Research Progress of Loess Permeability Coefficient Measurement

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Abstract

The permeability characteristics of loess, especially collapsible loess, have been the key work in the related research field. As a quantitative index reflecting the permeability of soil, permeability coefficient is an important parameter in hydrogeology, and its accuracy is of great significance to relevant research. The permeability of loess is the main characteristic of soil, and its measurement can be divided into direct measurement and indirect measurement. The direct measurement methods are mainly steady state method and transient method, among which transient method is the most commonly used method to measure unsaturated permeability coefficient. Indirect method is based on the characteristic curve of soil and water, and the unsaturated permeability coefficient is determined by model.

Keywords

Permeability Coefficient; Loess; Steady State Method; Transient Profile Method; Indirect Method.

1. Introduction

Loess in China is well-developed, widely distributed, thick, highly representative and has special engineering properties. In Northwest China and North China, there are the largest loess plateau and North China Plain in the world, with a thickness of 200-300 meters. Due to the unique engineering geological characteristics of loess, the research is of great significance in the process of engineering construction. Since the founding of new China, with the development of industry and agriculture in the loess area, loess related research has been widely and deeply carried out. Loess has water sensitivity, so the loess area is prone to geological disasters. The hydrogeological characteristics of loess have attracted the attention and in-depth study of scholars. Permeability coefficient, as an important parameter in unsaturated soil research, naturally becomes the focus of scholars. The permeability coefficient of loess is a complex parameter. The permeability coefficient of loess in different regions and different states has obvious differences. The determination method of loess permeability coefficient is also very important for the study of loess. The author will briefly introduce the main determination methods.

2. Determination of soil permeability coefficient by steady state method

There are two methods to measure the permeability coefficient of unsaturated soil: steady-state method and transient method. In the process of measuring the permeability coefficient of unsaturated soil, the steady-state method needs to keep the matrix suction, water content and hydraulic gradient of soil constant [1]. In the past 60 years, with the gradual expansion and in-depth study of Chinese scholars, the study of loess permeability coefficient has made great improvement and development. Wang Wenyan et al. [2] studied an experimental device for simultaneously measuring three parameters of soil unsaturated hydraulic conductivity, diffusivity and soil water characteristic curve on a horizontal soil column γ. The results are accurate and reliable, and the operation is simple. Shao Longtan et al. [3] developed a steady-state seepage test device for unsaturated soil, which can be used to measure the soil water characteristic curve of unsaturated soil under the conditions of dehydration and moisture absorption in the laboratory, and measure the water diversion number of unsaturated soil under the conditions of different matric suction at the same time. The advantages of the device are simple and flexible operation, good stability and reliable experimental data.

3. Determination of soil permeability coefficient by transient method

Transient method is a kind of unsteady method, in the process of measuring soil permeability coefficient, the matric suction, water content and hydraulic gradient of soil are changing from time to time. The transient method mainly includes horizontal infiltration method, overflow method and instantaneous profile method [4]. Because the permeability of unsaturated soil is very low, the steady-state method takes a long time, so the transient profile method has become a common method to measure the unsaturated permeability coefficient [5]. The horizontal infiltration method is to let the water enter the soil sample from one side of the horizontal soil column under the condition of a certain water head, so that the water content increases gradually until saturation. The permeability coefficient is obtained by analyzing the water content distribution at different times, as well as the initial conditions and boundary conditions. Based on the multi-step overflow method, Shao Longtan et al. [6] proposed a method to directly measure the permeability coefficient by using soil water characteristic curve and transient water content curve. Ye Weimin et al. [7] studied the permeability characteristics of Gaomiaozi bentonite by using instantaneous profile method, and designed a set of test device suitable for high pressure compacted expansive soil.

4. Determination of soil permeability coefficient by indirect method

The direct method can determine the permeability coefficient of unsaturated loess, which can be divided into two types: indoor test and field test. There are many factors influencing indoor test and high uncertainty of results. Compared with the field test in indoor test, the results are more reliable and practical value is higher, but both of them are time-consuming and costly, The spatial variability of loess limits the application of direct measurement in practical work. Through theoretical research and scientific practice, it is generally believed that the permeability coefficient of soil can be predicted according to the distribution of pore size. This is the indirect method of determining the permeability coefficient of loess. Based on the characteristic curve of soil water (matrix suction volume moisture content curve), unsaturated permeability coefficient can be determined by model [8]. Liu Cuiran et al. [9] has found that the permeability coefficient of unsaturated loess in the drainage section of big pore and microporous gap can be determined by direct measurement and indirect derivation. The results of Zhang Hongfen [10] and other studies show that when the confining pressure of triaxial apparatus is 100-400kpa and the volume water content is 0.07-0.23, the permeability

coefficient of unsaturated soil obtained by direct and indirect methods is very close, and the error is not more than 10%. Shao Longtan [11] based on the principle of interaction between the phase medium and Newtonian mechanics, the control equation of the water movement of saturated and unsaturated soil is deduced again, which makes the control equation of saturated and unsaturated soil have a unified form, and under the condition that the saturated permeability coefficient and soil water curve are known, The permeability coefficient of soil under unsaturated condition can be calculated by using this expression.

5. Conclusion

Through the research of many scholars on Loess permeability, it is known that the direct measurement of unsaturated soil permeability coefficient is more complex and difficult than indirect measurement. The permeability coefficient obtained by direct method is reliable, but the test is difficult, time-consuming and expensive; The permeability coefficient obtained by indirect calculation has error, but the test is simple and less time consuming.

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