SOIL WATER MOVEMENT

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Land and Water Management

The Golf Course provides a microcosm of all the various conditions which are connected with the soil, including the principles of how water moves in the soil. On an average course you have an example of each of these conditions. When I am talking about the soil, I mean the soil profile, the soil in depth.

The Chairman has already mentioned two points that I wanted to pick on about how important it is going to be for us in the future to pay full attention to principles and I do not think we have always done so in the past. Firstly, he tells us that 500 courses are needed; 40 are being built. With the pressure on planning that there is to-day, it is inevitable that a large proportion of those courses will be on soils which are not ideal for the purpose. This is where a very thorough knowledge of how to manage those soils, how to improve the water management situation, is a vital prerequisite for a successful course as well as for a pleasant game. The second point from your introduction, Mr. Chairman, which I should like to pick on, is the question of maintenance. There is a lot of expertise available at present (some of it sitting in this hall) on how one can apply remedial action to the soil, so that the management of turf grass becomes simplified and the Greenkeeper's task facilitated. Maintenance, aeration of the fairways and greens can be improved a great deal and it is going to be essential in my view, to so simplify the task of those looking after a golf course, that they can attend to more routine duties. The system overall must achieve better results. I shall now try and point out some of the principles.

First of all, a golf course, when you are speaking of greens and fairways, or for that matter any turfgrass, is affected in the same way as most other land in the country except we find modified water situations to our advantage. Our problem is the balance between the various quantities of water arriving at and leaving the site, the principal one of these being rainfall. It should be remembered that up to 2/3 of the rainfall arriving at the surface of the ground can be lost by evaporation in the course of a season. Slightly less evaporation takes place on the Western side of Britain, but in general only 1/3 of the rainfall has to be drained away.

It is rather like opening a current account in a bank. You open the account—that is the rainfall. Your wife has a cheque book and you look at the account at the end of the month and you find it has gone down. She has evaporated some of it and you don't get the benefit. The rest of it either passes into the plant system which is a vital part of the operation or passes into the ground which is a seasonal measure. It is taken into soil storage, and that storage goes on opening the top soil and the sub-soil. Later on some water may move away through seepage and work its way out of the system.

Now some water is unable to penetrate fast enough. That water is held up on the surface of the ground and will cause trouble by ponding. This is due to the fact that the infiltration rate which the ground is capable of withstanding is less than the arrival rate of rainfall. It is just the ratio of the two speeds. Clay soils, as you know, particularly when they have been heavily trafficked over, become less and less permeable. It is a useful thing to know that clay soils may have a permeability, (without relying on the soil structure—the cracks and crannies—or any artificial means such as sand slitting), one ten thousandth of the permeability of a well-constructed green.

This is the basic situation. You have rainfall arriving, evaporating—leaving, and some water penetrating. The question of how much depends on the soil and this is where the first stage of remedial action comes in. If you are not able to remove the water through the sub-soil naturally, and of course, many golf courses have this natural drainage in the form of chalk, then you have got to put in a drainage system. The real purpose of this is to modify the balance of the quantities of water arriving and departing and to create a new quantity. This will prevent the water table building up. This is satisfactory so long as the water can actually penetrate. There are charts to tell us how high the water table will rise above the drains in relation to the permeability of the soil and the distance between the drains.

That is the first instrument of modification which is an essential one but it is not the only one that may be needed. You can get the situation where the surface of the soil requires a modification to allow water to enter quickly and so prevent considerable damage by poaching. Now the underdrainage situation with the water table is all laid down in calculations. You can modify it by putting gravel bands over the drains and so on; you can modify it by sub-soiling to improve permeability. We do not however, have a fully satisfactory method of calculation for removing water off the surface of the ground. It is not amenable at present to a proper calculation. One extreme of surface water drainage is ground covered with tarmac, like a carpark. What rate will the water have to be removed from that ? There is no penetration at all, hardly any kind of evaporation. It has all got to run off by the surface and that rate is about 1″ a day on average—one inch a day has to be taken off otherwise you are in serious trouble.

Now soils are not so severe situations as that, but we have got these arbitrary figures, one inch of water per day, the equivalent of one inch of rainfall coming onto the surface of the ground. Water which cannot penetrate has to be removed by surface drainage. In a peaty or sandy soil it may be a much lower figure, say 1/4″ a day or even zero. But there are these arbitrary amounts which you have to cater for. Now, what has happened in more recent times is that instead of having to rely on the underdrainage with some sort of assistance to water penetration, there is now an instrument whereby one can insert vertical bands of sand at intervals through the top soil, which does enable one to achieve a new path for the water. When this rainfall arrives and you know it is not going to be evaporated off quickly enough and you don't want it hanging around, you can cut away about 3/4 or even 9/10 of that rainfall within a matter of a few seconds and you remove it from the surface of the ground. With the balance of the water totally upset, in your favour, you have then a much more favourable soil situation in which to deal with the tiny 1/8th part that is left. We have in fact got a very good basis for calculating this surface water removal operation. The sand slit itself is amenable to the same sort of calculating approach that one can apply to the underdrainage situation. It is almost the same theory used again, the sand slits 10″ deep 5/8″ wide are emptied of water at intervals by connecting with tile or plastic drains, or by being connected with, in the case of a green, a total blanket of clinker or ashes which would be 9 or 10 inches below the surface. Calculations must ensure that the height to which the water rises in the sand slit while the water is passing through to the drain, does not get more than 2 or 3 inches from the base of it. The way in which we calculate the entry of water through a sand slit is to assume that all the in-between soil has zero permeability, like tarmac. That is, all the water must go through the sand which it does, by removing a foot, or even less than a foot naturally to the sand which is a permanent indestructible passage for the water, unlike spiking and other methods of aeration. There are tables to help with different sands of varying permeability, which are measured in the laboratory, and for different climatic situations like a heavy rainfall area or a light rainfall area. The tables indicate what spacing is required between the sand slits to achieve water removal at the rate we want. There is a different theory for the conditions where you have a total blanket of ashes underneath, as opposed to only having them at intervals, between the places where the water can drain through. Most sands are not graded by Zone 2 or or Zone 4 for this purpose, but are measured for hydraulic conductivity or permeability. We are then able to cope with any situation with sand slits 1. 2 or 4 feet apart almost regardless of sand type, although we naturally prefer the better ones.

Where you have the situation where water has to move laterally along the sand, then one has to be fairly careful and we will only allow the use of sand of a better permeability on a fairway or green, because of the need to remove water laterally. Drought resistance by some golf courses is exceptionally good. We have seen some of it this year. Water can move upwards and that is one reason for not in some cases, putting a full ash blanket in what you might think to be a badly drained zone, simply because in fact, it prevents water moving upwards in times of drought. Now one can show examples of the amount of water stored in the soil from ground level down to about 3 ft. on differing sites at the same date. Each site will show different percentages of of moisture, which are stored at this particular time. Cowbit Wash is a good example of a silt soil where some water is retained in the upper part but is much more saturated at, say, 2 feet deep. Another situation is where you have far too much water stored in the upper part of soil and then you would not be able to get a satisfactory turf. Now in a year, one can add up the quantities of rainfall on any particular site and you can account for all those other quantities that I mentioned, seepage, drainage, storage and you can build up a picture of a normal site, a wet site and a droughty site. A very typical situation is where a large quantity of water is removed from drainage during the winter and in summer all that stored water is given up and helps to keep the plants going without artificial watering.

A word on water supply. Some people go to great lengths. I mean the Moors built canals to keep themselves going. There are easier ways these days, pop-up water systems where one simply presses a button and the water comes. Now we are modifying water on the surface of the ground to make up a deficit as opposed to draining. I would like to draw your attention to a new piece of equipment which is now available on the market. A moving boom machine covering a width of 400 ft. could water two fairways in a day with only one hour's work on the part of the groundsman. It travels up the middle of the fairway at night when, presumably, golfers are not so active as in the day, following an underground wire which is very easily installed.

Question Time

Q. You spoke of the selected sands which you used in the slits. What are the gradations that you recommend ?

A. The gradations that we recommend don't, in fact, fit in with any of the existing types of zone, because we are primarily interested in one quality only, which the zone sands are not, in themselves, meant to fulfil.

We are interested in the hydraulic conductivity of the material, and we have found a wide range of sands which fulfil these conditions. We do have a measurement, in fact, which determines and gives each sand a figure. You can take a zone 2 or zone 4 sand, and they don't always have this high hydraulic conductivity, whereas a finer sand might have. Therefore, the people who have been doing this generally carry out a test with any sand with which they are unfamiliar, in order to make sure that they do get the right figure. What you are trying to achieve, in fact, under conditions in Britain, is certain minimum rates of water removal through the sand, and based on a 2 ft. spacing between sand slits which would be 5/8″ wide. We would say a good sand should be capable of taking between 5 and 15 inches of water off the surface of the ground per day. So we allow for the width of a sand slit and an interval between the slits to achieve that, and we finish up with a figure for the hydraulic conductivity of the sand, which is equivalent to that 5—15 inches. There are plenty of situations on the other hand, particularly where you are draining to a free draining layer, or to a naturally free-draining soil, where you have bad soil on top and the water can't get through. But with the moderately good soil underneath here a lower figure for conductivity is acceptable. It would be in the region of 2—5 inches per day and that is a lot of rain. We do not often get even 2″ a day, and that is a design figure. As Engineers we specify for a course, particularly on a fairway, even more so on the greens, and we work to that by doing this test on the sand. I am afraid I cannot give it to you in fraction sizes, because there is an infinite number of combinations.

Q. Are most of those Loess sands ?

A. Well, loess sand is particularly good because loess sand for the benefit of anybody who hasn't come across it, is a wind blown sand which is such as you would find round Thetford, the nearest place to here, but there are plenty of other deposits in Britain. A wind blown sand sorts itself out because the bigger particles go a short way and the smaller particles can go up to 150 miles. Therefore, we find a big zone with single small range particle sizes, and that is rather good. But it is not the only type you can use; a clean silt loam would do very well.

Q. How long can we expect a 5″ wide slit filled with your sand to remain intact and not contaminated ?

A. There is no evidence we have so far that this sand slit does in fact get any encroachment or illuviation from soil, but I would not rule it out as a possibility. A number of grounds one would perhaps sand slit 4 ft. apart and achieve a big measure of impro-

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vement but one could have a second go-through at 2 ft. apart. This isn't because we have experienced failures or evidence of encroachment. I would, in fact, say the opposite is the case. We cannot find any evidence of encroachment. The 5/8″ width is tremendously tolerant of what is actually needed. We are letting through vastly greater quantities of water than are actually needed to be passed, and there is no evidence of soil encroachment, physical movement in, or alluviation, which is washing in by water.

Q. We find that when we make slit trenches in the United States any cultivation of the soil, or covering over the slit trench itself with dirt, actually seals off the sand layer, or the pea gravel layers that we use predominantly, and this makes the slit itself useless in a short period of time. Do you find that true?

A. Yes, it is absolutely true. As little as 1/4″ or an 1/8″ of the wrong sort of soil—it often comes in with turf or some sort of traffic which has moved over the ground—can be enough to seal it. But there is no need to have any soil on top of the sand slit because the mechanism is that the turf grows into the sand and bridges over the top in a matter of weeks, you won't see the band and there is no need to add soil or do anything—it is damaging, and not necessary.

Q. Dr. Ede, Have you done any research into the long-term effectiveness of PVC drains as opposed to tile drains? I'm thinking particularly of the silting up of the small slits in the PVC drains and to combat that I have always used porous fill above PVC drains.

A. The answer to the first part of the question—yes, I have done research. We did have PVC drains introduced to the country which passed various tests we set up in relation to field trials. We specified a formula for these PVC drains that means they do not require any special treatment, because the widths of the slits and the size of the perforations of PVC drains, and this is unique to a factory product, are built into the product before they leave the works, and there is a British Standard now emerging from the provisional standard which we had six years ago. You need a surround of gravel or clinker on drains but not for the reason which you put forward. It is to do with the particular soil profile that you are working in, and there are at least three, or possibly more, different situations where you need it. One is to prevent hydraulic resistance in the soil near the drains so you keep soil further back.

The second one is to act as a filter, which is a different matter in fine sandy soils where you need a surround to keep the sand from flowing towards the drain. The third, and by far the most common one, is to put a band of permeable material above the drain and extending up as far as needed. I cannot tell you more than that but it is anywhere from ground level to say 10 or 12 inches below so that you provide a path for the water that cannot be destroyed. That path has to connect with something, it may be connecting with more permeable top-soil, it may be connecting with an ash or clinker blanket, or it may be connecting with a periodic operation on your part by means of an aeration tool which achieves temporary conductivity for water through the upper layers, but it must be there to conduct water down from whatever layer in which you have got the water available and freely moving, even if you have to make that layer yourself.

Q. Dr. Ede, What is the most common type of tile being used in Britain right now ? Is it still the clay tile ?

A. The position on Sports fields, I was saying, is that it is about 50/50 in the usage. That is between PVC of either the corrugated type that is coilable, or the more rigid type which is straight tube. About 50/50 with tile drains. A good drain makes no difference, as long as the design is correct, whether it is one or the other. There are a few situations where you have to choose between one or the other for special reasons, but in general, it makes no difference. Over the country as a whole, it is doubtful whether the PVC market has penetrated further than 15% but in certain areas, for instance in Scotland, where it is obviously not very convenient carting tiles over difficult ground, the penetration is over 50% and there is no difference in the effectiveness when properly used.

Q. Do you think there is any future in wetting agents for improving hydraulic conductivity ?

A. I do not think a wetting agent, straight, is going to be of consequence but there are various admixtures, more of the physical type. It is a physical, biological activity to improve soil conductivity. It is not just the stuff you put in but the fact that the root growth is improved, worms become more active and they help conductivity. Other biological actions come into play often as a result of an admixture. We are testing quite a number of different substances in addition to purely physical compositions of profile, so that you make up a soil or a profile to your own specification on an engineering basis.

Q. Thinking of sand slits on a putting surface, will it not affect the texture and growth on the putting surface during periods of perhaps, dry weather. Will these slits be more obvious than at other times ?

A. To deal with the dry weather aspect first, once the turf has grown across the sand and it only has to go in a matter of 1/4″ so it isn't a very big bridging it has to do, we generally get a stronger growth of turf, perceptible to the eye rather than to the lawnmower along that line. The reason is that the turf there has got deeper roots than in the soil on either side. Therefore, once that turf is established on the sand slit it does not become more droughty, for instance, than the turf either side because of the deeper rooted system.

Secondly, the sand slitting equipment that is available; it works on a vibrating basis in the main, has different widths of blade that you can use, and the compromise that one always has to make is between achieving a whacking great slit and a very narrow one, but one generally tends to err on the larger side to be safe. In fact, in the case of a putting green you want an extremely narrow slit, in order to get minimum soil disturbance. Each sand-slitting blade has a spring-loaded roller, which presses down the immediate disturbance it caused. You might in the case of a putting green have to do some remedial action as well, to get it quite plane but I think a putting green is something similar to a hockey pitch. The job is acceptable on a hockey pitch virtually as it is done, provided you have got the right width of blade, and generally if you need a narrower blade, all you have to do is to put the same quantity of sand in a greater number of slits; disturbance is minimized and the greenkeeper has then very little to do.

Q. Dr. Ede. Don't you think that as soon as you start top dressing your greens, you are starting to eliminate your slits on a putting surface? We have a regular programme in the States which I presume you have in this country, of top dressing greens, perhaps twice a year. This would seal off that tiny slit, wouldn't it?

A. I think there is a lot of scope for getting the right top dressing and the question is, we don't always keep doing the same things year in year out without question. We have a new instrument of attack on a severe problem which arises on very many courses, and we may need to take a second look at our existing practices and modify them. A little less Kettering silt perhaps.

Mr. McPartlin thanked Dr. Ede on behalf of the Panel and Audience for his excellent paper and the interest it provoked.

Charles Bramall, Chairman Flymo Group of Companies, watched by a group including the Lord Mayor of Sheffield Ald. S. K. Arnold, plants a tree at a Conference at Sheffield to mark the 10th Anniversary of the Flymo Hovermower. Third from left is Henry Gillespie, Sheffield Branch Secretary BGGA.