DRAINAGE FOR ATHLETIC FIELDS

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Introduction

The amount, size, and continuity of the porosity of the soil control water movement through soil. Sufficient quantities of large diameter, stable, and continues macropores will ensure satisfactory infiltration of water, drainage, and aeration within the soil. But, small pores (micropores) are also needed within a soil to store water that can be extracted as plant available water. Therefore, both macro and micro pores are needed in a soil to produce the drainage and storage of water at the same time.

In soils with significant amounts of silt and clay, soil structure, or aggregation, naturally produces macropores. Unfortunately, soil structure can be degraded by compaction and a significant proportion of macropores in soil can be destroyed. Water movement rate is then greatly decreased many times causing wet and anaerobic conditions to persist. These conditions not only provide an unfavorable environment for root growth, but may also cause a reduction in soil strength. If play were to occur under such conditions, the field would likely deteriorate quickly and cause much damage to the soil that would be very difficult to remedy.

High sand content soils (low in silt and clay) naturally have a large proportion of macropores and a low proportion of micropores. Since the large pores of a high sand content soil are produced by the arrangement of the relatively larger sand grains and not reliant on natural soil structure and aggregation, they are stable and not prone to destruction with compaction. This is the main reason high sand content soils are chosen for high-input sports fields where the rootzone is totally replaced.

Not all sport complexes have the resources to significantly modify and/or replace the surface soil during construction. Many superintendents are faced with managing the native soil and doing the best job possible. Knowing and understanding what control water movement in soil and how to design systems to remove excess water as quickly as possible will improve the quality and safety of sports fields.

Water Movement in Soils

Soil water movement is important in the movement of water from the soil via evaporation and/or drainage, and from the soil into plant roots. It occurs as liquid flow in saturated soils, and as liquid and vapor flow in unsaturated soils.

In saturated flow all soil pores are filled with water and gravity is the driving force that causes water to move. The rate it can move is controlled by the size of the pores; water moves rapidly through larger pores and very slowly through small pores. Therefore, in saturated soils the largest amount of water is flowing through the larger pores. The rate which water drains from saturated soil is analogous to water flow from a water tank on a rooftop to a faucet in a house. The larger the pipe the more rapidly will water be able to flow from the tank to the faucet.

As a soil drains the first pores to empty are the largest pores and with subsequent drainage smaller and smaller pores become air-filled. The water that remains in the soil is then confined to smaller pores in the soil and water flow through an unsaturated soil is slower than through a saturated soil. As a soil becomes very dry the rate which water can flow can be more than one million times slower than through the same soil when saturated. When thinking about drainage, fortunately, the largest pores control the rate of water movement in the soil.

Types of Drainage Systems

Surface drainage is the collection and removal of water from the surface of the soil. Surface drainage is particularly important on soils with relatively low infiltration rates. By directing the water off a site before it can enter the soil decreases the problem of dealing with subsurface drainage. Very few sports fields are perfectly flat and most are sloped to encourage the runoff of excess surface water. Even high sand content sports fields are sloped to encourage surface and subsurface water flow.

Subsurface drainage is really nothing more than the installation of continuous very large pores in the soil. Generally, perforated plastic tubing is installed at some depth below the soil surface. That tubing is connected to some outlet system that excepts the water that flows into them and away from the soil or sports field. Their purpose is to remove excess water from the soil and allow the fields to be used even under wet conditions. Many different systems have been developed and used. Some of the more important used on sports fields are discussed below.

Slit Drainage Systems

Slit drainage systems (bypass systems) consist of vertical channels of highly permeable material connecting with the surface and passing through the surface soil. The slits usually connect with gravel backfill overlying a system of lateral pipe drains situated deeper in the soil profile, but they can connect with a permeable subsoil.

The most common type of installation involves excavated slit drains which are installed using a trencher or other cutting device where the spoil is removed and the trench filed in a separate operation either with sand or sand over gravel. Also injected slit drains are installed using a modified plow utilizing a cutting blade which forces the soil apart and fills the fissure in a single pass either with sand or sand and gravel.

Excavated slit drains are generally 2 to 3 inches wide and up to 14 inches deep with a large capacity for water transmission and as such are normally used where they provide the major route for water flow from the surface to a subsurface drainage system. Injected slit drains containing only sand are normally narrower and shallower than excavated slits and are often installed on a more intensive basis because they are not as efficient as excavated slit drains for transmission of water.

A number of products (waffle structures, fiber-wrapped honeycomb, etc) have been developed which are being placed in the bottom of excavated slit drains. One potential advantage of using such products is the need for traditional lateral pipe drains is removed since they function in that capacity. These slit drains usually need to be at a much closer spacing than conventional lateral pipe drains and more labor is required for installation.

Although there are many variations of slit drainage systems, the basic principle of operation is the same. In brief, the system permits an increase in water infiltration rate into the surface without the need for major reconstruction or amelioration of the native soil. This increase is achieved by allowing rainfall to flow across the surface until it enters a highly permeable slit drain which allows lateral transmission of water until an intersection with a pipe drain is reached.

Although slit drainage systems overcome the initial problem of the existing soil being physically unsuitable for rapid surface water removal, these systems do not improve the rootzone properties of the surface soil as the slits generally occupy no more than 5 % of the surface area. Conditions for turfgrass growth are improved only with respect to a general reduction in excess surface moisture. Slit drainage systems have often been considered as a technique for removing the symptoms of saturation rather than as a technique for curing the problem.

Sand/Silt Drainage Systems

In contrast to silt drainage systems, the purpose of these sand/soil systems is to provide and maintain a free-draining and well-aerated rootzone material despite the effects of compaction, instead of relying on a small amount of surface area for rainfall interception and removal. These systems can be constructed in a number of ways with some methods being specific to certain designs.

In general, the sand/soil drainage systems vary from where a predetermined quantity of sand is mixed with a specified or existing soil either on-site or off-site to produce the required rootzone mixture to a mixture prepared and brought in for the rootzone of a total profile reconstruction. However the surface soil is prepared, a subsurface drainage system underlies the rootzone to remove excess drainage water.

The success of these systems depends on the use of the correct sand/soil mixture. If too much silt and clay are in the mixture it would then be susceptible to a reduction in macro-porosity with compaction and anaerobic conditions could persist under wet conditions. If the correct mixture is used and with sensible management, the rootzone would be expected to withstand foot traffic, maintain drainage and yet retain an adequate supply of water for plant growth. The amount of fine particles that may be included in the mixture and maintain the above conditions is generally thought to be about 10 to 12 % by weight. Adams (1976) demonstrated that a sand/soil mixture should contain no more than 12 % particles less than .05 mm in diameter in order to maintain a drainage rate greater than about .5 inches per hour.

The main advantage of these kinds of systems is that, unlike the slit drainage systems, the entire rootzone can be expected to remove rainfall even after compaction has occurred. Inadequate mixing of the prescribed rootzone or poor designs has been the biggest problems with these kinds of systems. This points to the fact that very careful selection and testing of the rootzone mixture must be done before such a design should be built. But, if done correctly many years of successful play should be possible.

All Sand Drainage Systems

These systems are very similar to sand/soil drainage systems except for the rootzone mixture used. By omitting soil form the rootzone, the problems of incorrect mixing and segregation of the fine particles can be avoided. Many times peat or other organic soil amendments are added to increase nutrient and water retention and aid in turfgrass establishment and growth.

Although all sand drainage systems overcome the problem of saturated conditions, other problems are created. These problems are:

1. Plant available water retention is low and irrigation is essential. This can particularly be a problem at turfgrass establishment.
2. These rootzones have low cation exchange capacity and need to be carefully fertilized so nutrients are available and little fertilizer leaching occurs.
3. Disease and pest susceptibility is often increased in these rootzones because of the lack of beneficial microorganisms.
4. The surface can become unstable when the turf is thin or absent.

These problems can be overcome and the reward for skilful management is a high quality playing field.