A = cross sectional area (cm^2) of the soil core,
T = time (sec) required for the water to pass through the core,
dL = length (cm) of the soil core,
dH = head (cm) of the water imposed on the core.

Appendix B

Calculating Soil Porosity

In calculating total pore space or porosity, two weight measurements of soils, *particle density* and *bulk density*, must be known. By knowing these two variables, the total solid space makeup of a soil can be determined. From here, total solid space is subtracted from 100 to indicate *total pore space.*

% pore space = 100 - [(bulk density of a soil/particle density of the soil) x 100]

For example, if a sandy soil has a bulk density of 1.50 g/cm^3 and a particle density of 2.65 g/cm^3, then the pore (air and water) space will be 43.4%. A silt loam with 1.30 g/cm^3 bulk density and 2.65 g/cm^3 particle density possesses 50.9% pore space.

Next is determining what percentage of pore space is actually filled with water and what portion is filled with air. In order to determine this, two additional variables must be calculated. The first is the *water content of the soil* by weight. In other words, this determines the weight of water in a soil in relation to the total weight of the soil. A sample of soil is weighed, then completely dried and reweighed. The numbers are then inserted into the following equation:

Water content of a soil, by weight = (wet weight - dry weight) / dry weight

Next, the water content of a soil, by volume (often called the *volume metric water content* of a soil) is determined. This is simply found by multiplying the water content weight by the bulk density of the soil.

Water content of a soil, by volume = (water content, by weight) x bulk density

The total porosity (that portion which is filled with air and that portion filled with water) can now be calculated. Total porosity, as explained earlier, can be determined by several methods. Above, this was found using the equation:

Total soil porosity = 1 - (bulk density/particle density)

The portion of the total soil porosity filled by air (*aeration porosity*) is then simply determined by the following:

Air filled (aeration) porosity = total soil porosity - the volume metric water content of the soil.

Water filled porosity is then determined by simply subtracting air filled porosity from the total soil porosity.

The classical laboratory method of determining soil porosity involves measuring the water retention capacity of a saturated sample held at a tension of 40 cm at 15 atmospheres. Water removed by this tension is considered to be that which occupies non-capillary pore space and that retained is considered to occupy capillary pore space for a golf green. The calculations are as follows:

$$\text{Percent total porosity} = \frac{\text{saturated weight of soil (g) - oven dry weight (g)}}{\text{volume of soil (cm}^3\text{)}} \times 100$$

$$\text{Percent non-capillary porosity} = \frac{\text{saturated weight of soil (g) - weight with 40 cm tension (g)}}{\text{volume of soil (cm}^3\text{)}} \times 100$$

$$\text{Percent capillary porosity} = \frac{\text{weight with 40 cm tension - oven dry weight (g)}}{\text{volume of soil (cm}^3\text{)}} \times 100$$

Field capacity is traditionally determined by subjecting soil cores to a pressure of 1/3 atmospheres on a pressure plate apparatus. The water released at this tension is considered to be *gravitational water* (water pulled from a soil by the force of gravity). The *permanent wilting point* is determined by exposing the cores to 15 atmospheres (15 bars) tension of a pressure membrane extraction apparatus. Although 1/3 atmosphere and 15 atmospheres are accepted values for most soils, there is a debate that sands, by their nature, hold considerably less water and little available water is left at pressures greater than 1/3 atmospheres.

By determining the rooting depth of the turf, and knowing the evapo-transpiration rate, the amount of water available to the turf may be calculated. A water retention capacity between 12 and 25 percent by weight is desirable with an ideal capacity of 18 percent. This translates to the equivalent depth of water being 0.18 inch held per inch of soil. The equivalent depth of water is calculated as follows:

Equivalent depth of water = volume metric water content x the soil depth of the sample.