MEASUREMENT OF SOIL PROPERTIES

Moisture characteristic curves for a particular soil can be determined by any of three approaches (Charbeneau and Daniel, 1993). The first technique is to estimate the curve (water content versus capillary pressure head) from published data for similar soils. For example, Rawls et al. (1983) collected and analyzed data from over 500 soils. Gupta and Larson (1979) describe the use of grain-size distribution data, organic content, and bulk density to estimate moisture characteristic curves. The second technique is to assume an analytic function such as that of Brooks and Corey (1964) or Van Genuchten (1980). These equations were presented in Section 9.2. The empirical coefficients in these functions are usually estimated based on correlations of various soil characteristics.

The third approach is to actually measure the soil moisture characteristic curve directly. Incremental equilibrium methods allow the soil to come to equilibrium at some moisture content θ, and then capillary pressure ψ is measured. Next θ is changed and time is allowed for equilibrium to reestablish and ψ is remeasured. The process is repeated until a sufficient number of ψ–θ points have been measured to define the entire curve (Figure 9.2). One can also allow ψ to come to equilibrium and measure θ for changes in ψ. The pressure plate is the most commonly used method of measurement and involves placing a chamber around soil samples that have been soaked with water. Positive air pressure is used to force water out of the soil samples and the outflow is monitored to confirm equilibrium. After equilibrium is established, the chamber is disassembled, and the soil samples are oven dried to determine θ.

Hydraulic conductivity in unsaturated soils is determined from Ks, the value at saturation and the relative permeability kr, which is a function of capillary pressure head, volumetric water content or degree of water saturation. The relative permeability kr can be estimated from other soil properties or can be directly measured in the laboratory. Klute and Dirksen (1986) summarize several methods of unsaturated hydraulic conductivity in the laboratory. They report on steady state methods for a steady flow through a soil column with controlled pressure at both ends of the column. This technique is not practical for soils with low K because the flow rate cannot be measured accurately. Olson and Daniel (1986) report on transient tests where soil is placed in a pressure plate device, a step increase in air pressure is imposed, the rate of water flow out of the soil is measured versus time, and K is computed from the resulting data.

Hydraulic conductivity at saturation K_s is measured in the laboratory using rigid-wall permeameters and flexible-wall permeameters. Hydraulic conductivity tests may be performed with a constant head, falling head or constant flux (Olson and Daniel, 1986; Klute and Dirksen, 1986). Differences have been noted between laboratory determined values and those estimated from field tests. Olson and Daniel compared laboratory and field measured K_s values for 72 data sets involving clayey soils and found significant differences, since hydraulic conductivity tends to increase with increasing scale of measurement relating to structural features of the soil.

Capillary pressure head can be measured in an undisturbed soil sample in the laboratory or the measurement can be obtained in the field. In both cases, a tensiometer, consisting of a porous element inserted into the soil and a pressure sensing device at the surface, is often used. The tensiometer is initially saturated with a liquid and when brought into contact with the soil, and the soil will pull water out of the tensiometer creating a negative pressure, that can be measured (Charbeneau and Daniel, 1993). A tensiometer generally cannot read more negative than 0.9 bar due to problems of cavitation of water. Figure 9.5 depicts a tensiometer for field use.

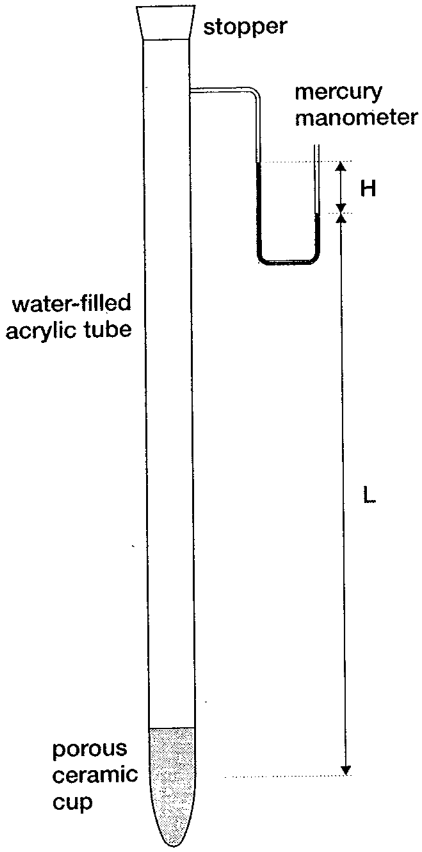

FIGURE 4.4.1 A soil water tensiometer

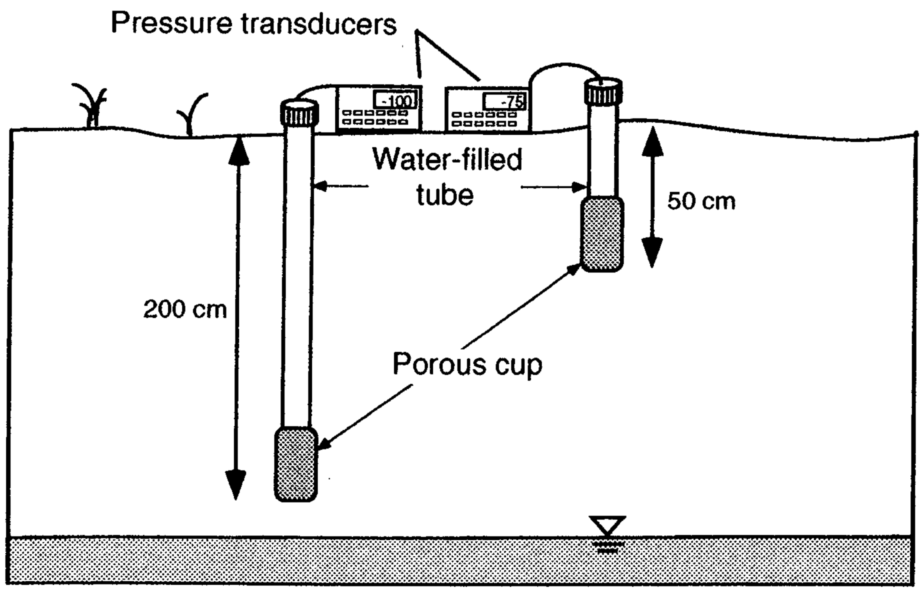

Figure 9.5 Two tensiometers used to determine the gradient of the soil-water potential.