Source and Cure of Course Drainage Problems

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FOR MANY YEARS I was intimately concerned with golf course drainage both as a golf course builder and as a technician of the USGA Green Section. I have had little to do with golf course problems during the past 11 years but have maintained contact with the utilization and control of water, including drainage, in my work with the USDA Soil Conservation Service.

I have investigated the recent developments in golf course drainage and the present thinking of those engaged in fine turf maintainance. I was impressed with the fact that the same questions concerning moisture supply and drainage in putting greens are being raised today as were 10 years ago and that there appears to be an absence of any new data bearing on this subject. This situation while indicating the need for further investigation in this field also gives me more assurance in discussing it.

It would seem that a review of some of the accepted data on drainage, a little theorizing on what we are after, and what use we can make of the facts at hand may be helpful to some and will at least stimulate constructive thinking. My remarks will mostly concern putting greens. Drainage problems on other parts of the golf course are present but are less specialized.

Water and Air Balance

We should bear in mind that we must maintain a correct balance in the soil between water and air for plant growth. Plants need water which they get through their roots; they also need oxygen at their roots or they will die. The optimum condition is where the soil particles are surrounded by a thick layer of water with air filling the voids between the moisture-coated particles. Therefore our first requirement is to build a soil sufficiently porous to allow water to infiltrate the soil and at the same time to allow the surplus water to drain away quickly either naturally or by artificial aids.

If we do not have sufficient drainage, natural or artificial, we are faced with several results all of which will be disastrous under various conditions.

If puddles remain on the surface of the greens after a heavy rain the greens cannot be played. If the soil remains saturated with water during cold weather the soil will heave, breaking many of the fine roots and as a result the sod will dry and kill at the next warm dry spell. This killing on greens should be differentiated from killing resulting from disease. If the soil remains too moist near the surface during hot weather the humidity created at the surface provides an optimum condition for fungus and other turf diseases. In any event under poor drainage the turf soon becomes weakened by lack of oxygen and certain plant nutrients which depend upon the presence of sufficient oxygen at the roots for their availability.

Possibly just as important, is the effect of the trampling by players and others on saturated soil. First the depressions left by heelmarks make the putting surface uneven and secondly the desirable soil structure, or loose arrangement of soil particles that leaves voids between the particles for moisture and air, is destroyed. Trampling a plastic soil, one with sufficient clay or silt in it to make it act like putty when wet, will compress it to a point where it is dense and compact and contains little pore space. Puddled or compacted soil will not support plant growth under extreme putting green conditions and will dry almost as hard as a pavement. Then the players will yell because they cannot hold a ball on the green.

Movement of Moisture in Soil

Before exploring for the answer to the problems created by these factors we should all have a clearer understanding of the movement of moisture in the soil. If you will examine the accompanying sketch you will see a cross section of soil which is typical of most putting greens. In other words you see the prepared top soil area underlayed with a compact soil, which is usually clay or silt that was used as fill in building up the green. The two types of water we are concerned with are illustrated. The dark areas that fill the voids between the particles are free or gravitational water. It will drain away by gravity if the subsoil is sufficiently porous or if there is tiling. But as it drains away it will suck air into the voids or pore spaces between the soil particles and will also leave each soil particle coated with a layer of water. This water is held to the particles by surface tension and is called capillary moisture.

Everyone knows the action of free or

gravitational water; the only impediment to it running from the soil by gravity is the interference of the soil particles. So if we have a porous subsoil or tile openings gravity will force it through these and away from the top soil. But fewer are aware of the action and value of capillary moisture. First we should realize that generally speaking it is the only type of moisture that plants use. It clings to each soil particle against the pull of gravity after the free water drains away and is unaffected by drainage up to this point. As the surface soil dries, however, it will be affected by the water table or level of free water in the soil which in turn is affected by drainage. This angle will be discussed later.

As the plants draw upon the capillary water coating the soil particles and as evaporation takes place from the surface, the layers of capillary water become thinner at the point where the water is being drawn from. But nature always seeks an equilibrium, so as the layers of capillary water become thin and the soil becomes drier at one point the capillary water moves from moist areas where the capillary layers are thick to drier areas until the layers are of equal thickness.

Four Factors in Drainage

From the above it would seem that we are concerned with several important factors.

1. Surface drainage.
2. Good porous soil structure.
3. Non plastic surface soil.
4. Adequate sub-surface drainage.

Surface drainage may be readily cared for by the shaping of the surface of the green. Most golf course architects feel that a 3% slope is the maximum grade that should be allowed on the main putting area, although more grade may be allowed around the edges or even through the green when changing from one putting level to another. With these possibilities there is plenty of latitude for adequate surface drainage. It is better not to drain all the water onto the approach of the green to avoid over-wet conditions on this important area. Greens can usually be graded so that some of the surface water can be drained to one or both sides.

Obtaining good soil structure is a more difficult task. It is not enough to find a good brown or black topsoil which seems to be open and porous under natural conditions. When some naturally porous soils are used on a putting green, they may soon lose their porosity and become compact and hard through frequent trampling when wet.

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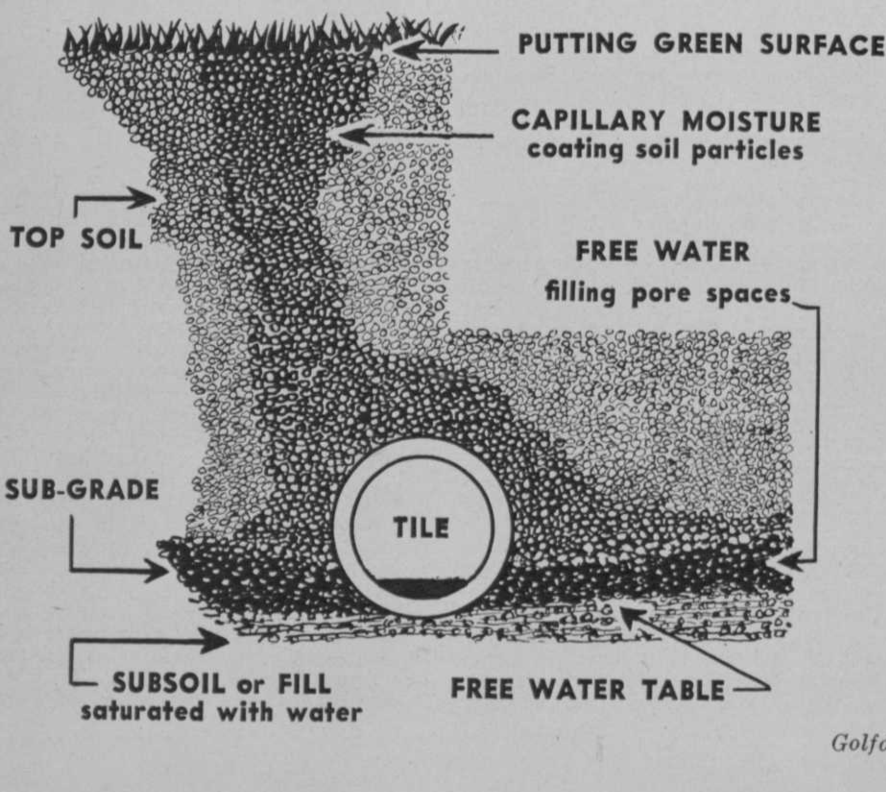
CROSS-SECTION OF PUTTING GREEN

Illustrative only—not drawn to scale



GOLF COURSE BUDGET
(year)

LABOR:	*Estimate*	*Actual (year)*	*Actual (previous year)*	
January	xx	to be	xx	
February	xx	filled	xx	
March	xx	in	xx	
April	xx	month	xx	
May	xx	by	xx	
June	xx	month	xx	
July	xx	for	xx	
August	xx	com-	xx	
September	xx	parison	xx	
October	xx	with	xx	
November	xx	estimate	xx	
December	xx		xx	
Total	xx			xxxx.xx
SEED:				
Lbs. Blue grass	xx			
Lbs. Fescue	xx			
Lbs. Bent	xx			
Lbs. Red Top	xx			
Lbs. Others	xx			
Total	xx			xxxx.xx
FERTILIZER:				
Tons Fairway	xx			
Tons Tees	xx			
Tons Greens	xx			
Tons Rough	xx			
Tons Miscellaneous	xx			
Total	xx			xxxx.xx
CHEMICALS:				
Amt. Fungicide	xx			
Amt. Insecticide	xx			
Amt. Weed Chemical	xx			
Amt. Others	xx			
Total	xx			xxxx.xx
SMALL TOOLS AND REPAIRS				xxx.xx
GAS & OIL				xxx.xx
WATER				xxx.xx
ELECTRICITY				xxx.xx
			TOTAL	xxxx.xx

Drainage Problems

(*Continued from Page* 22)

Proper Soil Structure

Most soils when dry, and especially under sod, will bear the weight of a person or of greens equipment without leaving a permanent impression. This means that the soil structure is not broken down and the pore spaces remain. But clay or silt particles become plastic and putty-like when wet and tend to flow together and fill in the pore spaces when put under added pressure. If the soil has a high enough proportion of clay and silt it will not readily assume its previous structure after being compressed. After such a soil becomes wet and compressed by play from time to time it finally loses its porous structure entirely and dries as a compact hard mass. The comparatively large non-plastic particles in sandy soils will not fit tightly together and thus these soils retain their pore space. Organic matter will compress but as it dries will again assume its porous nature; therefore, we must reduce the percentage of plastic clay and silt particles and increase the percentage of sand and organic particles in the surface soil of the putting green.

The topsoil should be tested to learn its reaction to putting green conditions before being prepared on, or for, the surface.

A simple mechanical test to aid in finding a suitable soil is described in detail in one of the old Green Section bulletins. Briefly, it consists of mixing water with a sifted sample of soil until it is like a mix of mortar. If you have it in a pail, the moisture content is about right when you can draw a line across the surface with your finger and the line will still be visible after you have gently jarred the bottom of the pail against the floor a couple of times. Then trowel the mud into a container, a cigar box is OK, and allow it to dry thoroughly throughout. Make the brick about 1¼ inches thick. If the soil is suitable for putting greens a man of average strength will be able to crumble it between his thumb and forefinger. If he can't crumble it this way then it is too plastic and needs to be mixed with sand and organic matter to reduce the percentage of clay and silt (plastic materials) in the sample.

In this connection, raw organic matter, such as peat, is more effective than sand. We want a high percentage of fine organic matter in the soil for ideal plant growth but too much may create a problem.

Organic matter absorbs moisture readily and under dry conditions will rob the soil particles of moisture; some of the moisture absorbed by the organic particles will be held from the roots. Coarse organic matter in particular, will create an open, porous, well-ventilated soil which dries quickly except for the moisture held within the organic particles. Hence in dry periods the soil at the root zone may actually contain less available moisture for plants than if it had less organic matter. Also too much organic matter may create a very spongy putting surface when wet.

Some soils become even more compact with a slight amount of sand. You will have to experiment with the materials at hand, but I feel that a fairly safe rule is to first add ⅛ by volume of peat, then add ⅛ by volume of sand and continue in this way until you have overcome the extreme plasticity. You will probably mix four samples. 1. Add ⅛ peat. 2. Add ⅛ peat and ⅛ sand. 3. Add ¼ peat and ⅛ sand. 4. Add ¼ peat and ¼ sand. One of these will feel just right and it is improbable you will have to go beyond the fourth sample even with anything but the stickiest of clays, if you are unfortunate to have nothing better for a base.

Topdressing Trouble

Having discovered a suitable, natural

or an artificial mixture, we should build the surface of the green with this to a depth of at least 4 inches and then continue to use the same material as topdressing. It is in this connection that many greenkeepers get into trouble. The surface soil is poor so they start to remedy the situation by applying so called corrective topdressings of such materials as coarse sand, pure organic materials and even fine cinders. These materials are extremely different in structure to the soil below and in time become buried by successive application until the layer of open and coarse material is at the root zone. Trouble then starts due to the effect of this material on capillary moisture. Capillarity works uninterrupted through soil of uniform structure but it is a fact that has been frequently observed that if you change the soil structure at or near the limits of capillary movement the rise of water will abruptly cease and we find a dry layer buried in the soil. The roots then tend to stop at the dry layer and depend solely on the moisture in the relatively thin surface layer. This means that we have to maintain an extremely shallow-rooted turf which requires almost constant watering and feeding. Also in building greens the practice of laying down a sand or peat layer in the green serves no good purpose and if it happens to be near enough to the surface will act either to keep the surface unnaturally dry or wet depending upon the material and the rainfall or watering.

The topsoil of a green should therefore be blended into the sub-soil. This can be done in building a green but in correcting an old green we are faced with some difficulties. If the soil is particularly tight and hard I would recommend removing the sod (cut as thin as possible) and plowing and disking in the correct amounts of sand and organic matter that have been discovered by test.

But if the green has not got to such a bad condition then the surface should be raked and cut closely and as much of the prepared soil as possible incorporated by rubbing it into holes or cuts made with forks or other equipment now available to golf courses. Then start building up the surface with continued application of the correct soil mix.

Tiling Layout

The remaining question now is as to the depth and spacing of tile in a green. In deciding this we should keep in mind the points we have examined previously. We want to get rid of excess water quickly and we want to maintain a supply of capillary moisture. We have taken care of the soil structure and now comes the question of height of the free water table. Actually turf on putting greens depends upon comparatively shallow root system because of the extremely close cut. So if we allow 6 to 8 inches of desirable soil condition as an area for root growth we are probably safe. We should therefore strive to keep the free water table as close to the bottom of this area as possible. This means keeping the tile comparatively shallow, and so we will not have wet spots between the tile, the tile should be laid at a comparatively close interval.

In deciding this we have some data available mostly from the researches of the highway engineers. The data indicates that capillary water will rise about 5.5 inches in 1 day in peat, 11.5 inches in fine sand, 20 inches in silt and somewhat higher in most clays. At this point I wish we had some specific data applicable to putting green soil conditions. But failing this we will have to depend upon judgment. I'll hazard a guess that since our ideal putting green soils are made up of a mixture of these materials we can get along fairly well on the average of these until we will have to depend upon judgment. at about 15 inches. Therefore I would place the bottom of the tile about that depth in the soil and space them as close as 10 feet apart, depending somewhat on the surface character of the green, or in other words spacing them that close where the surface water naturally concentrates and wider on the higher and more sloping areas.

A 4 inch tile is large enough under these conditions and I would use this size chiefly to allow more depth of soil over the tile itself. A grade of a few inches in 100 feet is sufficient and there is no need to set the tile in cinders or gravel under these circumstances, although it is better to pack and cover the tile with the topsoil to improve drainage to the tile lines. Some people like to put a thin layer of straw, cinders or gravel around the tile to keep sand and silt from getting into the tile before the soil has set. This practice is usually OK providing you keep this material well below the root zone so as not to create a super dry area immediately over the tile. As the purpose of a layer of this kind is to keep large quantities of soil from getting into the tile until the soil has settled, a fill of 1 or 2 inches over the tile in the trench is usually sufficient.