Principles of Water Movement

Sportsturf drainage systems exist in many forms and shapes, but all share one common trait. While some water can be evacuated by surface runoff, most must percolate through the rootzone to reach some form of underground drainage pipe system.

How fast and effectively this percolation can occur, and the amount of water which will remain available for the turf determines the drainage system's overall performance. All of this is dependent on the interaction between soil particles and water molecules.

Up, down, all around

Water movement in soil can be compared to that of water through a sponge. When a dry sponge comes into contact with water, we see a wet front moving. This front can move downwards, but it will also move sideways, or even up.

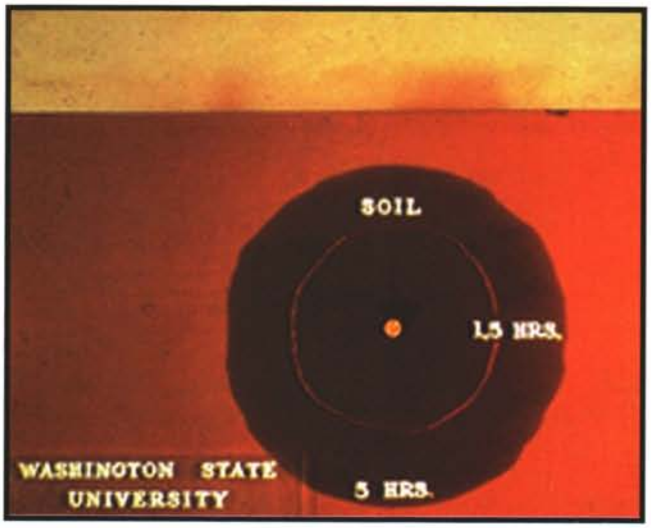
If a sponge is dunked into water and pulled back out, some water will flow out, but a certain amount will be held by the sponge. The forces holding water in the sponge are the same that cause the wet front to move through the dry sponge: capillarity and adsorption.

Water travels in soils exactly the same way. When water moves through a soil profile, water molecules attach themselves to individual soil particles by adsorption. This describes the attraction between dry surfaces and water molecules, and it's the same phenomena that explains why rain drops cling to a glass surface.

Once water molecules wet a particle, they seek another dry surface on which to cling. This movement from particle to particle is ensured by capillary forces, which bind water molecules together.

As the water front moves ahead, it pulls more water along with it. This is why we say that water is under negative pressure. The water doesn't push its way through the maze of pore spaces in the soil profile; it's pulled in by the combined adsorptive and capillary forces.

These forces cause the water front to move, but they also hold the water mass inside the soil. This attraction causes water molecules to move any which way there is a soil particle, independently of gravity.



Capillary and adsorptive forces combine to pull water through a soil profile in movements independent of gravity. *Courtesy: Lanco*

As water moves through the soil, the pores between soil particles gradually fill. Some water will freely escape the soil profile, having found its way through the bigger pores (≥0.06 mm in diameter).

As more water enters the system, all the pores become filled. Additional water has nowhere to go, so it starts to pour out of the soil profile. This is the actual drainage.

When the water supply is cut off, the larger pores empty out and drainage stops. Water caught in the smaller pores is held back by capillary forces, and it can be used by the turfgrass root system.

Compaction and water movement

In sports fields of every type of soil profile, the rootzone layer presents a certain pore structure. This unique combination of small, medium, and large pores determines the field's initial drainage capability.

The presence and arrangement of larger pores determines the soil's ability to drain freely. A soil composed of mainly fine particles will have few large pores. Water will be held captive, and poor drainage will result. On the other hand, a soil composed exclusively of large, coarse particles will drain freely, but will be incapable of retaining water necessary for plant growth.

Play and regular maintenance practices apply incessant pressure to the surface, which results in localized compaction. Compaction patterns are specific to each sport, but they're similar to the surface's wear patterns.

Pressure that's applied over and over will gradually pack soil particles together. This decreases the number of larger draining pores, and consequently decreases drainage performance.

Modern sports field design and construction increasingly integrates manufactured, compaction-resistant soil mixes. Combining medium- to fine-grade sands with organic matter and other materials, these soil mixes can withstand compaction while ensuring water retention compatible with turfgrass growth.

In a fine soil overlying a coarser, free-draining layer, water is held in, resulting in a perched water table. *Courtesy: Lanco*

Water retention and perched water table

Up to this point, the principles of water movement in homogenous soils are fairly easy to understand and visualize. Things get a little more complicated when we start laying one soil type over another, as is common in many sports field constructions.

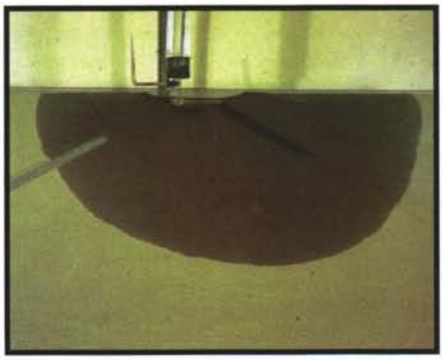
Let's get back to our sponge. After free-flowing water has stopped pouring out of the larger pores, you can pick up the sponge and it holds water. Put it down on a bed of gravel, coarse sand, or another material, and the water will remain in the sponge. Contact with a free-draining material will not induce water to flow out of the sponge.

The same is true with soils. Negative forces applied by the combination of adsorption and capillarity pull at water molecules and hold them captive. As particle and pore size decrease, these combined forces strengthen. If more water is added, it spreads through the profile and accumulates to the point of saturation.

If the soil profile overlies another which is coarser, water will accumulate in the finer soil until the weight of the water cannot be contained by the retentive forces and it starts flowing. This is called a perched water table.

This very common phenomenon is widely misunderstood. It's natural to assume that by placing a free-draining layer below a heavy soil, drainage will be induced from one layer to the other.

In fact, the exact opposite occurs. The greater the difference in particle size distribution between the two soils (granular discontinuity), the



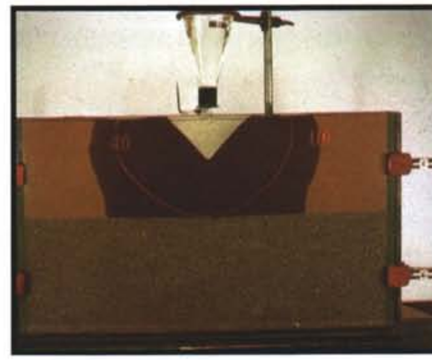
When water is allowed to flow freely into coarse material, it moves unimpeded. When it must cross from a fine material into a coarser one, it is held by negative forces.
Courtesy: Lanco

harder it is for water to cross over from one to the other.

This phenomenon will also occur when water tries to flow through a coarse material imbedded in a fine soil. The retentive forces keep water molecules captive in the fine soil, and perfectly dry coarse spots can be found in moist or wet soils. This can cause problems for drainage systems when water is supposed to flow from a fine soil into gravel or other material surrounding drainage pipe.

Water and soil stratification

Layers of fine material in an oth-



A fine soil layer can act as a barrier for water movement. *Courtesy: Lanco*

erwise well-draining soil can also have very disruptive effects on water movement. Water will have no difficulty crossing from coarse to fine material, but water movement is much slower in the fine soil.

Such a barrier affects the whole potential of a drainage system. Once the fine material is saturated and water flows through into the coarser soil, its percolation rate has been reduced to that of the finer layer.

This common situation may seem inconsequential, but it can greatly affect a field's performance and it can be very difficult to correct. Stratification can have many causes, but the most common are related to faulty maintenance practices.

Topdressing and turfgrass repairs can sometimes spread layers of fine materials, which over time develop into severe stratification problems. A 1/8-inch layer of fine soil is enough to block water flow in an otherwise perfect soil profile.

We sometimes see a succession of the layers, each further slowing the percolation process to the point where it can seem to stop.

Stratification is difficult to correct. Aeration and sand topdressing can help, but they must be done repeatedly to effectively correct the problem. Prevention is much easier and economical. ❑

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