design and use of irrigation systems

Having a proper irrigation system is a simple necessity, but understanding how to plan and employ it effectively is highly complex.

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The planning and installation of a golf course water system involves a seemingly unending series of compromises between the ultimate in effectiveness and efficiency and economic feasibility. The questions that must be reconciled are sufficient to disturb the equanimity of even an experienced and competent designer.

At the outset, we must define the ultimate irrigation system and decide how much deviation from the ideal may be tolerated. "Field capacity" is the term applied to that moisture condition where soil holds as much water as it is capable of holding by capillary attraction. All the excess moisture which can be drained away by gravity has been removed.

A good soil, at this moisture level, has about half its pore spaces filled with water and half are filled with air. The plant will thrive in this situation if other growth factors are satisfactory. Little energy is required for the plant to take up moisture and ample oxygen in the root zone conducive to permeability of the root cell membranes.

If the soil is wetter than "field capacity," there is necessarily a reduction in the air holding pore space and if the too wet condition persists for very long the plant will begin to suffer from a lack of oxygen. At the time of, and following, rainfall or irrigation, the soil is wetter than field capacity. Whether or not the condition will create problems depends upon the speed with which water is evacuated from the large (air holding) pore spaces. This is where good subsurface or internal drainage is an important factor.

Conversely, following irrigation or rainfall, drainage will occur until all excess moisture has been removed and the desirable state of "field capacity" has been reached. No more moisture will be removed by drainage, but the plant begins to use the capillary water and this water is transpired through the leaves. Some is evaporated from soil surfaces.

As these phenomena proceed the soil becomes drier. With drying, the film or shell of water held on the soil particle holds the remaining water more tenaciously. Eventually, a considerable amount of energy will be required for the plant to overcome the stress and to take up the moisture.

At this stage, a temporary wilting will occur in the plant. If the situation continues and the plant cannot take up water it permanently wilts and dies.

The ideal irrigation system, then, should provide water frequently enough to prevent serious moisture stress from developing and it should not provide water so frequently that soils stay too wet for very long periods.

This reasoning leads us to a consideration of the soil type and the "water use rate." A sandy soil has less total pore space than a clay soil, but the pore spaces are relatively larger. There is less "surface" on a given volume of sandy soil and therefore water is held under less tension. A sandy soil has a high infiltration rate. Water moves into it and through it quite rapidly. Therefore precipitation rates can be high.

This is important to the irrigation system designer. A great deal of water can be applied in a short period of time without wasteful runoff. A sandy soil will hold much less water at the "field capacity" stage, however, than will a clay soil and therefore the reservoir of available moisture in the soil will be exhausted more quickly. The frequency of irrigation, then, must be greater.

Clay soil has much "surface" in a given volume. Pore space percentage is relatively high and much of the pore space is in the size range normally occupied by water. Clay soil is plastic and subject to compaction when it is wet. Clay soils normally have a fairly low rate of infiltration and percolation.

The irrigation system must permit water to be applied slowly so that it will soak into the soil instead of running off. Because of relatively slow percolation, clay soils require more time for excessive moisture to drain away and to achieve the state of "field capacity." Clay soils hold a high percentage of water at this point, however, and they are able to sustain plant growth between irrigations longer than sandy soils.

These concepts are fundamental and they seem simple enough. Complications arise, however, when we consider that soils on a golf course are very likely to be quite variable.

During construction, loam topsoil may be removed from an area exposing a clay subsoil. In other areas there may be sand pockets. There are subtle variations as well, and unless careful studies of physical properties are made, the designer may not recognize these differences until after the system is installed.

Slopes are a complicating factor. Infiltration rates for a given soil on flat ground may be quite different from those on a slope.

Water use rate depends to some extent upon the type of vegetation but it is primarily a function of weather. Water use increases directly with temperature and inversely with humidity. Wind movement is also important. A commonly used "rule of thumb" is one inch of water per week, but this figure will vary greatly from one climatic zone to another.

Effective rooting depth is another factor to consider. This depth is defined as the depth to which roots will exhaust all available moisture before permanent wilting occurs. Obviously, this will vary with the species of grass being grown. This variable affects the extreme interval allowable between irrigation applications.

Wind provides another variable. Both velocity and direction are significant factors. To design a system to operate efficiently, the designer must be able to estimate the amount of pattern distortion and to space sprinklers appropriately to provide adequate coverage despite the distortion which may occur.

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The available supply of water and the methods of distribution are factors to be considered. If the available water supply is limited, this fact may outweigh all such considerations as infiltration rates and soil types.

Time available for irrigation is closely related to water supply, rate of application and frequency of irrigation. If golfers use the course from before sunrise until after sunset, the nighttime hours may be the only ones available.

A series of calculations can be used to reveal the options available. The available supply must be distributed over the required acreage in the available time at appropriate precipitation rates to provide the proper soil moisture environment —taking into account the matters of wind direction and velocity, slope and variability of the terrain—and the designer must be cognizant of the costs involved.

Now our simple concepts suddenly have become fearfully complicated. But we haven't finished enumerating the factors we must consider.

How much will it cost? While this question is far down the list in this discussion, it is very often the first question asked when a club begins to discuss the installation of a system.

There are two approaches. The club may adopt a figure which represents the maximum permissible expenditure and then buy the best possible system with that amount. The alternative is to design a system that will provide suitable irrigation and then install that system as economically as possible.

It appears quite likely that most clubs use a combination of the two approaches.

Irrigation systems *are* costly and few clubs are able or willing to simply decide to buy the best possible system without regard to cost. Preoccupation with costs has in some cases, however, caused a club to buy unwisely. It frequently occurs that a greater initial investment will provide more satisfactory performance with reduced maintenance.

Related to initial cost is the question of how the water is to be applied. One of the cheapest kinds of water systems is based on the use of hoses and portable sprinklers. Such a system is obviously one which requires an enormous expenditure of labor in relation to the amount of area watered. This kind of system may be quite satisfactory however, in areas where rainfall is high and only "spot" watering is needed.

Perhaps the most widely used system in the United States depends upon quick coupling valves and sprinklers that are moved manually. In order to use labor efficiently in this kind of installation, it is necessary to set a relatively large number of sprinkler heads in one part of the course.

This practice demands large mains supplying water to the area. If only a few heads may be used in an area because of low water supply, then much moving from one part of the course to another is necessary.

Both the hose and portable sprinkler and the quick coupling systems depend upon men to make the changes and regulate the time of watering. As labor problems increase, men who will work at night and who will irrigate intelligently become scarcer and the man becomes an ever weakening factor in proper irrigation.

At one club, the superintendent went on the course at night to check on his irrigation and found his workman had built a bed of old sacks under a culvert and had literally "sacked out."

It is a common complaint that the water man will relax too long too early in the evening and get behind in his schedule of sprinkler sets. He then must hurry the last few hours of the night and some areas get very little water.

While these short sets may not be immediately apparent, the superintendent usually recognizes what has happened

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when the grass starts to wilt too soon.

Automatic irrigation systems have become more popular in the last five years. While most people will agree that the problems have not all been solved, automation does provide many advantages.

Perhaps the most important advantage is that irrigation is placed under the control of the superintendent. He does not have to depend upon the judgement and the energy of one of his employees to dispense the desired quantity of water on an area.

Automatic systems permit recycling so that on soils with low infiltration rates or on slopes, water can be applied intermittently. Thus, watering is more efficient and runoff is eliminated.

Automatic controls allow the operation of sprinklers in widely separated locations so that only a few are operating in any one area. This permits the use of smaller pipe sizes without creating velocity problems. There are very many special uses for irrigation beyond that of keeping a desirable level of moisture in the soil. In seasons when light frosts form on putting greens, it is desirable to water the frost off the leaves. Not much water is required but all the greens must be watered during a relatively short time.

Likewise on hot summer afternoons, greens sometimes tend to wilt simply because transpiration rates are such that water is being lost from leaves faster than it can be taken up by roots.

Showering of all greens within a short period of time is desirable. This can be done by four or five men with hoses and shower nozzles or it can be done by one man with an automatic control panel.

Because showering is done at a time when golfers are on the course, some system must be used whereby the person controlling the water can see the green. Satellite controllers in various sections of the course offer one solution, and two-way radio another.

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At one club, there is a siren at the pump house where the control panel is located. The superintendent sounds the siren to signal golfers and two minutes later the greens are being showered.

In parts of the country where *Poa annua* fairways are commonplace, the summer months are usually accompanied by weakening turf and sometimes by thin fairways. Some success has attended the efforts of superintendents to air-condition fairways by applying small amounts of water at frequent intervals on hot days.

All of the special uses are related to an ability to control the amounts of water applied, and the duration and frequency of application. It is an approach to eliminating the stress placed on turf by lack of moisture. Precise control demands either a great expenditure of manpower or rather elaborate automatic equipment. As labor costs rise and quality declines, the trend is toward more automatic equipment.

The day will soon come when we see computer-designed irrigation programs which take into account the humidity, the temperature, the wind direction and velocity, the slope of the ground, the moisture content and the infiltration rate of the soil.

The information will be digested and proper schedule of irrigation will be recorded on tape. The tape in turn will trigger radio signals to operate the valves.

Such dreams will be reality only after the employment of a great deal of technology, innovation and "cut and try" experimentation. Such a system will never be cheap, but the more precise control together with the resulting effectiveness will offer a very tempting prospect. •

New 18 for Firestone

Firestone Country Club has begun construction on a new 18-hole golf course.