic matter in turfy soil was consisted by undecomposed plant residues and humus, mainly humic acid and followed by cellulose, hemicellulose, asphalt in peat and lignin (Li, 1999). And the influences that the plant residues and humus had on the engineering properties of turfy soil were different, so it is necessary to respectively study the organic matter content of the two parts.

3.1 The determination of organic matter content

Generally, there are two methods to measure the organic matter content in soil: loss on ignition and the potassium dichromate method. The LOI was employed in this study according to Test Method of Soils for Highway Engineering (JTJ051-93, 1993) and ASTM(1997) that the potassium dichromate method inaccurate when the organic matter content exceed 15% while turfy soils were featuring high organic matter which could even exceed 90%. The soil samples in Fig.1(b) were dried in an oven at 65℃, ground, and sieved to a 0.5-mm mesh prior to use. Then the soil samples (1g for each depth) were burned at 550℃ for 1 hour, weighed and repeated ignition till there was no further weight loss taking place (less than 0.5 mg) and measured the final weight (m_2 g). Repeated the test process above to plant residues in Fig.1 (a), measured the weight loss for $m_c^{'}$ g.

3.2 Calculation of ignition loss

From the definition of ignition loss, the loss of turfy soil, i.e. organic matter content, could be calculated from the following formula, as seen in Eq. 4

$$S = \left(G_1 - G_2\right) / G_1 \times 100 \tag{4}$$

Where, G_1 and G_2 g are the weight (g) of turfy soil before and after ignition, so the loss of humus part (S_h) could also be derived as following formula,

$$S_h = \frac{(m_1 - m_2 - M_3)}{m_1 - M_4} \times 100 \tag{5}$$

Where, M_1 and m_3 are the ignition loss (g) of plant residues; and M_4 and m_1 are the weight of plant residues, which could be obtained from Eq. 6 and Eq.7 as following,

$$M_3 = \frac{m_1 m_c^{'}\left(1-F\right)}{V_c^{'}\rho_s} \tag{6}$$

$$M_4 = \frac{m_1 \rho_c^{'}\left(1-F\right)}{\rho_s} \tag{7}$$

Where, $V_c^{'}$ is the volume (cm^3) of plant residues in decomposition degree test; $m_c^{'}$ is the corresponding weight (g) loss of plant residues; $\rho_c^{'}$ the dry density of plant residues (g/cm^3); ρ_s is the soil particle density of turfy soil (g/cm^3) and F the decomposition degree (%). The results are listed in the Table 2.

Thus it can be seen that the organic matter was much lower in surface layer than others and it increased with the increases of depth till a certain depth then decreased. And the results drawn from amended method were somewhat more precise than the original method.

Fig. 4 displayed the comparison photos of turfy soil before and after ignition loss test, fig. 4 (A) and (B) were the photos of the soils that contained plant residues and fig. 4 (C) and (D) were the photos of plant residues. It could be inferred from the color change of soil samples from black to pale yellow that the organic matter was fully burned.

[a] The total ignition loss of turfy soil (organic matter content of turfy soil)
[b] weight of turfy soil before test
[c] weight of turfy soil after test
[d] the ignition loss of plant residues
[e] dry density of plant residues
[f] the ignition loss of humus parts

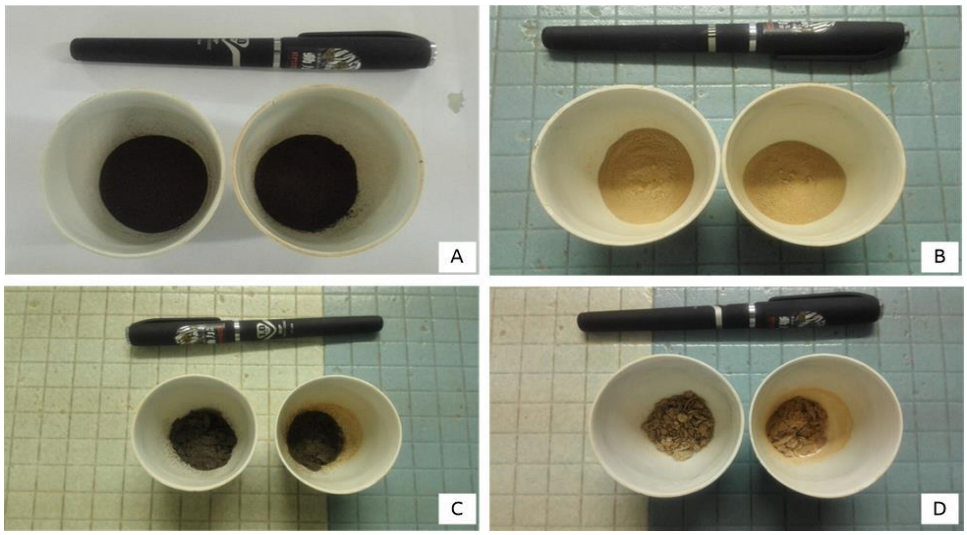

Figure 4: Photos of soil specimens before & after loss on ignition test.

Table 2: The results of organic matter content test

Sampling site	Sample name	S (%) [a]	m_1 (g) [b]	m_2 (g) [c]	m_c' (g) [d]	ρ_c' (g/cm^3) [e]	S_h (%) [f]
Dunhua Jiangyuan	1#	36.47	1.23	0.78	1.31	0.68	23.44
	2#	74.23	1.16	0.30	0.50	0.71	77.48
	3#	64.55	1.04	0.37	0.32	0.70	69.19
	4#	73.91	1.17	0.30	0.40	0.70	74.91
	5#	43.77	1.33	0.75	0.31	0.67	43.35
	6#	53.36	1.41	0.66	0.41	0.66	49.78
Jingyu Longquan	1#	55.84	1.15	0.51	0.22	0.75	59.69
	2#	63.12	1.12	0.41	0.40	0.71	62.55
	3#	62.03	0.83	0.31	0.31	0.70	63.97
	4#	38.96	1.06	0.65	0.19	0.65	38.63

4. Conclusions

The amended method could efficiently separate the plant residues and soil particles by boiling turfy soil in NaOH solution, which made the test results more accurate. The decomposition degree varied form different soil layers and usually the surface and bottom layer were accompanied by high decomposition degree while the middle layers had a lower dergee.

More precise results for organic matter content could be obtained from the amended method because it removed the undecomposed plant parts in the soil. And the regularities of organic matter in turfy soil were opposite to decomposition degree which meaned that the organic matter was low in surface and bottom layer but much higher in the middle parts. The comparison showed that there were some differences between the ignition losses calculated by two methods since the amended method removed the plant residues.

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