# **Development of Automatic Soil Water Retention Test System**

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# **1** Introduction

The soil water retention curve has played a dominant role in the study of unsaturated soils such as soil science, soil physics, agronomy, and agriculture. The soil water retention curve is commonly defined as the relationship between the amount of water and the soil suction. The amount of water in soil is generally quantified in terms of gravimetric water content w, degree of saturation S, or volumetric water content  $\theta$ . The primary application or the SWRC has been in the estimation of unsaturated soil property functions. The soil water retention curve is the key to the behavior of unsaturated soils, and it also relates to other properties of unsaturated soils, such as the unsaturated coefficient of permeability, shear strength and volume strain, grain-size distribution. But soil water retention test is however very time consuming. When the data was got by observation of people and the sample is sandy or silty soils, such kind of test will be very tired.

This study have developed a whole soil water retention test system consist the apparatus and the corresponding control software, which can control test process and process data. The software was made by the author by using visual Basic Language. This system can give out a better result than a manual one above the minimum system error.

# **2 Developing Process**

### 2.1 Method of Soil water retention test

For soil water retention test, there are five methods which are usually used (Table. 1). In this system, for drying process, pressurized method was used. Both pressure plate method or pressure membrane method can be chosen to use. While for wetting process, the suction method was used, which water head method and decompression method were used in this automatic soil water retention system.

#### 2.2 Schematic of apparatus and functions

The schematic of automatic soil water retention test system was shown in Fig. 1. As shown in Fig. 1, the green line was air pipe, the blue line water pipe and the red line was electricity cable which used for data and control commanders. The water tank is used for making and storing water without air. The barometer was used to measuring air pressure for varying the real pressure in the air pipe. The air tank has two meanings, the first is that it can support more than one device to use in this time, second is that it can protect the E/P sensor in case the water back to the sensor if minus pressure occurs. The sample chamber is the main part of test, the bottom of this part is place to put ceramic disk or cellulose filter. The water pressure meter was used to measure the water pressure of the tube.

Method		Potential measuring range (kPa)
Suction	Water head	-0.1 to -30
	Decompression	-0.1 to -50
Pressurized	Pressure Plate	-10 to -1500
	Pressure Membrane	-10 to -1500
Centrifuge		-10 to -1500
Vapor Pressure		-3 000 to -300 000
Psychrometer		-300 to -150 000

### 2.3 Procedure of test

An automatic soil water retention test system was assembled as in Fig. 1. A soil specimen is placed on the porous barrier inside the retaining cylinder of the tempe pressure cell. The outlet tube located at the bottom plate underneath of the porous barrier allows the drainage of water from the soil specimen. The top and bottom plates are fastened together during the test. The air pressure is supplied through the inlet tube on the top



Fig. 1 Automatic soil water retention test system

plate, and water level between soil specimen and outlet was measured by water pressure meter.

The SWRC test started by saturating the porous barrier and soil specimen. After saturating the specimen, the excessive water is removed from the cell. the top plate is the mounted and tighten into place. Once the tempe pressure cell was assembled and ready, open the software and input basic property of soil and some control parameters, then click the 'start' button, then the test will be started automatically. The software will judge the balance of start point and every air pressure steps, record the corresponding air pressure and water pressure automatically. The water starts draining from the specimen through the porous barrier until equilibrium is reached. The flowchart of automatic soil water retention test system was shown in Fig. 2.





Where  $\Delta T$  is time interval of balance time.  $\Delta P$  is change of pressure between two steps, which is set in the software at the beginning of test.  $\Delta Q$  is water flow change in time of  $\Delta T$ .  $Q_{min}$ is minimum error of system.  $P_{max}$  is maximum air pressure of drying process, which is also set in the software at the beginning of test. After completion of the drying process, the test is continued with the wetting process if it was set in the beginning. Using air pressure data and water volume change between two successive section to calculate the water content corresponding to each matric suction. The corresponding data of drying and wetting path will be recorded and calculated by computer. When the test finished, take out the sample and measure the water content, then input it into software, the data and corresponding curve will be shown.

#### **3 Results and Discussion**

Some test results were shown in Fig. 3, from this results we can see that the automatic soil water retention test system was developed successfully.

Actually, the real time of test process both manually or automatically is same, but automatic way can save the time which is unavoidably wasted in manual way. This is illustrated in Fig. 4. A common relationship between water pressure and elapsed time in soil water retention curve was shown in Fig. 4. From the fig, we can see that usually, when using manual way, after at least two continue elapsed time interval, then the balance condition can be judged. But for automatic way, with the help of program, after a certain time (can be set in software), such a balance can be judged. Finally, the time between point ① and point ② can be saved.

#### **4** Conclusion

Based on the well known method, the automatic soil water retention test system which consist the apparatus and the corresponding control software was developed. Comparing with manual method, it has some advantages on convenience, accuracy, time saving and persistency.

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Fig. 3 Test results by using automatic SWR test apparatus



Fig. 4 Explanation of 'time saving'

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