SOIL PERMEABILITY & CAPILLARITY

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ABSTRACT

Soils are permeable materials because of the existence of interconnected voids that allow the flow of fluids when a difference in energy head exists. A good knowledge of soil permeability is needed for estimating the quantity of seepage under dams and dewatering to facilitate underground construction. The purpose of this study is to firstly explain broadly soil permeability and highlight reasons it should be studied as civil engineers along with factors affecting it and how to conserve soil. Secondly, explain capillarity, highlight soils with greatest capillarity, and method to prevent loss of capillarity through evaporation.

INTRODUCTION

In soil mechanics and foundation, engineering, you must know how much water is flowing through a soil in unit time. Permeability is the capacity of soil to allow water pass through it. The ability of various soils and rocks to allow water to move up through them is capillarity. Capillarity is somewhat dependent upon a rocks porosity and permeability. The forces involved in capillarity are gravity pulling downward on the water, and attraction between water molecules and the molecules of the rock.

**SOIL PERMEABILITY**

Soil permeability is “the ease with which gases, liquids or plant roots penetrate or pass through a bulk mass of soil or a layer of soil” (Glossary of Soil Science Terms, 1997).

Permeability refers to the movement of air and water through the soil, which is important because it affects the supply of root-zone air, moisture, and nutrients available for plant uptake. A soil's permeability is determined by the relative rate of moisture and air movement through the most restrictive layer within the upper 40 inches of the effective root zone. Water and air rapidly permeate coarse soils with granular subsoils, which tend to be loose when moist and don't restrict water or air movement. Slow permeability is characteristic of a moderately fine subsoil with angular to sub-angular blocky structure. It is firm when moist and hard when dry. A soil with high porosity has high permeability. A soil with a smaller value of permeability is categorized as impervious.

Sandy or silty soils are considered ‘light’ soils because they are permeable, water-draining types of soils.

Soils that have lots of very small spaces are water-holding soils. For example, when clay is present in a soil, the soil is heavier, holds together more tightly, and holds water.

When a soil contains a mixture of grain sizes, the soil is called a loam.



*PERMEABLE SOIL*

IMPERMIABLE SOIL

When soil scientists want to precisely determine soil type, they measure the percentage of sand, silt, and clay. Soils with less than 50% clay are loams.

Need to Study Permeability

Permeability is one of the most important engineering properties of the soil that is a solution for a number of engineering problems encountered in construction. Some of them are:

1. Settlement of foundation and buildings
2. Seepage below the earth structures
3. Seepage through the earth structures
4. The Yield of the wells
5. Control of Hydraulic Stability of masses
6. For designing filter in hydraulic structures in order to prevent piping

**Which factors affect soil permeability?**

One harmful practice is removing the vegetation that helps to hold soil in place. Sometimes just walking or riding your bike over the same place will kill the grass that normally grows there. Land is also deliberately cleared or deforested for wood. The loose soils then may be carried away by wind or running water. In many areas of the world, the rate of soil erosion is many times greater than the rate at which it is forming. Soils can also be contaminated if too much salt accumulates in the soil or where pollutants sink into the ground.

 A good study of soil profiles provides an essential check on such measurements. Observations on soil texture, structure, consistency, color/mottling, layering, visible pores and depth to impermeable layers such as bedrock and clay pan form the basis for deciding if permeability measurements are likely to be representative.

**Soil Conservation**

There are many practices that can protect and preserve soil resources. Adding organic material to the soil in the form of plant or animal waste, such as compost or manure, increases the fertility of the soil and improves its ability to hold onto water and nutrients. Inorganic fertilizer can also temporarily increase the fertility of a soil and may be less expensive or time consuming, but it does not provide the same long-term improvements as organic materials. Agricultural practices such as rotating crops, alternating the types of crops planted in each row, and planting nutrient rich cover crops all help to keep soil more fertile as it is used season after season. Planting trees as windbreaks, plowing along contours of the field, or building terraces into steeper slopes will all help to hold soil in place. No-till or low-tillage farming helps to keep soil in place by disturbing the ground as little as possible when planting.

**Darcy’s Law and Coefficient of Permeability**

Darcy’s law studied the laminar flow of fluid in a homogeneous soil profile and demonstrated that the velocity of flow (v) is directly proportional to the hydraulic gradient (i). i.e.

**v =ki**

Where k is a constant called coefficient of permeability. This velocity of flow is also called as superficial velocity or discharge velocity.

If the discharge velocity (v) is known, the discharge (q) can be obtained as:

**q = vA = kiA**

Where ‘A’ is the cross-sectional area of soil including both the solids and voids.

When, the hydraulic gradient is equal to 1, k = v;

Hence, the coefficient of permeability can be defined as the velocity of flow occurring in the soil for a unit hydraulic gradient. The unit of coefficient of permeability is mm/sec or cm/sec or m/day.

**CAPILLARITY**

Capillary action is the same effect that causes porous materials, such as sponges, to soak up liquids. Capillarity is the primary force that enables the soil to retain water, as well as to regulate its movement. Capillarity is the primary force that enables the soil to retain water, as well as to regulate its movement.

 In addition to water retention, capillarity in soil also enables the upward and horizontal movement of water within the soil profile, as opposed to downward movement caused by gravity. This upward and horizontal movement occurs when lower soil layers have more moisture than the upper soil layers and is important because it may be absorbed by roots. The height to which the water rises is dependent upon pore size. As a result, the smaller the soil pores, the higher the capillary rise.



This picture shows how more water may be held between finer particles against the force of gravity, as compared to coarser particles. As a result, finer-textured soils have greater water holding capacities.

**Water holding capacity**

Since water is held within the pores of the soil, the water holding capacity depends on capillary action and the size of the pores that exist between soil particles. Clay soil has the highest capillarity, followed by loam and then sandy soil.

**How to prevent the loss of capillary water through evaporation**

The best technique to keep capillary "hang'' water in the soil, is to add a layer of loose surface soil. During the day, capillary water evaporates because of the sun's heat hitting the soil. At night, the soil is warmer than the air; and so, the water evaporates. The best way to stop this evaporation is by protecting the capillary column by putting a small layer of loose soil on top. 50 Years ago in Holland, when there was no irrigation, growers used an old technique to lose the top layer. This technique combined maintaining the humidity with weed control. The instrument they used for this purpose was the ‘roller scraper’.

CONCLUSION

Soil is a valuable resource that supports plant life, and water is an essential component of this system. By understanding some physical characteristics of the soil, you can better define the strengths and weaknesses of different soil types. Proper measurement/evaluation of soil permeability is required for calculating the seepage under hydraulic structures and water quantities during dewatering activities. Soil texture and composition, plus the amount of organic material in a soil, determine a soil’s qualities and fertility.

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