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SOIL PERMEABLITY AND CAPILARITY

Soil permeability

The permeability of a soil is the ability of water to move through it (permeate it). It depends on the physical and chemical properties of the soil, notably particle size distribution (the range of particle sizes present), pore space, pore size and the continuity of the spaces

Factors affecting permeability of soils

A number of factors affect the permeability of soils, from particle size, impurities in the water, void ratio, the degree of saturation, and adsorbed water, to entrapped air and organic material.

Particle Size

It was studied by Allen Hazen that the coefficient of permeability (k) of a soil is directly proportional to the square of the particle size (D). Thus permeability of coarse grained soil is very large as compared to that of fine grained soil. The permeability of coarse sand may be more than one million times as much that of clay.

Impurities in water

the presence of impurities in soil decreases the permeability of soil

Void ratio (e)
The coefficient of permeability varies with the void ratio as e/sup>/(1+e). For a given soil, the greater the void ratio, the higher the value of the coefficient of permeability. Here 'e' is the void ratio.

Based on other concepts it has been established that the permeability of a soil varies as e2 or e2/(1+e). Whatever may be the exact relationship, all soils have e versus log k plot as a straight line.

Degree of Saturation
If the soil is not fully saturated, it contains air pockets. The permeability is reduced due to the presence of air which causes a blockage to the passage of water . Consequently, the permeability of a partially saturated soil is considerably smaller than that of fully saturated soil. In fact, Darcy's Law is not strictly applicable to such soils.

Absorbed water
Fine grained soils have a layer of adsorbed water strongly attached to their surface. This adsorbed layer is not free

to move under gravity. It causes an obstruction to the flow of water in the pores and hence reduces the permeability of soils. According to Casagrande, it may be taken as the void ratio occupied by absorbed water and the permeability may be roughly assumed to be proportional to the square of the net voids ratio of (e - 0.1)

Entrapped air and organic matter
Air entrapped in the soil and organic matter block the passage of water through soil, hence permeability considerably decreases. In permeability tests, the sample of soil used should be fully saturated to avoid errors.

Soil 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

Water molecules behave in two ways:
Cohesion Force: Because of cohesion forces, water molecules are attracted to one another. Cohesion causes

water molecules to stick to one another and form water droplets.

Adhesion Force: This force is responsible for the attraction between water and solid surfaces. For example, a drop of water can stick to a glass surface as the result of adhesion.

Water also exhibits a property of surface tension:

Water surfaces behave in an unusual way because of cohesion. Since water molecules are more attracted to other water molecules as opposed to air particles, water surfaces behave like expandable films. This phenomenon is what makes it possible for certain insects to walk along water surfaces.

Capillary Action:

Capillary action, also referred to as capillary motion or capillarity, is a combination of cohesion/adhesion and surface tension forces.

Capillary action is demonstrated by the upward movement of water through a narrow tube against the force of gravity.

Capillary action occurs when the adhesive intermolecular forces between a liquid, such as water, and the solid surface of the tube are stronger than the cohesive intermolecular forces between water molecules.

As the result of capillarity, a concave meniscus (or curved, U-shaped surface) forms where the liquid is in contact with a vertical surface.
Capillary rise is the height to which the water rises within the tube, and decreases as the width of the tube increases. Thus, the narrower the tube, the water will rise to a greater height.
Capillary rise in tubes of varied widths.
Capillary rise in tubes of varied widths. This picture demonstrates the phenomenon of capillary rise. As you can see, the liquid rises to the greatest height in the narrowest tube (at far right), whereas capillary rise is lowest in the widest tube (at far left). Although easily demonstrated by simple experiments using tubes, capillary action occurs in soils. Smaller pores that exist in finely-textured soils have a greater capacity to hold and retain water than coarser soils with larger pores.

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.
The phenomenon of capillarity also occurs in the soil. In the same way that water moves upwards through a tube

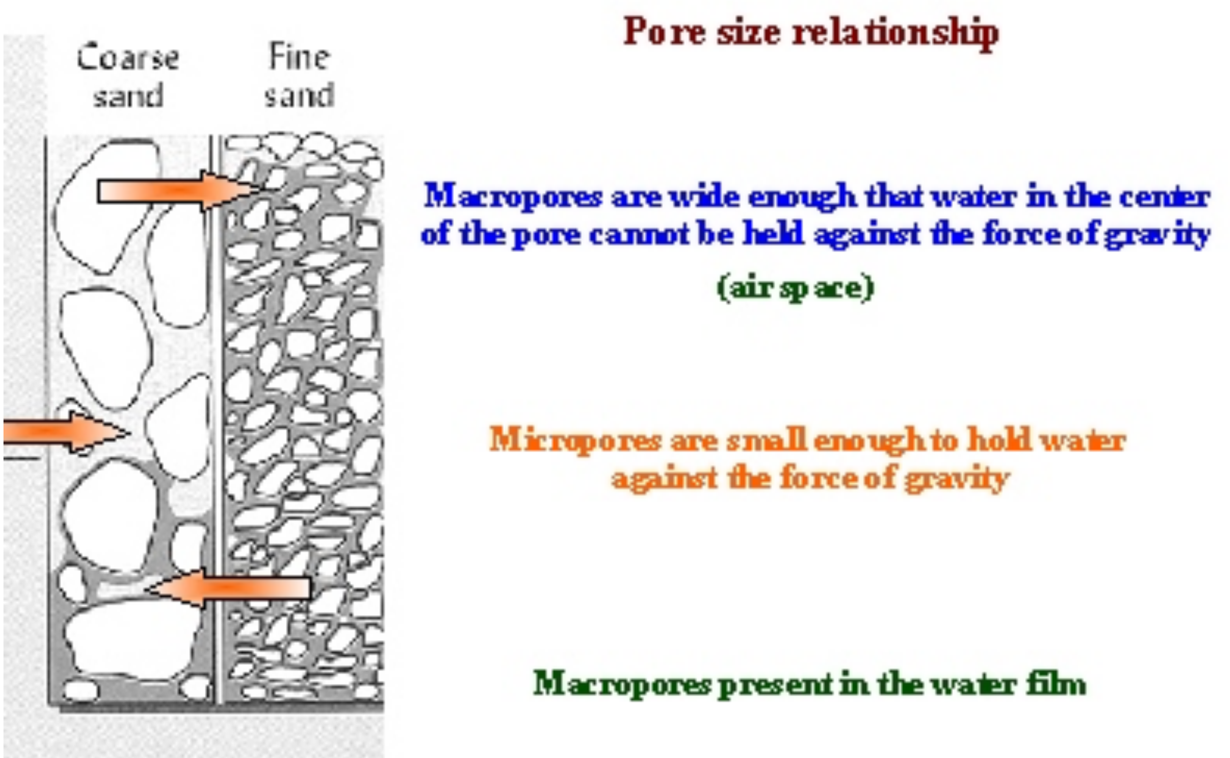
against the force of gravity; water moves upwards through soil pores, or the spaces between soil particles. The height to which the water rises is dependent upon pore size. As a result, the smaller the soil pores, the higher the capillary rise.

Finely-textured soils, like in Maui, typically have smaller pores than coarsely-textured soils. Therefore, finely-textured soils have a greater ability to hold and retain water in the soil in the inter-particle spaces. We refer to the pores between small clay particles as micropores. In contrast, the larger pore spacing between lager particles, such as sand, are called macropores.

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.

water retention in port spaces

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


Coarse sand
Fine sand
Pore size relationship
Macropores are wide enough that water in the center of the pore cannot be held against the force of gravity
(air space)
Micropores are small enough to hold water against the force of gravity
Macropores present in the water film