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Research Article

Effects of Decomposition Degree and Organic Matter Content on the Compressibility Index of Agricultural Turfy Soil

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Abstract: Agricultural turfy soil compressibility index significantly influences sedimentation characteristics. Influences of plant roots, plant fibers and organic matter content (excluding plant roots and plant fibers) on the compressibility index mechanism are different. In this study, some related experiments were designed to determine the difference in influences among plant roots, plant fiber and organic matter content on agricultural turfy soil compressibility index. Test results showed that decomposition degree (F) was negatively correlated with compression coefficient a1-2, compression index Cc and swelling index Cs. By contrast, organic matter content (Sh) was positively correlated with compression coefficient a1-2 and compression index Cc but no obvious correlation with swelling index Cs.

Keywords: Agricultural turfy soil, decomposition degree, plant roots

INTRODUCTION

Swamp agricultural turfy soil is a special type of humus soil with high void ratio, high water content, high organic matter and formation age of less than 1 million years. This special type of soil is widely distributed in Changbai Mountains, Great Khingan Mountains, Lesser Khingan Mountains, Sanjiang Plain, Qinghai-Tibet Plateau, Yunnan plateau and the Middle and Lower Reaches of Yangtze River in China (Nie *et al*., 2012a). This soil consists of plant fibers (commonly from moss, sedge, reed and wood), humus and mineral matter (Gnatowski *et al*., 2010; Nie *et al*., 2013). As a result of different depositional ages, plant residual roots and fibers, organic matter content and minerals in agricultural turfy soil vary during deposition.

Soil compressibility directly affects the characteristics of the consolidation settlement of building foundation; several researchers have conducted research on the compressibility of sand, clay and so on (Alawaji, 1999; Yukselen-Aksoy *et al*., 2008; Chen *et al*., 2014). However, research on the compressibility of agricultural turfy soil is rare. Therefore, the compressibility of agricultural turfy soil should be studied. Nie and Lv investigated the effect of organic matter content and decomposition degree in agricultural turfy soil on the engineering properties in Northeast China (Lu *et al*., 2011; Nie *et al*., 2012b). However, plant roots and fibers also belong to organic matter, which are not separated from organic matter in ignition loss test. The influence mechanism and effects of plant roots, plant fibers and organic matter in agricultural turfy soil on physical and mechanical characteristics are different. Designing related experimental research on the separation is therefore necessary to provide a theoretical basis for analyzing structural characteristics and establishing a constitutive model of agricultural turfy soil.

MATERIALS AND METHODS

Materials: Soil samples were collected from JiangYuan Town, Dunhua, located in the hinterland of Changbai Mountain at east longitude 127°50’-128°05’, north latitude 43°06’-43°14’ and altitude 550-600 m, which belongs to temperate continental monsoon climate. Rivers are gathering here, the water system is developed and the landforms are significantly affected by the “box” and “partition” effects. Consequently, drainage is difficult here, the perennial water forms a wet environment and swamp agricultural turfy soil is developed.

A drilling sampling method was adopted for six groups of undisturbed soil samples at different depths. The soil samples are shown in Fig. 1.

Decomposition degree test: In this experiment, decomposition degree was defined as the percentage of the volume of agricultural turfy soil without

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Table 1: The test results of decomposition degree and organic matter content

Number	DYJ-1	DYJ-2	DYJ-3	DYJ-4	DYJ-5	DYJ-6
Depth (m)	0.80-0.95	1.15-1.30	1.30-1.50	1.80-2.00	2.55-2.70	2.80-2.95
F (%)	71.71	39.00	53.62	62.37	67.19	88.29
S_h (%)	23.44	77.48	69.19	74.91	43.35	49.78

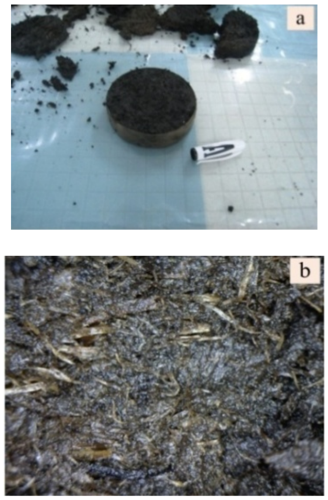

Fig. 1: (a): The agricultural turfy soil samples; (b): is a mesoscopic photo magnified 50 times

undecomposed plant roots to the total volume. The value can be obtained through Eq. (1). The results are shown in Table 1:

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

In the above equation:

V_c' = The undecomposed plant residues after baking volume (cm^3)

e = The agricultural turfy soil void ratio

V_c = The volume of agricultural turfy soil before test (cm^3)

Organic matter content test: Two methods are generally used to test organic matter content in soil, namely, ignition loss method and potassium dichromate content method. When organic matter content is more than 15%, the latter is not suitable (Osano and Sixtus, 2011). Therefore, the former is used to determine organic matter content in agricultural turfy soil because it contains considerable organic matter content.

Organic matter content was defined as the percentage of the quality of organic matter in soil (excluding plant roots and fibers) and the total quality of the soil sample in this experiment to reach the test goal, that is:

$$S_h = \frac{(M_1 - M_2)}{M_1} \times 100\% \quad (2)$$

where, M_1 is the total quality of soil samples and M_2 is the quality of residuum by igniting the sample without plant roots and fibers under 550°C for 2 h.

The organic matter content of the soil samples is shown in Table 1.

High-pressure consolidation test: A three-linked lever-type consolidometer was used in the high-pressure consolidation test. Twelve samples were extracted with a ring knife (volume 100 cm^3, height 2 cm) before the experiment. The soil samples were placed in a saturator with vacuum environment for 1 h to make the soil samples fully saturated. At the start of the test, 0.001 MPa load was added and the reading of the dial indicator was adjusted to zero. The load was increased every 24 h and the dial indicator was read every hour after each loading. Compression stability standard was set. The compression deformation was not more than 0.005 mm per h.

RESULTS AND DISCUSSION

The curves of *e*-*p* and *e*-lg*p* can be drawn in accordance with the data obtained through the high-pressure consolidation test, as shown in Fig. 2 and 3.

The compressibility $a_{1\text{-}2}$ can be calculated through the *e*-*p* curve and the compression index Cc and swelling index Cs can be calculated by the *e*-lg*p* curve. The final results are shown in Table 2.

Relationship of compression coefficient with organic matter content and decomposition degree: Figure 4 presents the following findings:

- The compressibility of agricultural turfy soil is negatively related to decomposition degree, that is, a low decomposition degree indicates a large compression coefficient. The smaller the decomposition degree of agricultural turfy soil, the larger the percentage of plant roots and plant fibers in soil and the greater the proportion of the void ratio. Consequently, the compressibility of agricultural turfy soil increases.
- The compressibility of agricultural turfy soil is positively correlated with organic matter content, that is, a high organic matter content leads to a large compression coefficient. Organic matter can change the internal structure of soil and make it porous; thus, compressibility increases.

Relationship of compression index with organic matter content and decomposition degree: The compression index of soil is a constant within the scope that consolidation pressure is high, as shown in Fig. 4.

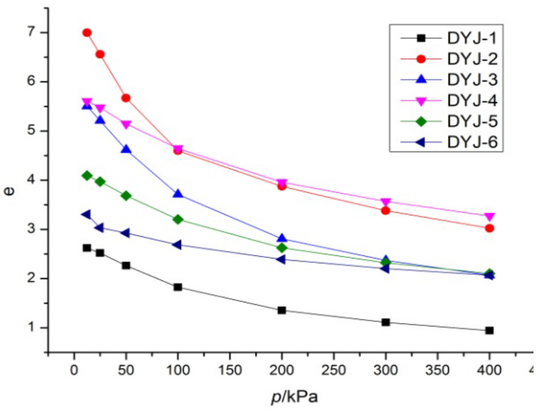

Fig. 2: The *e*-*p* curve of the samples

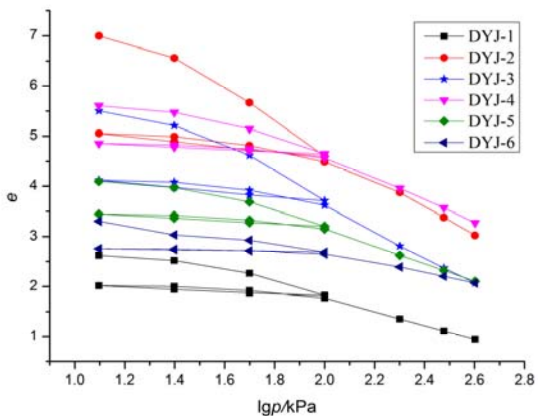

Fig. 3: The *e*-lg*p* curve of the samples

The compression index and decomposition degree of agricultural turfy soil present a negative relationship. By contrast, a positive correlation is found between compression index and organic matter content, but they are not as strong as the former regularity. Decomposition degree reflects the content of plant roots and fibers in soil. Over a wide range of consolidation pressure, plant roots and fibers cause a strong compression effect.

Relationship of swelling index with organic matter content and decomposition degree: The average slope of unload and recompression in the e-lgp curve, which is called swelling index, can be obtained by the high-pressure consolidation test of agricultural turfy soil. This index is a measure of the elastic component in soil. Swelling index expresses the degree of elastic deformation in the deformation process. A high swelling index indicates great elastic deformation of soil. Figure 5 shows that agricultural turfy soil swelling index and decomposition degree present a negative relationship, but the relationship of agricultural turfy soil swelling index with organic matter content is not obvious. This result is mainly because of the fact that agricultural turfy soil contains numerous plant roots. Organic matter exists in fibers in the form of humus and plant roots in soil are mainly distributed vertically (JTJ051-93, year). Under the action of vertical load upper soil, tensile stress will be generated in the lateral of plant roots and bending deformation occurs. After unloading, the bending of plant roots can recover deformation, which significantly influences the elastic

Table 2: The final compressibility index results of samples

Number	F (%)	S_h (%)	a_{1-2} (MPa^{-1})	Cc	Cs
DYJ-1	71.71	23.44	4.7	1.3784	0.2234
DYJ-2	38.99	77.48	7.24	2.4233	0.4802
DYJ-3	53.62	69.19	5.93	2.5835	0.4641
DYJ-4	62.37	74.91	6.89	2.128	0.2367
DYJ-5	67.19	43.35	5.78	1.7393	0.2759
DYJ-6	88.29	49.78	2.99	0.9626	0.0659

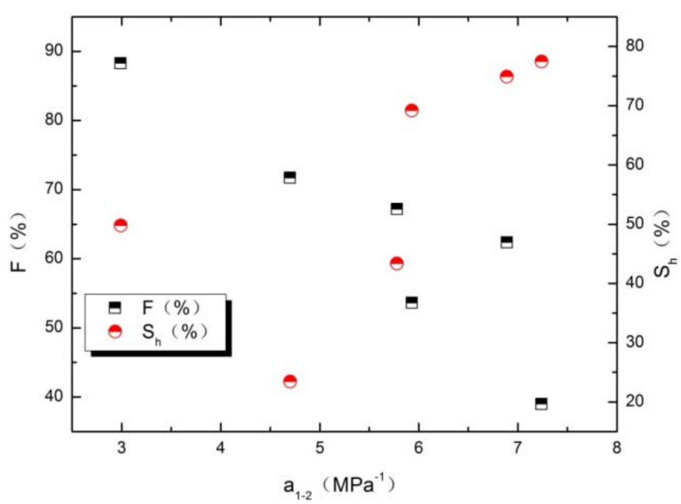

Fig. 4: The relationship diagram of compression coefficient and organic matter content, the degree of decomposition

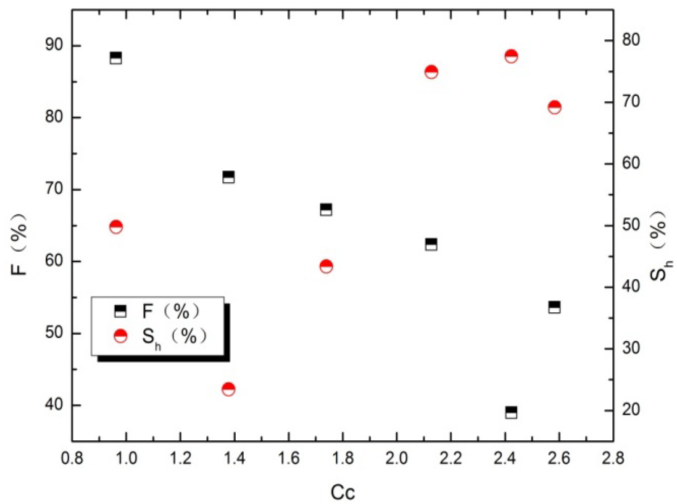

Fig. 5: The relationship diagram of compression index with organic matter content and the degree of decomposition

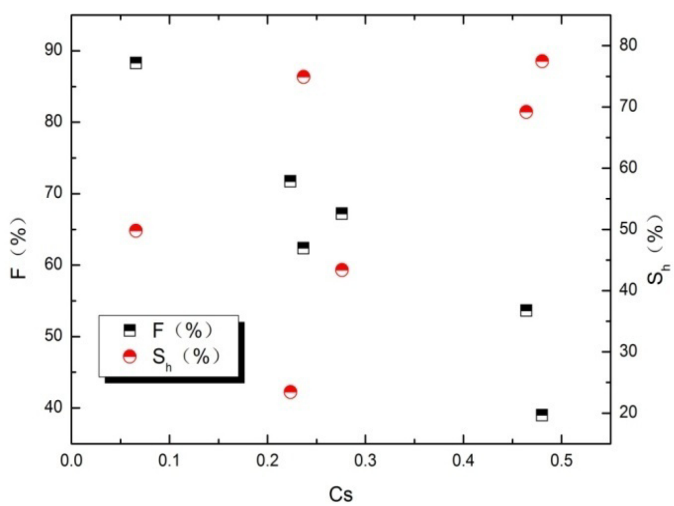

Fig. 6: The relationship diagram of swelling index with organic matter content and the degree of decomposition

deformation of soil. However, humus does not largely affect the elastic deformation of soil.

CONCLUSION

In conclusion, the decomposition degree and organic matter content of agricultural turfy soil show a certain influence on its compressibility. A high decomposition degree results in small compressibility, whereas a high organic matter content leads to great compressibility. However, they present different correlation degrees for soil compressibility index. The decomposition degree of agricultural turfy soil has a significant negative correlation with compression coefficient, compression index and swelling index. Organic matter content had an obvious positive correlation with compression coefficient, a slightly positive correlation with compression index and an insignificant correlation with swelling index. Plant roots and fibers in soil have significant influence on its compressibility. Organic matter content and decomposition degree have a mutual influence on compressibility. They are considered in analysis. As shown in Fig. 6, in the relationship diagram between compression coefficient and decomposition degree, DYJ-4 (F = 62.37%) of compressibility is larger than DYJ-3 (F = 53.62%) because the organic matter content of DYJ-4 (74.91%) is larger than that of DYJ-3 (69.19%). For this sample, the organic matter content of soil plays a lead role on compressibility. In the relationship diagram of compression coefficient and organic matter content, DYJ-6 and DYJ-5 also has the same phenomenon.

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