Proceedings

of the

Sixteenth Annual

Texas Turfgrass Conference

TEXAS A & M COLLEGE

AND

THE TEXAS TURFGRASS ASSOCIATION

COLLEGE STATION, TEXAS

DECEMBER 11, 12, 13, 1961

TABLE OF CONTENTS

CAUSES OF COMPACTION AND WEAR ON TURFGRASS AREAS

Tom Mascaro
West Point Lawn Products, Inc.
West Point, Pennsylvania

Compaction, in its broadest sense, simply means the reduction of pore spaces within a soil mass. Turfgrass roots do not grow in the soil particles; rather, they grow in the spaces between the soil particles. Space between these soil particles is not only needed for roots but also for air, water and nutrients.

There are many forces which are constantly at work on turfgrass areas that create compaction. The major forces of compaction on turfgrass areas might be listed in the following order: (1) water, (2) mowing equipment,(3) people, (4) golf carts, and (5) maintenance equipment. Water is certainly a major source of compaction. The impact of a water droplet, whether natural or artifically applied, will disassociate soils. Admittedly, a turfgrass cover reduces this effect considerably but on thinly covered turfgrass areas the effect can be serious. Water moving through the soil causes compaction by the simple process of melting the soil to finer particles which in turf fill the pore spaces.

Also, water being a good lubricant, allows soil particles to slide together into a solid compacted soil mass--commonly called mud. When the soil dries, the particles remain together. This is compaction.

Mowers, people, golf carts and maintenance equipment are all forces causing compaction. Not only must we consider the weight of these forces, we must also consider the kneading, or puddling action of these forces. The sheer weight of tractors, mowers, people, etc. compress the soil, reducing the pore span within the soil mass. However, we must also consider that the greater force of compaction results from the kneading or puddling effect. When a wheel turns, or a person's foot rolls on the turf, soil particles, lubricated with water, move quite easily into compact masses. Water is squeezed out and its plan is taken by solid particles.

Turfgrass management must bear these fundamental facts in mind. Although we realize that these compacting forces cannot be eliminated, many things can be done to minimize these effects.

These principles also apply to turfgrass wear. Grass can be compared to a steel beam. A steel beam can support just so much weight, and then it is going to break. The same is true of turfgrasses. Managing turfgrass areas to distribute wear over large areas will do much to minimize this problem.

The various panels of this conference will cover many ways to minimize compaction and how to overcome it as it occurs. Compaction in my opinion is a problem that must be controlled as it occurs.

Compaction must not be allowed to become so severe that major renovation is needed.

The slides I will show will illustrate many of these causes of compaction.

Let us not forget that the turfgrass areas we are charged with maintaining are not out paradise. We must maintain them for the use of the people. Therefore, we must explore every method, consider every plan and constantly develop new approaches in order to give people what they demand.

SOME SOIL PHYSICAL EFFECTS OF TRAFFIC

Dr. J. R. Watson, Jr.
Toro Manufacturing Corporation
Minneapolis, Minnesota

Turfgrass areas of all kinds are being subjected to an increasing amount of traffic each year. True, new facilities--parks, school grounds, athletic fields, and golf courses--are continually being constructed, but many of the older recreational sites are being converted into housing and industrial developments. This, along with a rapidly increasing population--over five million since the 1960 census--and the availability of more leisure time than at any period in history is placing heavy demands on all types of recreational facilities and services. Improvement in economic and production efficiencies will, unquestionably, result in even more leisure time in the future.

That the American people will devote a large share of their leisure time either directly, as participants, or indirectly as spectators, to utilization of recreational facilities involving turfgrass is most apparent. To illustrate: consider the number of teams in major league baseball and professional football today as contrasted to five years ago; think for a moment of the number of post-season college football "bowl" games that will be played this year--most of us can remember when there was only one and all will recall when there were only four; ask the Golf Course Superintendents about the number of golfers today as compared to ten years ago; talk to the park and school representatives about "park league" sports, little league baseball and intramural programs. All of these (and more) activities may be cited as examples of the trend toward increasing traffic on recreational turfgrass. Stepped up physical education programs and intramural activity in our elementary and secondary schools, colleges and universities insures continuing participants and interested spectators. As an example, many colleges and high schools teach golf in their regular physical education curricula. It would seem then, that "Traffic on Turfgrass"--the theme of this Conference--is an appropriate subject and one worthy of the emphasis your program committee has chosen to place on it.

SOIL PHYSICAL PROPERTIES

There are certain basic requirements which soil must provide for satisfactory plant growth. These are: support, water, air (oxygen), temperature and nutrients. Of these, water and air along with their inter-relationships directly relate to soil physical properties. Hence, the subject "Some Soil Physical Effects of Traffic" may be discussed in light of the effects that traffic has on the air-water relationships of the soil and how this influences turfgrass growth. The chemical and biological properties of soil are equally important in the growth of turfgrass and their influence must always be kept in mind, but basically this discussion will deal with soil physical properties.

The texture, structure, porosity and organic matter content of a soil governs the infiltration (movement of water into a soil), retention (water holding capacity) and movement of moisture through (percolation) and out of (drainage) the soil. These physical properties likewise control the air-water relationships and, because of their inter-relation with the chemical and biological properties, exert a major influence on the productivity of the soil.

A brief review of the terms pertinent to a discussion of soil physical properties as effected by traffic may be in order.

Texture

This is a soil term which refers to the size of the individual soil particles. Sand, silt and clay are the basic textural terms. "Soil class" (terms like sand, clay, clay loam, sandy loam, etc.) indicates the predominant soil separates. Texture is a most important characteristic of soils because it describes, in part, the physical qualities of soils with respect to porosity, coarseness or fineness of the soil, soil aeration, speed of water movement in the soil, moisture storage capacity and, in a general way, the inherent fertility of the soil. Sandy soils are often loose, porous, droughty and low in fertility, whereas clay soils may be hard when dry or plastic when wet, poorly aerated, but high in moisture retention and possibly high in fertility. Between these two extremes we find the loams and sandy loams which, in general, are more desirable for turf growth.

Structure

This is a soil term which refers to the arrangement or grouping of the individual particles into units. A structural unit may be defined as a group or groups of particles bound together in such a manner that they exhibit different physical properties from a corresponding mass of the individual particles. Such a structural unit is called an aggregate. Terms used to describe various types of structure are granular, crumb, platy, etc. In general, the granular and crumb structure is most desirable from the standpoint of plant growth. Platy structure is generally associated with slowly permeable soils derived from shales. Soils in which structure has been destroyed--partially or completely--are said to be dense and compacted.

The structural aggregation of soil is greatly influenced by the amount of colloidal organic matter present. The end product of decay or organic matter--humus--is an integral part of soil aggregates and is sometimes referred to as the cementing or binding agent in aggregates. Stability of aggregates is directly dependent upon the amount organic matter and the degree of biological activity obtaining. The structural aggregation of soil determines, to a large extent, the porosity, permeability and water capacity of soils of like texture.

Porosity

This term may be defined as that percentage of the soil volume not occupied by solid particles. In a soil containing no moisture, the pore space will be filled with air. In a moist soil, the pores are filled with both air and water. The relative amounts of water and air present will depend largely upon the size of the pores. Two types of pores are recognized--the small (capillary) and the large (non-capillary). The small pores hold water by capillarity and are responsible for the water-holding capacity of soils. The sum of the volumes of the small pores is called "capillary porosity." The large pores will not hold water by capillarity. They are normally filled with air and are responsible for aeration and drainage. The sum of the volumes of the large pores is called "non-capillary porosity."

The total porosity of a soil is not as important as the relative distribution of the pore size. Total porosity is inversely related to the size of the particles and increases with their irregularity of form. Porosity also varies directly with the amount of organic matter present in the soil. Clays, for example, have a higher total porosity than sands. Clays have a large number of small pores which contribute to a high water-holding capacity and slow drainage. Sands, on the other hand, have a small number of small pores which are responsible for a low water-holding capacity and rapid drainage.

If traffic were not a consideration the ideal soil for plant growth, in general, should have about fifty percent total porosity equally divided between small and large pores, or in other words, contain twenty-five percent water space and twenty-five percent air space. On areas where traffic becomes an overriding consideration, then the total porosity of the soil is of less importance than ability to resist pressure (traffic). This is evidenced by results of studies sponsored by the USGA Green Section and conducted at Texas A & M. These studies have shown a requirement for a minimum total pore space of 33 percent; maximum, 38.40. Significantly, the small and large pore space is approximately equally divided twelve to eighteen percent for large pore space and fifteen to twenty-one percent for the small. The aim or purpose in using high sand percentages is textural stability of pore space.

It must be recognized that the exact proportions of solids, air and water space seldom exist in native soils. The specified proportions are merely a goal or standard to strive for. Modification of the physical properties of soils for certain turfgrass areas may be desirable, but for most, modification is not practical and one must work with the existing soils. Size of the area and the amount and kind of traffic (intensity of usage) to which the grass will be subjected are the major factors governing the decision to modify.

TRAFFIC

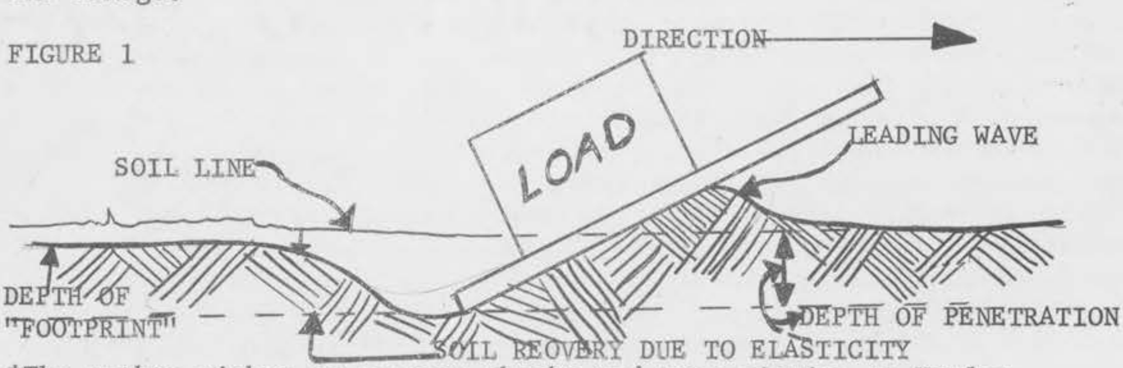
Traffic, per se, needs to be considered from the standpoint of friction and unit pressure and then these related to the effect or influence they have on turfgrass and soil physical properties.

Friction*

Friction is usually thought of as being of two forms--sliding and rolling. Although quite similar in their overall effects, there are differences that should be pointed out.

Sliding friction, for example, may be defined as the force required to move an object and is determined by multiplying load by the coefficient of friction of the two materials in contact. The actual area in contact is of no consequence in this case. The coefficient of friction for materials such as steel, cast iron, leather and etc. have been calculated and are readily available. As an example, it requires 0.3 X load to slide steel on cast iron, 0.2 X load to slide cast iron on cast iron and 0.5 X load to slide leather on steel. Exact figures (coefficient of friction) are not available for direct applicatinn on turfgrass. Nevertheless, by considering area and studying the effects of friction from the standpoint of the damage it may produce, it is possible to obtain a relationship between area and damage.

FIGURE 1



*The author wishes to express thanks and appreciation to Harley Kroll, Research Engineer, Toro Manufacturing Corporation, for his help and assistance in preparing this section of the paper.

In this illustration which is obivously distorted it may be noted that pressure is the major factor affecting soil displacement. Pressure is a function of load divided by area. Pressure is the direct course of the depth to which the footprint penetrates the soil.

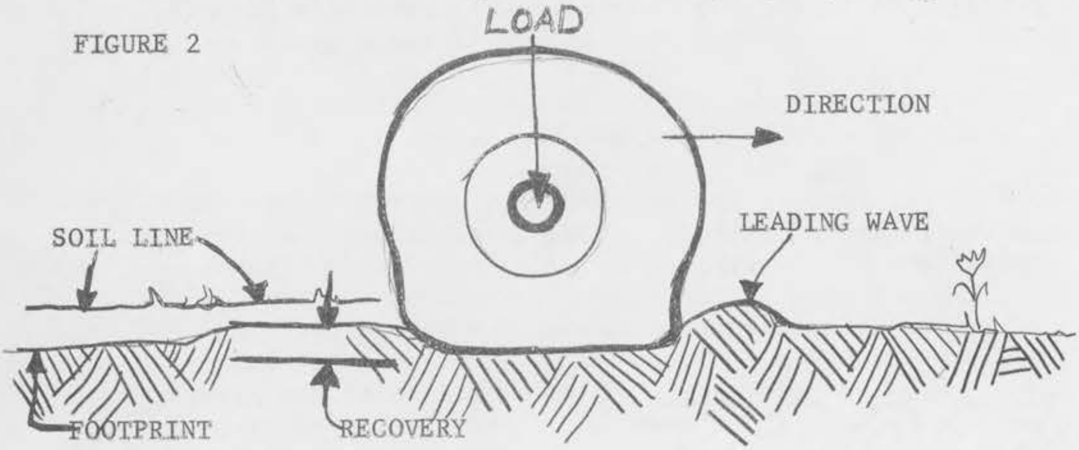
In Figure 1 the force required to move the load over the soil is actually greater than just the force determined by the coefficient of friction. This is true because in addition to the coefficient of friction between the load and the soil on additional force is required to lift the load out of the depression produced or, in other words, to lift the load up the "hill" created by penetration into the soil.

This second force (that above the requirement to overcome coefficient of friction) may be reduced by increasing the area in contact with the soil. This may be illustrated by comparing a trapper walking on snow with or without snowshoes. When walking on snow one is literally always walking "uphill." The steepness of the hill is a function of the depth to which the "load" penetrates. When equipped with snowshoes the trapper will not sink into snow as deeply as he would without snowshoes. With snowshoes the depth of penetration is less because of the greater contrast area; therefore, the "hill" or incline which he is climbing is less, hence, the force required to overcome sliding friction is reduced. This is one of the reasons why heavily thatched turfgrass areas (St. Augustine lawns) are often said to "tire you out."

Another consideration of sliding friction and its relationship to area involves the "fragility"of the sliding surfaces. For example, by using a long plank (greater area) one is able to stand on thin ice which otherwise would not support his weight. In this case, weight is distributed over a much greater surface area. Similarly a load may be slid over turfgrass without crushing or bruising the grass or deforming the soil if the contact area is sufficiently broad. Visualize the difference in damage resulting from a 200 pound man wearing football shoes and the same man wearing regular shoes. Football shoes are equipped with seven (7) cleats. Each cleat has a diameter of 0.9 centimeters or an area of 0.636 square centimeters. Thus, each shoe has a surface area of 4.452 square centimeters. Converting this to square inches of surface will show that the entire weight of the player and his equipment is supported by only one and one-third (1 1/3) square inches. This means that the 200 pound player exerts 150 pounds static pressure per square inch. When running he will easily exert two to three times this pressure. In contrast a regular shoe print would have approximately thirty-two (32) square inches of surface and the 200 pound man would exert only some 6.25 pounds per square inch. If walking normally and placing his entire heal down first he momentarily exerts approximately 17 psi.

Rolling friction, or the force required to move a load bearing wheel over the ground is in most respects quite similar to sliding friction. The force required to overcome penetration is the same in both cases (sliding and rolling) and if the materials are the same, the force required to overcome the coefficient of friction is the same in both cases. The differences between sliding and rolling friction comes about because a load supported and being moved by a wheel produces a decrease in radius of the wheel directly under the axel. This is illustrated in Figure 2 which is, again, exaggerated.

FIGURE 2



This shows a rubber tire moving over soil into which it penetrates and leaves a "footprint" or trail. The tire is trying to climb out of the depression; hence, is going "uphill" in the same sense as explained under sliding friction. This explains why it is harder to push a wheel barrow through soft sand than over solid ground or pavement.

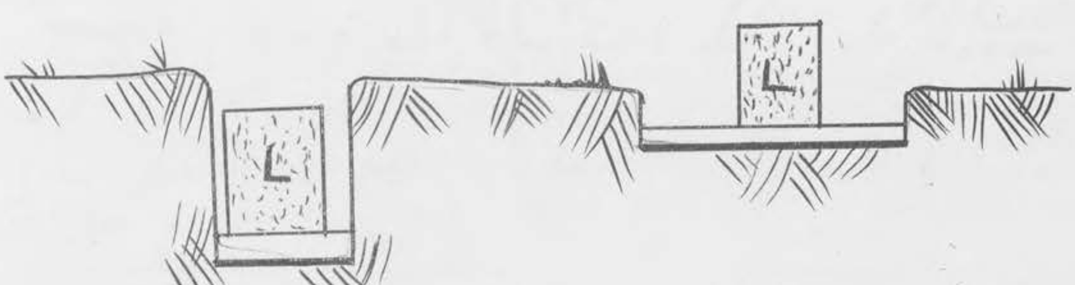
Note also that the bottom of the tire is flattened, and therefore, the area in contact with the ground is increased, thus spreading the load over a larger area, thereby reducing penetration. This fact will help one when driving a car through snow or mud. The car will move through places with soft tires that it cannot negotiate if the tires are hard or have a higher inflation pressure (which precludes the development of extensive deformation).

Figure 2 also shows that the distance from the point of contact with the ground to the center of the wheel is constantly changing throughout the contact area. This means that the velocity of the tire is changing throughout this zone. The tire periphyery is moving at maximum velocity at the instant of first contact with the ground, then slows down because the radius is reduced. This reduction continues until the point of contact is directly under the axel at which point it reaches its minimum radius and velocity. When it passes this point its velocity increases until the tire rolls free of the ground. This change in velocity means that there is some sliding taking place, and further, that the speed of a point in contact with the soil is varying directly with the change in radius.

As the load passes over the soil it is deformed. This deformation is of two types--permanent and temporary. The permanent type is easily recognized as a footprint or tire makr after the load has been removed. The temporary deformation is not so easily seen becuase it exists only while the load is actually applied and is a measure of the tensile strength of the soil (the soil's elasticity, or its ability to recover from deformation). This temporary deformation or compression may be just as destructive to plant roots as the permanent deformation because of its tearing action.

Most materials such as steel and rubber have a uniform rate of deformation with load--by this we mean that if a given load will cause steel to bend one inch, twice this load will cause adeflection of two inches. This is not true of soils. When a load is applied to soil it compacts or increases in density. Because of this, a support area that will sink into soil one inch with a given load will sink <u>less than</u> two inches when the load is doubled. The rate per inch is a function of soil texture, structure and moisture content. The depth of penetration is a function of pressure and "compactibility." (Pressure is defined as load divided by area as explained earlier.) Compactibility is defined as an increase in density--weight per unit volume. Pressure may be modified as shown in Figure 3. In this case penetration is modified by varying the support area. This is the same as was described in the case of the trappers snowshoes and football vs. regular walking shoes.

FIGURE 3



1. LARGE LOAD

   SMALL TREAD AREA

2. SAME LOAD,

   LARGE TREAD AREA

EFFECTS OF TRAFFIC ON SOIL PHYSICAL PROPERTIES

It is evident from the preceding discussion that the effect of traffic on turfgrass areas falls into two categories (1) the effect on the grass and (2) the effect on the soil physical properties. In this discussion we are primarily concerned with the latter, but the effects of traffic on the grass as well as the effects of the grass cover cannot be overlooked or omitted from an overall standpoint.

The effect of traffic on soil physical properties may be further divided into visible and invisible damage.

Visible damage on soil would include marking (depressing) slipping and sliding. The degree of soil damage is directly related to the resistance offered by the turfgrass cover and the soil. Resistance offered by the turfgrass cover is a function of the degree of coverage (stand or density), the amount of thatch or cushion, the inherent wear resistance of the grass and the general state of moisture within the grass plant. Cells with a low water content (wilted) offer less resistance than cells filled with water--tugor pressure. Resistance offered by the soil as already mentioned is a function of the texture, structure and moisture content.

Invisible damage to soil physical properties is that associated with "compaction"--destruction or breakdown of soil structure. This, of course, is directly related to the amount of pressure delivered by traffic and expressed in pounds per square inch. (psi).

Compaction brings about an increase in density with a corresponding decrease in pore space, particularly the large pore spaces. A severely compacted soil may become so dense that for all practical purposes the air space (large pores) is almost completely destroyed.

Date compiled by Dr. R. B. Alderfer (Head, Soil Dept., Rutgers University) illustrates the effect of compaction on soil density and pore space.

Effect of Compaction on Soil Weight per Cubic Foot:

Compaction Intensity	Weight of a Clay-loam soil per cubic foot
None	68 pounds
Medium	92 pounds
Heavy	112 pounds

This table shows that as the intensity of compaction increases there is a corresponding increase in the weight of an equal volume of soil. In other words, the greater the applied pressure the more dense the soil becomes.

The next table shows the effect of compaction on pore space:

Effect of Compaction on Non-capillary Soil Porosity

Compaction Intensity	Percent Non-capillary Pore Space
None	33.1
Medium	12.2
Heavy	6.1

Non-capillary pore space in this table refers to the large pores (air spaces). These two tables illustrate the effect of compaction on soil density and porosity as aptly as any information available.

Changes in soil density and porosity are reflected directly in the quality of the turf. A severely compacted, as well as a water-logged soil, prevents normal root activity and, in most cases, results in definite injury.

Under such conditions the oxygen supply becomes practically exhausted. Oxygen is, of course, just as essential for the proper functioning of turfgrass roots as it is for the proper functioning of an animal. A compacted soil slows down the movement of air and water and results in it becoming sturated with carbon dioxide, other gases and certain reduced compounds quite toxic to plant roots. Plant roots cannot perform their function of absorbing water and nutrients under such conditions.

Compaction fortunately occurs at or near the surface (most in the upper 2 inches). It is recognized that good turfgrass must be grown in spite of the fact that many factors seem to operate adversely. The use of mechanical cultivating equipment is perhaps the first approach to alleviating compaction. The results of cultivation are, unfortunately, not permanent and it is necessary to repeat the operation every so often. At the present time, however, this technique affords the most practical means of correcting and improving poor physical soil condition on large areas. On small areas (golf greens) incorporation of the proper amount of organic matter is present and proper adjustment of texture (addition of sand) will do much to prevent compaction). Cultivation of all areas provides a means of maintaining proper air-water relationships on heavily used turf areas where good soil structure exists.

SOILS

Marvin H. Ferguson
Mid-Continent Director and National Research Coordinator
USGA Green Section

Soils upon which turf is to be established deserve considerable attention whenever rebuilding or remodeling is contemplated. Putting green soils are so often the source of turf trouble that the USGA Green Section began about 10 years ago to sponsor research dealing with the physical relationship of soils. This work has been done at Beltsville, at Oklahoma State University, at UCLA, and more recently at Texas A & M College.

There are four primary functions of a soil. It provides support, nutrients, water, and air (oxygen). In addition to these primary functions, the soil used in a putting green must fulfill other peculiar requirements. (1) It must resist compaction under traffic and during all kinds of weather conditions. (2) It must hold a properly played golf shot, yet be firm enough to resist the pitting caused by golf balls played with a high trajectory. (3) The soil must provide the primary requirements to a plant handicapped by the attrition of traffic and constant close mowing.

Soil is not an inert material but is rather a complex chemical, physical, and biological system in which all factors must be considered in their relationship one to another. Thus, among the functions that a soil performs, there are numerous interactions. A few examples will serve to demonstrate this fact. (1) Air in the soil affects the plant's ability to take up water and nutrients and to use them in its growth. (2) Air affects the depth and distribution of roots and in turn influences support as well as nutrient "foraging" ability. (3) Water and air in the soil vary in inverse proportion.

The discussion of air and water content of a soil leads to a consideration of pore space characteristics. We have evidence that a good agricultural soil is composed of about 50% solids and about 50% pore space. The pore space in turn is divided about equally between capillary pore space (which may be thought of as the space which holds water) and non-capillary pore space (which may be considered air space in a well-drained soil).

The above description of a good productive soil will fit a well-tilled loam. This is where the imposition of putting green requirements begins to intrude upon accepted thought. A putting green cannot be tilled and the preponderance of relatively small particles which when wet are crushed and are pressed together by foot traffic causes the larger pore spaces (air spaces) to be excluded from the soil. Consequently, there is an imbalance between non-capillary and capillary pore space.

The use of a higher percentage of sand will tend to balance the relationship between large and small pores but this addition of a high percentage of larger particles brings about a reduction in total pore space. Thus, it appears that 34 to 38 percent is the maximum total pore space obtainable in a good putting green soil. This appears adequate, however, if the amounts of large and small pore spaces are about equal.

The considerations of pore space are important as they affect drainage and aeration of a soil. These soil characteristics are closely related. Both are affected by underlying strata. A layer near the surface may impede the movement of water, creating a false water table and causing roots to be shallow. On the other hand, layers of gravel at depths of as much as 12 inches may be desirable because a false water table at this depth may prevent "drouthiness" in a sandy soil.

The synthesis of a suitable soil for puttting green use can be accomplished quite effectively by the use of appropriate laboratory measurements. These measurements are (1) mechanical analysis, (2) pore space amount and distribution of sizes, (3) permeability (measured as inches per hour with a .25 inch hydraulic head), and (4) moisture retention. The use of these measurements upon compacted trial mixtures of soil together with careful interpretation will permit the making of a putting green soil that will maintain its suitability over a long period of time.

The actual putting green construction procedure should conform to the following outline:

1. Lay tile in a suitable pattern after the subgrade has been established. The contours of the subgrade should correspond to the planned contours of the finished green.

2. A gravel blanket (1/4 to 1/2 inch aggregate) should be placed over the tile lines and over the entire surface. Minimum thickness for this layer should be 4 inches.

3. Because of the tendency of soil to migrate downward into gravel, a layer of coarse sand 1 1/2 inches in thickness may be used over the gravel blanket. This is particularly desirable if the underlying gravel is coarse. If fine gravel is used, the sand may not be necessary.

4. Mix soil off the putting green site. Place carefully on the prepared base.

5. Save an ample supply of the soil for future topdressing.

6. Sterilize putting green after soil is in place by the use of methyl bromide or other suitable sterilant.

7. Firm the soil, rake it smooth, and firm it again until the surface is smooth and uniformly firm.

8. The green is now ready for planting.

The procedures which have been outlined may increase the costs of putting green construction, but it is believed that subsequent maintenance ease will more than offset this initial cost.

PUBLIC RELATIONS IN TURF MANAGEMENT

James M. Latham, Jr.
Agronomist
Milwaukee Sewerage Commission

Today's turf maintenance supervisor is usually "the little man who wasn't there." He is seldom thought of until something goes wrong. Some superintendents never meet with members of their supervisory committee. We have all heard of superintendents actually trying to avoid their employers. They never greet or try to meet club members or users of the turf. Now this doesn't mean they don't do a good job of producing turf. Most do or they couldn't work there long. It is easy to fire a man you don't know.

Thinking superintendents are attacking their problem of lack of communication with their employers. Golf Course Superintendents in the Chicago area initiated such a move several years ago. An example of excellent communication is Bob William's Periodic Report sent to Green Committee and Executive Committee members. He informs them of general course conditions, what he plans to do in the immediate future, and the long-range plans being activated.

The July 1961, issue of The Golf Course Reported contained a 4-part symposium on "Selling Yourself." This is really the core of good public relations - convincing others that you are doing the right thing, by ways other than argumentation. Everyone at this conference should read those articles.

Why do large companies, governmental agencies and individuals hire public information (relations) men? To inform the public what they are doing, the problems they face and to convince the public that they are doing what is best for John Doe. If this was not successful, they would not spend the literally millions of dollars a year for such services. We as individuals cannot hire an agency, but we can do a number of things to accomplish the same results. In your own job, the Golf Course Supereintendents Association, Texas Turf Association, or American Institute of Park Executives cannot do this for you. It must be done yourself.

Back in the so-called "Good Old Days" a turf manager might be able to get along just growing grass. Those were the days of 150 golfers a week, 5 football games each year on a field, small school enrollments and a 6-day week so there was little use of parks. Now, we know of 700+ golfers on an 18-hole course per day, 30 to 50 football games a year on some fields, heavy use of school grounds and a 4-day week week has been proposed.

This means that you are dealing with problems of heavy traffic by people and their contraptions. To deal with people, you must be able to communicate with them and convince them to follow your advice. Most people resent a commandment but will follow a suggestion if they know the reason for it. If a few people are sold on your ideas, they will be your best source of information for others. These people should include your employers, employees and co-workers.

The method of supplying information is important. You should first make a thorough evaluation of damage that directly results from improper use. On a golf course, enumerate the worn or rutted areas. Possibly the primary cause is not traffic but an overly wet area aggravated by traffic. Perhaps an architectural or natural condition channels traffic into restricted areas. Also included in the report should be a proposal for correcting the condition. Where possible, correction costs also help. If the work is to be extensive, a priority plan is necessary.

Not all traffic problems can be so easily corrected. Co-operation of the public is imperitive. They must be convinced that their care of the turf area is as important as the use they make of it. Your employers are the best source of help at a country club. If the committee men are shown the turf deterioration from improper use of golf cars, the expense of repair and the increasing costs of maintenance due to heavy play, they usually will inform others and request that they not contribute additional damage. At golfers' smokers or similar meetings the facts can be presented to a larger group. Convince them and the job is much easier.

Your co-workers also help. The golf professional and club manager have much more personal contact with the members. If you persuade them to accept your ideas, they will help educate the members to improve their golfing habits. Mel Warnecke, Superintendent of Atlanta's East Lake Country Club has informal weekly meetings with the pro and club manager. They discuss their problems and plans for the coming week. Certainly, they have minor differences of opinion, but never a misunderstanding.

Some people must be guided. Tactful, diplomatic signs, barriers and lines often suffice to guide traffic the way you want. It is a matter of education. Tell the people why they should follow your directions and they usually conform. Instead of all "Don't" show them what to "Do". Provide a direction to go and well-marked way to get there. Provide an alternative route if possible.

Most people are cooperative if handled properly. Tell them what you want them to do. Show what happens when they act improperly. Inform them of the cost of repair - that hits them right in the pinched pocketbook. Enlist the aid of co-workers, employers and employees in disseminating the information. The key to all these methods is Communication.

Writing and speaking assistance is available. It's up to you to obtain the necessary help. There are several correspondence and night school courses available for adult education. Many men, golf course superintendents included, have reaped the benefits of Dale Carnegie Courses or Toastmasters Clubs. You have taken the time, trouble and effort to attend this for furthering your turf education. Why not take a little time to expand your personality education? You will find that by increasing your ability to communicate your relations with the public will be improved. You will also find that your employees will make fewer mistakes when they know exactly what you want them to do, since you have better expressed yourself.

Turf managers will truly become what the name implies when they are better able to inform people what they are, what they do and what they want. Someone else can't do it for you; it must come from the individual.

THE NEED FOR PLANNING FOR TRAFFIC CONTROL

Marvin H. Ferguson
Mid-Continent Director and National Research Coordinator
USGA Green Section

In the title of this discussion we need to emphasize the word planning. We might compare our problem to that of the planners who are faced with the task of devising a transportation system for our nation's vehicles. It has not been enough to build wider streets and install more traffic lights. The ingenuity of the planners is shown in the installation of clover leafs and other types of interchanges which do not hinder the movement of traffic.

Planning is involved in golf course design and construction but also in day-to-day operation.

When a golf course has been built, any rearrangement of major features is difficult. Therefore, thoughtful advance planning is required. This is a good argument against the "do-it-yourself" type of architecture.

There are traffic controls, however, that the superintendent can employ. The most effective controls are those which can be exercised below the level of consciousness of the golf course user. Vistas which reveal a path to the next tee or subtle obstructions which will cause a slight detour are much more effective than printed signs. In driving an automobile most of us are influenced more by the lane dividers where traffic merges than we are by the signs which say "MERGING TRAFFIC."

As we progress around the golf course mentally, we can think of many places where the planner as well as the superintendent can exercise traffic control.

On the tee -

1. Placement of ball washers. There is an argument for portability.

2. Size of tees will influence the number of tee marker locations.

3. Shape of tees. Long narrow tees invite traffic over the entire length. Perhaps tees of different shapes (crescent, diagonal, etc.) would help solve some problems.

4. Placement of markers. Frequent changes are needed. Relation of placement to the ball washer. Relation of placement to location of flag on the last green.

5. Use of guard chains, ropes or other restraints. If these are

used they should be decorative and as inconspicuous as possible.

6. Locations of cart paths or parking areas.

7. Slopes around tees influence traffic. Easy slopes should be used in the directions of traffic flow. This will require careful planning to fit tees and slopes into existing terrain.

In fairways, there are relatively few problems, but even here there are some things to think about -

1. Cart paths should be wide enough. Edges must be protected to prevent erosion or "raveling." Paths should be wider at curves and there should be no sharp corners. The ends of paths should be flaired so that leaving traffic will not wear out turf completely. Leaving traffic may be diverted with small attractive saw horses or other similar devices.

2. An attempt should be made to vary mowing patterns. The approaches to greens suffer especially from this kind of traffic.

3. Eliminate steep grades where possible.

4. Eliminate poorly drained spots.

Approaches to greens -

1. Encourage carts to leave fairway before getting to the green, by placement of bunkers, by planting of trees, by vistas and paths to the next tees, and by location of the next tee.

2. If carts must come up alongside greens, make a more attractive path farther from the green.

3. Create parking areas.

On the green -

1. Numerous pin positions.

2. Location the pin to best advantage -

   In relation to approach
   In relation to the next tee
   In relation to areas most susceptible to wear

Around the green -

1. Location of traps affects mowing pattern.

2. Location of traps affects flow of traffic moving onto and off the green.

Perhaps there remarks will stimulate you to think of questions and solutions to problems. These may be brought up and discussed in the panel sessions to follow.

Note: This talk was accompanied by blackboard sketches to illustrate some of the points that were made.

DEVELOPMENT OF STABILIZED SURFACES FOR HEAVY TRAFFIC AREAS

BOB M. GALLAWAY
CIVIL ENGINEERING DEPARTMENT
A & M COLLEGE OF TEXAS

About a month ago Professor Holt came to me and asked me if I would be interested in talking to a group of people attending the Turfgrass Conference about specifications, construction procedures and maintenance methods for walks, parking areas, tennis courts, athletic tracks and related areas that require surfaces suitable for all weather use. He quickly added that I would have about 30 minutes in which to cover the subject and before I realized how difficult this time limitation would make the task I agreed to his request.

In areas with sufficient traffic to make it unsuitable for successful growth of turf you may be and quite often are faced with the problem of soil instability. As I see it in its simplest form, this is your problem. If the soil is cohesionless such as sand this instability occurs when the sand is dry. On the other hand if the soil is a fat clay, your problem is in evidence when the soil is wet.

Given enough money there is not a group or a single person here today who cannot solve the problem described, but it has been my experience that such amounts of money are seldom if ever available. Each problem in this area is actually quite individual and its solution should be separately obtained dependent upon the existing circumstances. Before a solution is reached it may be wise to ask and try to answer some or all of the following questions.

What methods then are available for soil stabilization? Which method is better? How difficult is the method to use? What is the relative cost? What is the expected life? Is stabilization a practical and economical solution? Can it be done without special equipment and trained personnel? Will it serve the intended purpose to the satisfaction of the user and be pleasing in appearance? Will the annual maintenance costs be reasonable? Is soil stabilization really the answer or would some higher type surface be more economical and practical? The foregoing questions should be carefully considered before a final decision is made. As a first consideration let us then suppose that stabilization is the answer. We have the following methods among others that we may consider.

a) Mechanical stabilization alone
b) Soil blending plus mechanical stabilization
c) The use of portland cement
d) The use of hydrated lime
e) The use of calcium chloride
f) The use of asphalt cement
g) The use of organic stabilizers and/or waterproofing agents

Probably most of you are familiar with sand-clay tennis courts. This is an example of soil blending plus mechanical stabilization. Mechanical stabilization, as you no doubt know, is compaction of the soil under controlled conditions of moisture and compactive effort. This, by the way, is the cheapest method of stabilization we have to offer but quite often it is not a suitable solution to your problem. You will, however, be surprised sometimes at what can be accomplished by mechanical stabilization alone.

The use of admixtures to promote stability and otherwise improve trafficability of heavily traveled areas is widely practiced. In many instances you may have more than one choice of additives to use. In general, however, the soil type largely determines which stabilizer will be more effective and economical. Portland cement is usually more effective and economical for sandy soil; whereas, lime is more effective for stabilizing clay soils. Calcium chloride acts to stabilize and when exposed to the air picks up moisture. It would then be useful for keeping down dust as well as for stabilizing an area.

Asphalt used sparingly on the surface serves to keep down dust. It may also be used as an admix to soil where it acts as a stabilizer and waterproofing agent.

It is difficult to give cost figures for stabilization work of this type due mainly to variability in the size of the job. Actual cost of the stabilizing agents can be set with reasonable accuracy. Those listed above vary in cost from about 20 to 25 dollars per ton. The cost of incorporating one of these stabilizers in a given soil would of course depend on such items as size of job, type of soil, amount of stabilizer to be used and available equipment. A fair estimate would be in the range of ten to twenty cents per square yard assuming a treated depth of four to six inches. Regardless of what soil you have and what stabilizer you select, adequate compaction is an essential requirement of the job and to neglect this is to invite sure failure. Such additives as portland cement, lime and flyash require definite and controlled amounts of water when they are mixed with the soil. Considerable loss in strength results if too much water is used with portland cement.

It should be mentioned at this point that some grass encroachment will occur regardless of which method of stabilization you use. To reduce this nuisance certain poisons may be used. One which is reasonably inexpensive and effective is sodium metaborate. There are also several selective poisons on the market which serve their intended purpose very well.

Let us now consider a higher type surface which may be desired or needed for various reasons. Such a surface may be designed into a new facility or it may be an added improvement to an existing area. You may select your materials from the following list.

a) Portland cement concrete
b) Natural stone
c) Brick or blocks
d) Hot-mix asphaltic concrete
e) Asphalt surface treatment
f) Special surfaces such as Grasstex or Saf Pla

Again you are confronted with problems and decisions as to which one to use. Once more available funds to do the work will quite likely be your No. 1 headache. Other important considerations are traffic requirements and existing conditions of the area to be improved. The overall landscape plan should not be neglected when the material choice is made. In this connection professional help is advisable.

I have a set of prepared specifications recently used as a guide for the construction of an athletic tract at Stephen F. Austin High School in Bryan, Texas. If you read this specification, you will find that reference is made to still other specifications. This is often the case with any specification in construction work and it is important that those responsible for work of the type under discussion be able to read, understand and interpret such job guides. Specifications are like fingerprints, they all look very much alike but they are really different as each set must be prepared to suit a particular job situation. Specifications writing is no job for an amateur; so be aware! It must also be pointed out that the best specifications alone do not guarantee a satisfactory job.

Let us return to the problem of selecting the most desirable all-weather hard surface to serve a given need. Jobs may be divided into two groups: namely new jobs or improvement of existing facilities. Assuming no financial problem the new jobs allow much more freedom of choice than the others and one should be guided largely by the landscape plan so the selected surface presents a pleasing as well as a serviceable facility.

Improvement of an existing facility may take on any one of a number of forms depending on funds available, the nature of the existing surface and service requirements demanded. Satisfactory stabilized areas may be surface treated with asphalt cement and suitable cover stone at very reasonable costs. Plant mixed asphalt-aggregate mixtures are available that may be placed by hand or machine on a stabilized and primed* surface. Both of these surfaces require compaction with pneumatic and/or steel rollers. Naturally in tight areas hand tamping may be required. Surfaces treated with the different types of asphalt-aggregate combinations, whether it is a surface treatment or the highest type of asphaltic concrete tend to promote encroachment of grass. This is caused by increased concentration of moisture under and at the edge of the paved area.

---

*Priming a flexible base consists of spraying the compacted and shaped surface with a liquid asphaltic material to aid in waterproofing and to promote adhesion.

Residual type poison mixed with the base material is a good preventative measure; otherwise, selected sprays may be used. It is to be remembered that petroleum solvents in excessive amounts are harmful to asphalt surfaces and should be avoided. Areas subject mostly to foot traffic should be designed to contain more residual asphalt cement than could normally be tolerated in an asphalt surface subject to medium or even light automotive traffic. Sidewalks, tennis courts, running tracks and similar surfaces made from fine graded asphaltic concrete would require from 25 to 40% more asphalt cement than a similar design on a street subjected to, say, 2000 passenger vehicles per day. The extra asphalt cement is used to insure reasonable durability. Cost figures cannot be given without detailed qualifications. A reasonable range would be \$0.50 to \$1.50 per square yard of surface for contract work.

Brick, blocks or natural stone may be used to form beautiful walks, borders and even drives and parking lots, but due usually to high labor costs such surfaces are expensive. During periods of limited or restricted use certain areas may be treated with any one of these materials with force account skill and labor and in this manner labor costs would not be charged directly to the job. Beautiful contrast in restricted areas may then be obtained at reasonable costs.

Portland cement concrete is a familiar material of proven quality; nevertheless there are certain areas, for the uses under discussion, that this material would not be the best choice. For cleated or spiked foot wear concrete is noisy and may even be dangerous especially if the area has a steel trowel finish. The required durability of concrete and desired resilience of other materials may be and often are combined. Concrete floors in a golf club house may be covered with rubber like materials. Areas in parks or schools subject to intensive foot traffic may be treated in a similar manner. A commercial material made principally of reclaimed rubber is available under the trade name of Saf Pla for use on playground areas. It is recommended for use over portland cement concrete or asphalt surfaces and when properly applied is durable, resilient and reasonable in cost. There may be some question as to how extensive an area should be treated. This question is resolved by observing similar areas already in use. In cases of doubt one should increase, not decrease, the area to be treated.

Concrete used on expansive clay soils such as the black lands of Central Texas should be lightly reinforced with 3/8-inch diameter steel bars on about 12-inch centers in both directions. This would include such services as passenger vehicle parking lots, sidewalks and small utility slabs like those under and around playground equipment and at ball washers and drinking fountains. The use of steel reinforcing prevents cracks from opening more than a few hundredths of an inch. This materially reduces encroachment by grass. Costs for such concrete may be expected to be in the range of 3.00 to 4.50 dollars per square yard.

Special surfaces are designed for outdoor running tracks, pole vault and broad jump approaches and high jump areas. The cinder track is quite common but has such disadvantages as being dusty and not being as fast as certain other surfaces. A. and M. College is one among several colleges that has successfully used a coarse graded sheet asphalt for athletic tracks. The mixture used at A. and M. consists of textured aggregate graded from 3/16-inch to dust and 9 to 11% asphalt cement. The mix is layed and compacted at 250 to 300°F and produces a fine surface for use with short spiked foot wear. Normally such a surface would require a light flush seal with asphalt at intervals of two to three years.

It is to be realized that the present discussion represents only an introduction to this subject but it should be sufficient to create interest and point out the availability of materials and method for soil stabilization and all weather surfaces for light vehicles and foot traffic.

Attached to this paper are references that are readily available to assist those of you who may be interested in proceeding with work of this nature.

In a concluding review it can be said that:

a) Stabilization by any one of several methods is available at reasonable cost.
b) Type and amount of stabilizer is primarily determined by kind of soil to be treated and the service demanded of the facility.
c) High type all weather surfaces may be an addition to existing stable areas or they may be part of a new plan.
d) Materials compatible with the landscape plan should be used.
e) When in doubt, seek qualified professional assistance.

Technical Publications Covering Materials and Specifications for Stabilization and Paving

1. Soil-Cement Construction Handbook
   Available from: Portland Cement Association
   33 West Grand Ave.
   Chicago 10, Illinois

2. Miscellaneous Construction Specifications
   Specification Series No. 4
   Available from: The Asphalt Institute
   286 Meadows Bldg.
   Dallas 6, Texas

3. Lime Stabilization Construction Manual ARBA Technical Bulletin 243
   Available from: American Road Builders Assoc.
   World Center Building
   Washington 6, D. C.

4. Rock Asphalt Paving Products Handbook
   Available from: White's Uvalde Mines
   P. O. Box 499
   San Antonio 6, Texas

5. Texaco Cold Patch
   Available from: Texaco Inc.
   Asphalt Sales Div.
   135 E. 42nd Street
   New York 17, New York

6. Calcium Chloride for Stabilization of Bases and Wearing Courses
   Available from: Calcium Chloride Institute
   909 Ring Building
   Washington 6, D. C.

EXAMPLE CONSTRUCTION SPECIFICATIONS
RUNNING TRACK
STEPHEN F. AUSTIN HIGH SCHOOL

Bob M. Gallaway

ITEM 1. Require construction of approximately 2,270 square yards running track on the Athletic Field at Stephen F. Austin High School, making use of existing curbing and having finished track surface flush with top of curbing.

Require the Following procedure to be adhered to:

1. Make 40' x 16' of cut at north end of track for total of 80' extension of track at that end. Use excess material and additional removed in leveling present track to desired base grade for fill at south end of track for 60' extension.

2. Contruct approximately 312' of curbing for straight way extension 12" deep x 4" wide corresponding to existing curbing.

3. Base preparation shall consist of first shredding track surface; leveling with maintainer and removal of surplus soil; compacting to grade 4 1/4" from top of curbing on each side. This subgrade when completed, shall be true to grade, hard, uniform, and smooth.

4. Base course shall consist of "Flexible Base (Bank-Run Gravel)"; and shall be contructed as herein specified in one or more courses equivalent to 3" thickness after completely compacted. The material shall consist of durable particles of gravel mixed with approved binding material; and shall be free from thin or elongated pieces, lumps of clay, soil, loam, or vegetable matter. The material may be bankrun or the binder may be added and incorporated by approved methods. Material containing gravel or conglomerate over 2" in their largest dimensions shall be broken up and uniformly mixed with the remainder of the material.

   Aggregate shall be spread with a base-aggregate or with a blade-grader. The materials shall be rolled with a 3 wheel, tandem 8-10 ton roller, or pnsumatic-tired roller during the blading and spreading operation. The entire area shall then be rolled until thoroughly compacted and true to grade at 2 3/4" below top of curbing.

   Only the amount of water necessary for compaction shall be used and in no case shall the base be flushed with water. The rolled base shall be primed with MC-1 conforming to Texas Highway Department, Item 350. The prime shall be spread at 1/3 gallon per square yard at application of 100° to 200° F.

Grades of base material shall, when properly slaked, meet standard test by Texas Highway Department's methods and requirements as follows:

Retained on 1 3/4" sieve . . . . . 0 - 5%
Retained on #4 sieve . . . . . . .30 - 75%
Retained on #40 sieve . . . . . .65 - 85%

Material passing #40 sieve shall be known as "Soil Binder" and shall meet the Texas Highway Department's test:

Liquid limit shall not exceed 35
Plasticity index shall not exceed . . 12

5. An asphaltic concrete leveling course shall next be applied. The paving mixture shall conform to Item 317-3, Type "D" T.H.D. It shall be plant mixed and furnished from a hot asphalt mix plant at temperature of 275° - 350° F. Asphaltic concrete shall be spread over properly prepared base. Contractor shall use skilled asphalt workers, modern methods and equipment. A paving machine shall be used and hand raking kept to a minimum only to remove excess material or add to low areas. This course shall be laid in one lift and shall have a compacted thickness of 1 1/2" and shall be 1/4" below surface of curbing after compacted.

   Compaction shall occur while mix is at such temperature as to secure maximum density. Rolling with an 8 - 10 ton tandem, steel roller shall start as soon as can be done without excessive displacement, and continue until surface texture has completely closed and roller marks removed. Areas which are inaccessible to the roller shall be compacted by hand methods. After rolling has been completed and surface is perfectly smooth without variation of more than 1/8" in 10 foot, the area shall be flooded and all depressions holding water shall be primed with a diluted binder and filled with a patching mixture made of 2 gallons Laykold Mastic Weathercoat, 2 gallons sand, and 1/2 gallon Laykold Tennis Court Binder (latter products as manufactured by American Bitumuls & Asphalt Company).

6. After the Asphaltic Concrete Course has been completed and rolled, it shall be primed with Laykold Binker mixed with an equal volume of water. This will give a

with water applied by a garden sprayer will also help prevent pickup. Alternate panels should be laid first and the intermediate panels filled in as quickly as possible thereafter. Using this method, excessive dilution of the Grasstex Composition should be avoided, for it rolls out best when at a medium consistency. If too much diluted, drying will be delayed. Precautions against showers, as given in Method 1, shall be observed.

8. After all the Grasstex Material has thoroughly dried, it shall be rolled with a light power roller. This done, the surface shall be thoroughly watered down, low areas outlined with chalk and then built up with additional thin layer of Grasstex Composition.

9. Require finally an application of Mastic Weathercoat finish as follows:
   A. Be certain Grasstex surface is thoroughly clean.

   B. Spray or brush on a tack coat consisting of one part Laykold Binder and three parts of cold water, at a rate of approximately 75-100 square feet per gallon of the dilution.

   C. Remove Mastic Weathercoat from container and mix to uniform consistency. May be diluted with clean water up to 25% by volume. Use no other diluting agency. Trowel or squeagee over the surface of Grasstex at a rate of 18-24 square feet per gallon. Allow to dry. Protect against water until dry.

BASIC COMPONENTS SUMMARY

Products of American Bitumuls & Asphalt Company of Mobile, Alabama, and distributed by John B. Kane, 3028 Albane Road, Houston, Texas.

Grasstex -- conforming to specifications LT-3 of American Bitumuls & Asphalt Co.
Laykold Mastic Weathercoat - Specification LC-7
Laykold Tennis Court Binder - Specification LT-1
MC-1 Prime or equal

ALTERNATES

I. An alternate to Step 4 - Base course quote on "Flexible Base (Crushed Stone)." This shall consist of a foundation course composed of crusher-run broken stone; and shall be constructed as specified. The material shall be crushed and shall consist of durable particles of stone mixed with approved binding material. When properly slaked and tested by standard Texas Highway Department Laboratory methods and meeting the following requirements:

thickness of some 3/8" which will dry down to 1/4". Before laying by one of the following optional methods, empty each drum into a mortar box or mixer and remix with sufficient water to provide a free troweling consistency.

METHOD 1. Use of short screed-strips as a measure of thickness, and hand-troweling in one application. Following Method 1, three or four hand-trowel finishers are required. Each finisher is equipped with short 3/8" screed-strips to lay down as a guage of thickness in the area upon which he is working. The application starts full width and full thickness at one end of the track. The Grasstex Composition must be of uniform troweling consistency. In areas where showers may be expected, we suggest only a part of a track be troweled per day to avoid substantial loss from rain. This thickness of Grasstex requires two or more days to dry. Preparations shall be made in advance for covering of newly poured Grasstex in case of showers.

METHOD 2. Use of Grasstex Composition diluted to a smooth, creamy consistency, and hand-troweling onto surface in a succession of this applications. Using Method 2, a number of hand-trowel operators are used, but the Grasstex Composition is more heavily diluted. Two successive trowel applications are made, each of about 1/8." Alternate applications should be at right angles to the application immediately preceding. Considerable pressure should be used in the troweling. This method has proved practical in spite of the additional trowel applications, and the thinner layers dry faster than one heavy layer.

METHOD 3. Use of continuous screed-strips and spreading with a roller made of 4" to 6" diameter iron pipe and about 6 feet long. A 1/2" round iron reinforcing bar mades a good screed-strip. Steel flats used as screed-strips may be 3/8." Following Method 3, using the iron roller, the full thickness of the Grasstex Composition is applied in one spread. The contents of the drum after remixing are deposited between 3/8" screed-strips set about +5 feet apart, and struck off with the iron roller, which spans and rides on the strips. (The material is rolled out much like the use of a rolling pin on dough.) The roller may be equipped with a scraper blade to keep it clean. Continuous dampening of the roller

Retained on 1 3/4" sieve 0%
Retained on #4 sieve . . . . .45% - 75%
Retained on #40 sieve . . . . .60% - 85%

Material passing the #40 sieve shall be known as "Soil Binder" and shall meet the following requirements:

Liquid limit shall not exceed 40
Plasticity index shall not exceed 12

II. Alternate 10: Construct walkway approximately 500 feet long outside the west end of track and back of north stands to 50 yard line:

A. With maintainer blade pull down grade to 6" below outer curb of track for width of 8' and compact. Allow 2" slope.

B. Cover area with 3" base course as used for track and compact.

C. Cover with black asphaltic topping.

D. Smooth out slopes with blade and clear out drainage ditches for proper fall and drainage.

CONCLUSION

Representative of the American Bitumuls and Asphalt Company shall supply on the job supervision throughout the construction of track and shall bear like responsibility for successful finish of job.

SUMMARY

Summary and Cost Estimates:

1. Cut and fill $__________
2. Curbing $__________
3. Preparation of sub-grade $__________
4. Base Course: Aggregate, compaction, & priming $__________
5. Asphaltic Concrete Course and priming $__________
6. Laying of Grasstex $__________
7. Application & finishing of weathercoating $__________

JOB TOTAL

8. (Alternate Item 4) Base Course $__________
9. (Alternate Item 10) Walkways $__________

PLANNING FOR TRAFFIC CONTROL

Fred A. Day, Director
Physical Plant Department
New Mexico State University

The control of traffic across turf areas seems to come under the heading of problems for which there is no solution. Our job is to produce a turf that will withstand traffic, so we must face the problem.

The usual solution to reducing traffic across turf is to put up signs reading "Keep off the grass." We all know how ineffective this is. Mr. Elo Urbanovsky, President, American Institute of Park Executives, says, "The 'Keep off' and 'Don't participate in me' approaches often become necessary when a lack of careful organization planning creates likely negative sites."

This subject has been hit from all angles, but essentially we have only one problem--maintaining turf under heavy use.

This one factor usually snowballs into several factors that contribute to failure.

First, the area gets too much use; consequently, maintenance is interrupted, watering becomes infrequent or irregular, we are called on to begin use too early in the season or too soon after an irrigation.

By this time we are convinced that the area should be paved, but we also realize that this is the one area that should be in grass.

It is at this time that we should ask other questions. Is the failure really due to too much use? Could it be the wrong grass? Could the area be too small for its intended use? Is the area properly arranged? Has it had the proper care?

Again, to quote Mr. Urbanovsky, "Usually, most 'Don't participate in me' situations can be remedied through careful planning and design. In some instances, not only the planning of physical features, but also the planning of activities, can change a negative approach--an offensive slap in the face, to a welcome handshake--an invitation."

In Los Angeles County, they have gone into some of the oldest parks which were barren of turf, surveyed the needs of the community, designed a park for these needs and redeveloped and rearranged the plantings and lawns. They have enticed over twice the population to use the parks and are still maintaining a good turf. Fred Roewkamp, the Director, says that it is possible with good planning arrangement and proper care.

Then, are we using the wrong grass? There is no such thing as a wonder grass--a grass that will meet all the requirements of all situations. There are many improved strains on the market that are worthless without good management. Because a grass is improved does not do away with the management problem. Man is just as important as the grass he selects.

Along with the right grass we need some measure of how much lawn area per person should be provided. Many of our failures could be corrected if we could spread the use over a larger area. Thus, adequate space may allow better maintenance of a turf if arrangements are worked out for balanced use of the area.

Paths across turf come in for a lot of criticism and advice. The advice is always the same--pave it. This seems rather unimaginative, as I see it, and probably contributes to another problem somewhere else.

For instance, at educational institutions schedules change each semester or new buildings are built and the patterns change. A good turf can take a lot of traffic so I don't think we should concern ourselves with eliminating all traffic. Here are a few things that can be done to encourage pedestrians to stay on the walks:

1. Provide wide landings at the entrances to buildings so that people can leave from many points.

2. Divide the landing with a planter to help spread the traffic out.

3. Use a planting to screen the destination from the pedestrian. If he cannot see the next entrance, he is more easily influenced to remain on the walks.

4. Use barricades--man made or thorned plants to shift the starting point over to an existing walk.

5. Use a wide flair (curve) where two walks join--not 3 or 4 feet as is usual, but 30 to 40 feet to indicate to the pedestrian that you are out to meet him halfway.

As Mr. Urbanovsky says, "Often, subtle changes in design can provide an answer to what appears to be a 'Don't touch' situation."

There are many ways to help solve paths across turf; the last of which is to pave it. We might take a lesson from the downtown malls that are being built today. Or take a look at Disneyland--

there is plenty of pavement there, but in every corner where traffic does not have to be they have something green planted.

Plan the central areas very much as a hotel lobby is planned. Attract the crowds to the center and then sort them out to the various component parts around the lobby area.

Above all, before you decide to pave those barren paths, try some imagination.

PLANNING FOR MINIMUM TRAFFIC EFFECTS

Jim Haines, Superintendent
Denver Country Club
Denver, Colorado

We all realize that golf carts are a problem--electric, gas and pull carts. The operators of these carts do have a responsibility in helping prevent excessive wear, but these responsibilities, in spite of well-intended rules and regulations, are often overlooked by the golfer intent on his game. They often drive over restricted areas and through soft spots without even realizing it. These same golfers, proud of their course and interested in seeing well-kept turf would be astounded and shocked if it could be successfully pointed out to them the unnecessary damage they had caused in one round of golf. It must be remembered that he, the golfer, is not looking at the turf in the same light as you, the Superintendent; namely, the maintenance angle. He doesn't look down deep like you do, compaction, soil puddling and excessive wear caused from following the leader.

Now, I should like to point out some of the responsibilities of the Superintendent and the Golf Course Architect. Plan for minimum traffic effect when planning new construction and rebuilding.

It is a sign of the times. Golf carts is big business. Road building and planning has been changed to meet increased traffic and speed. I am sure Golf Course construction and remodelling must be reconsidered to meet this same demand. A few suggestions are: contouring, trapping and planting of shrubs and trees in such a way, wherever possible, to split the cart traffic so it will travel two and three ways in a natural pattern, depending upon the play of the ball and the location of the next tee. This is particularly important around the greens.

I will attempt, later, to show you at least one good example of this with some picture slides taken at the Denver Country Club. Let me assure you that any golf holes built at the Denver Country Club for minimum traffic control are by chance and not planned in advance. The original construction at our Club was done in 1909 and some of these holes are still in use. I wonder what the original founders would have thought of golf carts?

In 1957 it was necessary to re-vamp part of the course, due to street widening along the north border. Cart control was considered only on one hole, No. 12, which I will show you later. On the balance of the course, it was decided to let the cart operators set up a natural traffic pattern, then take necessary corrective measures. This was done by signs and cart paths in bottleneck areas and shrub planting in other areas to divert traffic. Signs, to me, have no more part in the scheme of landscaping than litter.

I have been very interested in checking the new Pinehurst Country Club in our area. They finished seeding in September, 1959, opened to play June 25, 1960, and carts allowed in the spring of 1961. This is a privately owned 27-hole Country Club with a large membership. They own and rent 30 carts, all equipped with 12" terra tires. Bob Karbatch, the Grounds Superintendent, tells me that the cart traffic pattern was well established after the first week of play and certain corrective measures were taken: however, foot traffic in concentrated areas has caused more wear to date than cart traffic. It is too soon for any definite conclusions, but terra tires might be part of the answer to the traffic problem.

USE OF COVERS FOR PLANT PROTECTION

Dr. J. R. Watson, Jr.
Toro Manufacturing Corporation
Minneapolis, Minnesota

During the late fall, winter and early spring turfgrass areas are subject to varying degrees of injury. Such injury is directly related to the soil environment, weather and most important the kind and amount of traffic--foot and vehicular.

In some years, if climatic and environmental conditions are optimum little, if any, damage may occur irrespective of traffic. In other years, only slight variation in one or more climatic factors may cause severe winter injury without traffic.

The uncertainty involved in predicting weather and the certainty of damage during adverse winters (with attendant expenditures of time, effort and money to repair the injury along with loss of prestige) would seem to dictate the importance of using preventative measures if at all possible.

The injury suffered by turfgrass and the techniques employed to protect against such a possibility fall into two rather general and broad classifications--mechanical and physiological damage.

Mechanical Damage

As the heading implies, this type of winter injury is produced by mechanical means--primarily traffic. With one exception, it is caused by man and either damages turfgrass directly or indirectly (through its action on soil).

Direct injury to turfgrass is produced by traffic--foot and vehicular--when the grass is covered by frost or when it is dormant or semi-dormant and the soil is partially or completely frozen. Examples are: (1) bruising (cellular rupture) resulting from traffic on frosted grass--this is especially serious in late fall and early spring; (2) attrition caused by traffic on partially or completely frozen soil, especially when the grass is semi-dormant or dormant.

Indirect injury to turfgrass is produced by traffic on partially frozen or wet soil. The injury produced may be immediately evident (visible) or delayed (invisible) in its manifestation. An example of the visible type of injury is soil displacement--the footprinting and rutting caused by traffic sliding and slipping, as well as walking or rolling, on partially frozen or saturated soil. An example of the invisible type of injury is soil compaction. This is certainly not confined to the winter months, although it may be far more damaging during this period than generally recognized. Traffic on partially frozen or wet soil without the protection of living grass will exert greater pressure (hence, more compacting force) than during the normal growing season. This results, subsequently, in poor growth and may explain "problem areas" which show up in spring and summer for no apparent reason.

Heaving, the one exception to mechanical damage caused by man, is a natural phenomenon caused by alternate freezing and thawing of the soil which simply pushes or "heaves" plants with inadequate or poorly anchored (shallow) roots out of the soil. Heaving may be especially damaging to new stands planted late or without adequate nutrition or on poorly prepared seedbeds.

Methods of preventing or avoiding all the above types of mechanical damage with the exception of the injury caused by heaving may be avoided by simply preventing traffic during the late fall, winter and early spring when adverse weather or soil conditions occur. It is recognized that this is "easier said than done." It is also recognized that while such may be desirable from an agronomic standpoint it is not desirable from the standpoint of the club or the limited number of players who wish to take advantage of each opportunity to "get outside" during the winter.

Nevertheless, the Golf Course Superintendent does have certain obligations and responsibilities in this area. It is suggested that, among other things, the Superintendent in cooperation with the Green Committee should: (1) thoroughly acquaint the membership with the potential damage from uncontrolled traffic; (2) budget funds to provide for the additional maintenance required to correct injury and to bring the course back into top playing condition in as short a time as possible; and (3) prepare and present programs for diverting play to temporary greens (where such are feasible), absolute control of traffic during periods of adversity and re-routing traffic to avoid damage to critical areas. The club officials are then in a position to make an intelligent decision regarding traffic control, potential delay of spring conditioning and additional funds to correct injury or provide alternate playing areas.

Potential damage or losses from heaving may be reduced on established turf by carrying out recommended management programs to insure deep root development. On newly established areas, heaving may be reduced or avoided by earlier planting, good seedbed preparation and providing sufficient nutrition to insure deeper and more profuse root development. Making certain that the soil goes into the winter with adequate supply of moisture will also protect against heaving. When, in spite of such efforts, heaving does occur, then an early light rolling may save some of the plants.

Physiological Damage

This type of damage suffered by plants during the winter months is generally referred to as "winterkill." While most winterkill is the result of either disease or desiccation, under certain conditions suffocation and scald may cause severe localized damage.

Suffocation

Turfgrasses, even when essentially dormant during the winter months, carry on reduced metabilic (growth) activity, particularly respiration. For this process oxygen is taken in and carbon dioxide given off. Hence, grass may suffocate (a) if diffusion (of atmospheric and soil gases) is reduced or stopped; (b) if excess carbon dioxide accumulates: or, (c) if oxygen supplies are reduced to a minimum. Such conditions exist when an area is poorly drained and the soil saturated for extended periods.

Scald

In addition to the above effects, standing water or ice sheets may act as a lense under certain conditions. When this happens the sun's rays are magnified to the point where the excessive heat produced may cause a burning or scalding of the turfgrass.

Methods of preventing or avoiding suffocation and scald are related basically to improvement of drainage--surface and sub-surface--to prevent ponding or accumulation of water and breaking up of ice sheets when they occur. Topdressing, leveling or grading, installation of french drains and avoidance of heavy fertilization (especially with nitrogen) late in the fall are techniques and practices which help to offset winterkill caused by suffocation and scald. Ice sheets may be broken up mechanically or by spreading dark materials--Lampblack, Milorganite, Nutronite and other similar products, over the ice. Such materials absorb heat and penetrate the ice sheet, thus permitting an interchange of gases.

Disease

Winter disease, primarily snowmold (Typhula) and Fusarium patch (Fusarium) often cause considerable damage to turfgrass. Other disease producing organisms may also cause damage, but they appear to be controlled by the same treatments used for the more prevalent "snowmold" complex.

Snowmold and other winter diseases are readily prevented by fungicides containing mercury (inorganic or organic), Thiram, cadmium, or various mixtures and combinations of the basic compounds. In areas where the ground is frozen throughout the winter months mixing the appropriate fungicide with a suitable natural organic fertilizer or topdressing containing peat and applying this mixture in late fall, early winter, will usually protect golf greens until the spring. (See GOLF COURSE REPORTER, Vol. 24, No. 7--Sept. Oct. 1956 and GOLFDOM Vol. 30 No. 10--Oct. 1956). In other areas routine disease prevention programs are in order.

Dessiccation

Physiologically, dessiccation is a "wilting" phenomenon. It occurs when plants are transpiring moisture in excess of that which the roots are able to absorb. When soil is completely or partially dry, saturated or frozen, the roots simply cannot take in enough water to offset that being transpired (or to meet metabolic requirements) and the plant "desiccates" or dries up. Although more serious during periods when the soil is "on the dry side" or partially frozen, desiccation on high windswept sites may occur at any time during the winter months. The increase air movement causes excessive transpiration; hence, reducing soil moisture and under severe conditions causing death of the grass plants. Desiccation is particularly devastating when it occurs in combination with snowmold and Fusarium patch.

Methods of protecting against dessiccation will vary depending on the location of the course, amount of play and provisions for alternate playing areas, particularly temporary putting greens. Depending on the climatic conditions prevailing, Golf Course Superintendents employ several techniques to combat winterkill. Some of those in more general use are:

1. The erecting of snow fence and piling of brush to hold snow in place. Snow is an excellent protector or "insulator" and if adequate snowfall occurs, this technique is usually quite effective. Collecting and holding snow will offset desiccation, but increases the changes of snowmold development; hence, preventative treatments are essential if this technique is employed.

2. Covering permanent greens with various types of organic mulch, such as straw and peat, which provides adequate insulation and holds sufficient moisture to prevent desiccation. However, it is seldom possible to remove all of the litter from the green in the spring, and as a result a substantial amount of undecomposed organic matter is added to the greens each year. This further contributes to the buildup of thatch on the greens. In addition, such an environment is also conductive to disease development.

3. Where irrigation systems are shut off during the winter water is often hauled to greens in tanks and applied in late winter, early spring. This aids in combating desiccation and if sufficient amounts can be applied often enough it will prevent damage. The inconvenience and cost of such an operation are its major limitations. Where irrigation systems can be used during the winter months, periodic watering will save considerable grass.

4. Greens are cultivated late in the fall and the holes left open. This aids in maintaining adequate soil moisture and unless the greens are exposed to excessive wind movement may provide adequate protection.

5. Covering permanent greens, tees and other critical areas with polyethylene appears to be the most practical method of protecting against desiccation. This is a relatively new technique and for this reason perhaps deserves more detailed discussion.

Polyethylene Covers

Research conducted at the Toro R & D Center the past two winters (1959-60 and 1960-61) and being continued this winter (1961-62) has shown that covering greens and other turfgrass areas with polyethylene is an effective method of preventing desiccation and stimulating early growth. (See GOLF COURSE REPORTER, Vol. 24, No. 7--Sept. Oct. 1960). These studies have involved comparisons of different thicknesses (2, 4 and 6 mil and 2" insulated blankets) and colors (red, clear, white, black and green) of polyethylene. Temperatures at varying soil depths under protected and unprotected (check) plots have been recorded. Covers have been placed down in early December, February and in early April. A brief summary of results and conclusions to date shows:

1. All covers protect against desiccation because they preclude moisture evaporation. Water actually condenses on the underneath side of the covering.

2. The environment produced under the covers is most conductive to disease development; therefore, treatment to prevent disease is necessary.

3. All covers maintain a higher minimum soil temperature (average of 2, 4 and 6 inch depths) than uncovered plots during the winter months--5^{o} for unprotected, 10^{o} for polyethylene and 18^{o} for the insulated black blankets. Ambient temperature at the same date was 6^{o} at 3 inches and 9^{o} at 6 feet.

4. The black insulated blanket is an excellent "insulator" and, because of this property as well as its color, does not permit early growth in the spring.

5. As temperatures begin to rise in March the polyethylene covers act as a "greenhouse" and produce marked growth stimulation. By mid-April of 1960 the soil was thawed some 30 to 36 inches under these covers whereas it had thawed only 6 to 8 inches on the unprotected plots and only about one inch under the insulated blankets.

6. Thickness--other than the additional strength, which may be an advantage under heavy stress (high wind) conditions, there

appears to be little reason for selecting 6 mil low density polyethylene over the 4 mil. Two mil high density polyethylene appears comparable in strength to 4 mil low density.

7. Color--all films conserve moisture, but from standpoint of growth, clear film has proven to be the most satisfactory in both years of study. Insofar as the other colors (except black) were concerned, red produced about the same amount of growth as the clear. Unlike the clear, however, growth under the red was somewhat chlorotic indicating either a reduction in intensity of transmitted light or absorption or reflection of a part of the spectrum critical to chlorophyll synthesis. Growth under the opaque white covering was substantially slower than under the clear or red films. When greening did occur (some two weeks later than under other films) color and general appearance were excellent. Slower growth under the white film was caused by the high reflectivity--low transmissivity of the material, thus producing a reduction in energy transmission. Growth under the green film (placed down in February) was comparable in color and amount to that under the clear film.

8. Time of application appears to be critical, at least in certain years. Films should not be placed down until the grass has "hardened off" normally and has gone dormant. Coverings placed down in February and April stimulated growth (of the same general characteristics as found under covers placed down in December); however, under the conditions existing in 1961, large areas under the coverings had apparently been "winterkilled" prior to February--indicating the importance of earlier covering.

9. Time of removal in the spring is likewise critical. If the tarps are removed too soon, early growth stimulation will not take place. If they are left too long, excessive growth will be produced and the temperatures may reach levels high enough to either scald or burn the tall grass.

10. Management after removal of the covers is essentially the same as for unprotected areas with two possible exceptions. Additional fertilizer may need to be applied to protected areas to offset that utilized as a result of earlier more rapid growth. <u>Excessive growth must not be removed with one mowing</u>. Rather, the height of cut must be brought down gradually or the plants may be killed.

It is recognized that the direct applications of the techniques employed in this study are of proven value only in areas where the soil is frozen throughout the winter months and where play, if any, would take place on temporary greens. In areas where these conditions do not obtain, techniques employing the principles of protection and early growth stimulation need to be evaluated. Techniques for pinning or tying down the tarps need to be refined for large scale installations. Ability to cover putting greens or other intensively used areas rapidly just prior to adverse weather (frost or extreme cold snaps) would preclude damage from early play on frosted or partially frozen grass and soil. Techniques to accomplish easy placement and quick removal need to be developed. It is possible that polyethylene could also be used to advantage to stimulate early growth of bermuda in the spring; hence, hasten the transition period. Too, coverings could be used to protect late plantings, stimulate early growth of nurseries and hasten establishment of areas sprigged or stolonized in early spring or possibly during the winter months.

TURFGRASS NUTRITION AND FERTILIZER USE

Dr. William O. Trogdon, Head
Soil and Crop Sciences Department
Texas A & M College

The turfgrass plant is a minature factory which performs miracles of chemistry in the production of such complicated substances as sugars, starches, proteins, oils, hormones and vitamins. The above-ground part of the plant is the factory, but the underground portion is the part through which the raw materials of water and the plant food elements are supplied. Each golf course superintendent is, in effect, a plant manager and as such he must make management decisions. It has been conservatively estimated that during a year a golf course superintendent makes at least 20,000 decisions in his profession of growing grass that will meet the requirements of those who use it. Each specific use of turfgrass may require a different set of specifications. Surprisingly enough, the major turfgrasses are included within a limited number of species. Although grasses may differ in their adaptation to specific uses and management, their tolerance to soil acidity and drâinage requirements and fertility responses, fertilizers can play an important part in growing a more desirable turf if the simple principles of nutrition and fertilizer use are put into practice.

The growth of turfgrass in a given climate is determined largely by the solid, liquid, and gases in the soil. Consequently, the soil must be considered as having volume - that is, length, breadth, and depth. The solid part of the soil can be considered as the mineral and organic portion. The liquid part would be the soil moisture together with the dissolved minerals and gases. The gases in the soil would fill the spaces between the mineral and orgânic fractions not filled with water. The amount and balance of water and gases that a soil will have after being watered is largely dependent on the density (compactness or looseness) of the soil. The density of the soil is affected by man and his cultural activities, plant roots, freezing, thawing, wetting, drying and traffic.

For example, let us assume that a cubic foot container filled with a desirable dry soil weighs 80 pounds. If we take another container of the same size and by compacting and settling add half again as much dry soil, it would weigh 120 pounds. What has happened in order for us to put 120 pounds of soil into an equal volume that weighed only 80 pounds when the soil was considered desirable? What will be the difference if 2 inches of water are added to each container? Will both wet at the same rate and to the same depth? Which soil would require the most energy for the same size plant root to grow 6 inches?

Not only must a good soil provide anchorage and aeration for plant roots, store and deliver enormous amounts of water to growing plants, but it must also serve as a frugal custodian of a dozen or more plant food elements. The plant food elements may be abundant and available as shown by chemical tests, but largely unavailable to plants if the soil air supply inadequate. Soil structure is the governing property which not only controls air supply but also affects the growth of roots as they penetrate the soil. Thus, we can see that the soil must have the proper water and air balance and must also maintain a supply and balance of the various plant food elements so that the growing plant will be able to utilize those needed plant food elements so that the growing plant will be able to utilize those needed plant food elements at each stage of development for proper growth.

The plant food elements required by turfgrass are the same raw materials required by most green plants. They are carbon, hydrogen, and oxygen which are obtained from the air and water and nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, copper, boron, zinc, manganese, and molybdenum which are obtained from the soil or fertilizers or both. Some of these plant food elements are nutritive in that they become a part of the living plant. Others are regulatory in that they control certain processes taking place in the plant. Calcium, phosphorus, and sulfur may be both nutritive as well as regulatory. All of the factors that would affect the absorption, accumulation, upward movement, distribution, and utilization of these elements must be considered in fertilizer use.

Just as the three "R's" are a basis for evaluating learning and education, we can use three "R's" as a simple guide for proper fertilizer use. They are: The <u>RIGHT AMOUNT</u> of the <u>RIGHT KIND</u> of fertilizer used at the <u>RIGHT TIME</u> to grow the kind of turfgrass we want.

The desired quality of the turf must be of prime consideration. An excessively fast rate of growth requires more maintenance and is likely to be more susceptible to diseases and traffic damage. On the other hand, an extremely slow growth rate does not recover sufficiently rapid from traffic damage and will probably not have a good appearance. And we all know that such factors as temperature, light, humidity, and wind movement affect plant color and vigor.

What are some of the important factors in determining the <u>RIGHT AMOUNT</u> of a fertilizer to use? Both the soil and the plant must be considered. The amount and balance in the soil, the quantities used by the grass, the amount lost as a result of leaching, the quantities removed by clippings, and whether or not the plant is able to obtain at each stage of development the required plant food elements, must be considered. Some helpful tools are soil tests and tissue tests. The <u>RIGHT AMOUNT</u> of a particular fertilizer may be used to balance the plant food elements available to the plant, to raise the plant nutrient level in the soil, or in some cases to counteract high levels of certain elements that might be present and causing trouble. An example of this latter would be the use of iron sulfate to counteract the effects of high arsenic concentrations in the soil or adding calcium to reduce the tocicity of copper.

Fertilizers must be regarded as salts, capable of producing the kinds of chemical and physical effects expected of salts. Balance in the fertilizers is not to be measured merely by a certain ratio of nitrogen tophosphorus to potassium but rather by a consideration of the total ionic system. Due to the nature of nitrogen, phosphorus, and potassium, these elements and most others must be added to the soil as chemical compounds. Consequently, fertilizers affect the electrical conductivity of the soil solution as well as functioning as sources of certain plant food elements. They can cause alterations in the interdependence between ions and colloids of soil, plant and fertilizer salts. For example, if potassium chloride (0-0-60) is being used as a source of potassium, should not the effect of the chloride ion on plant growth also be considered? Almost as much chloride is being applied as potassium; nitrate of soda contains more sodium than nitrogen. This is not to infer that any of these are harmful or bad but to simply point out that when fertilizers are used, not only are we adding nitrogen, phosphorus, and potassium but also the other salts which are combined with these plant food elements to make them usable to plants.

No fertilizer use discussion is ever complete unless it mentions the use of lime. On acid soils, lime is the backbone of good plant growth. When it is needed to complete a balanced fertility program, it can greatly influence plant and root growth. A soil test is the best way to find out if lime is needed. Too much lime may cause certain of the micronutrient elements to become unavailable. In using fertilizers the old adage 'if a small amount will do a little good, then a large amount should do a lot of good' is not necessarily so. There is a RIGHT AMOUNT.

Turfgrass need relatively large amounts of nitrogen, phosphorus, and potassium depending on the fertility level of the soil, species grown, clipping management, leaching losses, and other factors. For example, the clippings from Bermudagrass will remove annually from the soil about 5.5 pounds of nitrogen, 1.5 pounds of phosphorus (P_2O_5), and 3.5 pounds of potassium (K_2O) per 1,000 square feet of area. When the clippings are returned to the soil some of the nitrogen, phosphorus, and potassium would become available for reuse as the clippings decompose.

The RIGHT KIND of fertilizer to use requires a simple understanding of the functions of the individual plant food elements in plant growth.

NITROGEN promotes rapid vegetable growth and gives plants a healthy green color.

PHOSPHORUS stimulates early growth and root formation, contributes to the general hardiness of the plant and promotes seed production.

POTASSIUM gives increased vigor to plants, helps produce strong stiff stalks, and helps plants to resist diseases.

CALCIUM is essential to healthy cell walls and aids in the development of root structure.

MAGNESIUM is an essential ingredient of chlorophyll and aids in the translocation and absorption of phosphorus in plants.

SULFUR is needed in protein and also aids in the synthesis of soils.

Nitrogen as a fertilizer is available in four principal forms--nitrogen, ammonium nitrogen, synthetic non-protein organic nitrogen, and natural protein organic nitrogen. Combinations of these forms are also available. The synthetic non-protein organic nitrogen and the natural protein organic nitrogen are either hydrolyzed to ammonium forms in the soil or decomposed by soil microorganisms to nitrates. In any case, the two forms utilized by growing plants are ammonium and nitrate nitrogen. Ammonium nitrogen which is held on the soil or organic particles does not leach but may be changed to nitrate nitrogen. The rate at which it changes is largely temperature and moisture regulated. Nitrate nitrogen is highly soluble and moves with the soil moisture. If the soil contains large amounts of nitrate nitrogen, the greater the amount of water absorbed by the plant the greater will be the amount of nitrate nitrogen absorbed. On the other hand, if the soil does not contain much nitrate nitrogen but does contain a considerable amount of ammonium nitrogen, increasing the amount of water absorbed by the plant will not necessarily increase the amount of ammonium absorbed. Ammonium is absorbed in relation to the root activity of the plant. A similar situation holds true for phosphorus, sulfur, calcium, magnesium, potassium, and perhaps a number of the micronutrient elements. This helps to account for the fact that young and rapidly growing plants tend to respond more to ammonium, phosphorus, potassium, and some of the other plant food elements than do slow growing or older plants. This is important because if one were interested in rapidly sitmulating slow growing or older plants, faster response would be obtained by using nitrate nitrogen than by using ammonium nitrogen or organic nitrogen. However, it must be kept in mind that the lasting effects would be in proportion to the rapidity in which the different forms of nitrogen would be absorbed and utilized by the plants.

The availability of the applied phosphorus to the plant is important. Since the greatest need is early in the growth of the plant, phosphorus to the plant is important. Since the greatest need is early in the growth of the plant, phosphorus tends to be used mainly in the early spring or for fall seedings. Phosphorus moves slowly and placement in the soil where the plant roots will intercept the material is especially important, as may be true for some of the other fertilizers. Consequently, it is generally better to apply phosphorus after aerification rather than before. In this manner some of the phosphorus will fall down into the root zone.

Not only is the particular kind of plant food element important in turfgrass nutrition but also the balance between the different plant food elements. Generally speaking, for establishing turf, fertilizers with a 1-2-2 or a 1-1-1 ratio of nitrogen, P_2O_5, and K_2O are needed. Young grass seedlings require an adequate amount of phosphorus for stimulating early vigorous root systems. A balance with potassium is needed in many soils for young plants but nitrogen is not required in large amount until after the grass is established and growing.

For maintaining lawns and fairways where the clippings are usually returned, a 2-1-1 ratio of fertilizer is most often needed. The additional nitrogen is needed not only to supply the needs of the grass but also to aid in the decomposition of the clippings and to replace the nitrogen that may be lost by leaching or otherwise. Turfgrasses often contain as much nitrogen as phosphorus and potassium combined.

On areas such as greens where the clippings are removed, a 4-1-2 ratio of fertilizer is likely to be needed. As can be seen from the composition of the Bermudagrass clippings referred to earlier, this is about the ratio that would be needed to maintain the proper balance in the soil. If considerable leaching due to over-watering should occur then the amount of nitrogen would have to be increased and to a certain extent, also the potassium. Phosphorus, not being subject to leaching, would not need to be applied in increased amounts. These are some of the reasons that different superintendents prefer to use a 5-1-3 ratio of fertilizer on greens rather than a 4-1-2.

Timing of fertilizer applications is also important in fertilizer use. Not only must the kind of fertilizer be considered and how the particular plant food elements are used by the plant but also the stage of growth and development. The <u>RIGHT TIME</u> of applying fertilizer can influence the normal development processes. For example, high rates of nitrogen tend to retard reproductive development whereas low rates of nitrogen tend to stimulate flower initiation. High rates of phosphorus also tend to stimulate flower initiation.. The practical implication from this is fairly obvious. If rather early in the season there is a tendency for the grass to start forming seed heads, one possible correction would be to apply a quickly available source of nitrogen, probably nitrate nitrogen. If the condition is aggravated by an over supply of phosphorus it may also be necessary to reduce the supply of available phosphorus in the soil. This could be done by using iron, calcium or magnesium to make the phosphorus less soluble.

Applying fertilizers after aerification or spiking is about the only means of getting fertilizers down into the active root growing zone in turf. In other instances, applying fertilizers and then using water to dissolve them and carry some of the plant food elements down into the root zone is another method of placement.

Timing is of considerable importance when using nitrogen fertilizers in the fall. Freeze damage is usually most severe on rapidly growing and very succulent grass. However, if the nitrogen is applied a month or more ahead of the freeze, chances are that the grass will have had sufficient opportunity to have adjusted to a balanced growth rate and freeze damage will be less serious.

In developing this article it was my feeling that since fertilizers are used to promote the growth of new leaves and to improve the appearance and quality of existing leaves, some simple rules were needed that could be used as guides in making decisions. Most of us recognize the importance of using the required amount of the proper kind of fertilizer at the correct frequency. The three "R's" of fertilizer use provide us with simple rules that prevent us from overlooking important considerations when we do use fertilizer. Using fertilizer properly will give better results than improper use. By properly considering the three RIGHT'S of fertilizer use there is much less likelihood of getting WRONG results.

PRINCIPLES AND PRACTICES OF OVERSEEDING

James M. Latham, Jr., Agronomist
Milwaukee Sewerage Commission

In discussing the overseeding of Bermudagrass greens, we should first think of the reason for doing such a thing. It is the basic job of a golf course superintendent to provide golfers with the best possible playing conditions the greatest number of days per year. This means fall and winter as well as spring and summer.

Some superintendents have done a good public relations job in avoiding the chore of overseeding greens. Through past transition periods their members have been convinced that more harm than good results from winter putting green use. They are then content with a 1,000 dquare foot area cut into the fairway and a few seed strewn over it. This is used from November until March. Most golfers will not even consider such inconvenience. It is not difficult to agree with them.

Some superintendents have chosen grass varieties that produce excellent spring putting surfaces, but do not look nor putt well during the fall and winter. They have, in some ways, let their golfers down by not fulfilling the basic requirement of their job. Certainly this is not malicious but because the grasses are easy to plant or are easier to dispose of in the spring.

There is more and more pressure to improve the year-round playing conditions in some areas. This pressure has encouraged the development of improved planting techniques, the choice of different grasses, better maintenance practices and more thorough utilization of knowledge during the transition period. Let us consider these individually:

Preparation & Planting

One superintendent has stated that his preparation for overseeding begins following spring transition. His entire summer maintenance is keyed to producing good quality turf, an adequate program to combat compaction and the prevention of thatch buildup.

More immediate to the overseeding date, however, we think of a moderate, but complete, renovation. Aeration is a must, since the use of present tools may be too drastic for the cool-season grasses. This should begin 3 to 4 weeks prior to planting.

Fertilization is necessary to assist the new seedlings' establishment. Many superintendents apply an organic nitrogen at the time of aeration to supply adequate N to the bermuda, but little to be on the surface at overseeding. This is though to reduce the incidence of Cottony Blight (Pythium aphanidimatum). A few days before over-seeding, 0-20-20 or similar grade of fertilizer is applied at 10 to 15 pounds per 1,000 square feet. Phosphorus is especially needed in the development of seedlings of small seeded grasses.

Thatch removal by Verticutting is a standard procedure. Spiking has been found especially useful also in preplanting operations. Topdressing before seeding is becoming more popular since fine seeded grasses are sometimes restricted in heavy thatch. Some people top-dress heavily before and lightly after seeding, to sandwich the seed between soil layers.

The chôice of seed is a moot question. Many tests being carried on throughout the South to determine the best grasses to use. This year we have test plots planted from North Carolina to Texas in hopes of finding the turf we want. In the South, redtop and bent trials have been almost complete failures. Ryegrass is still a component in mixtures north of Florida. Seaside plus domestic ryegrass is the most popular mixture where ryegrass alone isn't used. This gives fast growth in the fall and very excellent spring greens. Ryegrass is rather coarse and slow in the fall. It is, therefore, disliked by tourists who have played on bentgrass all summer.

Disease protection is imperative. A great deal of work has been done by Dr. Homer Wells, plant pathologist at the Coastal Plain Experiment Station, Tifton, Georgia. His current recommendation is Captan (16 oz. per 1000) plus Acticione (at manufacturer's recommendation), at planting. Subsequent applications reduce the Captan to about 8 ounces per 1000. Phygon XL is more efficient, but often damages bentgrass.

Maintenance

Winter green maintenance, of course, varies with individual course conditions. Mowing height is sometimes raised after planting then gradually lowered. Some superintendents retain a 3/16 or 1/4 inch cut all year. Frequent mowing is necessary.

Fertilization practices vary, but is generally agreed that an organic nitrogen should be used except in very cold weather. Then, urea or (occasionally) ammonium sulfate is used at very light rates along with ferrous sulfate to keep a pleasant green color.

Where play is heavy, spikers are used frequently to overcome crusting and to provide oxygen for the shallow rooted grasses.

Except during cold weather, a preventive fungicide program is necessary. The seedling turf seldom heals itself adequately after a severe disease attack. Frequent applications, even 3 or 4 times a week may be required during fairly warm, humid weather.

Transition Period

This is the real bugaboo of overseeding. In Georgia this has been found to be less a problem than originally thought. There, experience has shown that traffic and disease during the winter has more adverse effect than the variety of winter grass used. By restricting play during periods when the soil is frosted or thawing, transition has been reduced. Spring deadspot is also thought to cause much of the damage originally laid to ryegrass.

At Peachtree Country Club in Atlanta, Harry Wright uses about 70 pounds of ryegrass per 1000 square feet. He has fewer transition problems than others using only 25 pounds. His practices include play restriction when frost is apparent or when the soil is thawing. With the advent of warm weather, he begins spiking once a week. This produces holes in the ryegrass mat through which the Tifgreen emerges. He manages irrigation so that the ryegrass never quite gets all the water it can use, but short of allowing the grass to wilt. Fertilization levels are kept high to encourage the Bermudagrass growth. Disease prevention at this time is principally toward the leafspot and brownpatch organisms.

With proper management of all factors the superintendent is capable of successful overseeding. Selection of good quality seed is important. Utilization of specialized equipment is a key. Knowledge of plant growth factors is basic. Application of common sense is essential. The superintendent, by using these factors. to his advantage can provide top quality putting greens the year round, without spring or fall transition problems.