Greens which support a dense turf growing in a properly prepared seed bed mixture are resistant to pitting and foot printing even when adequately watered.

Evolution of a Putting Green

by MARVIN H. FERGUSON

Recently an inquirer requested information regarding the depreciation rate of a putting green. Obviously, the person was concerned with a privately owned golf course operated for profit, and he wanted to know how soon a golf green can be expected to wear out. He was told that some of the fine putting greens on old courses had been in existence for many years, and were now as good or better than they were in the beginning.

Our caller persisted. Aren't there many clubs which are rebuilding greens that have been in existence only a short while? He was told that this is, indeed, the case. Then why did these greens wear out? What is the criterion by which life expectancy can be predicted?

He also asked if present day traffic loads were not causing obsolescence of greens which may have been satisfactory in the days when golfers were fewer. We answered that this is true. Some greens become obsolete because of a change in demands made of them. Others might be labeled obsolete the day they are completed because of unsatisfactory construction.

By learning from the experiences of others, by inquiring into the fundamental laws of chemistry and physics, and through an understanding of the physiological phenomena governing the behavior of putting greens, we have made some progress in the matter of putting green construction.

The first serious efforts to determine optimum physical characteristics of soils for putting greens were undertaken by the USGA Green Section in 1947. Through arrangements with Saratoga Laboratories of Saratoga, N.Y., studies were made of the textural composition of "good" and "bad" greens from numerous golf courses. Unfortunately, the studies provided few clues to

A conference group discusses putting green construction and studies a model in the foreground. The thought provoking nature of the discussion shows in the faces of the audience.

explain why one green supported better turf than another.

In 1951 the author had the opportunity to work with a group of civil engineers engaged in paving work, and became acquainted with some of the criteria upon which they judged the suitability of base material for the support of pavement. Their aim was **density** and **stability.** The aim in a putting green soil is to achieve a degree of stability, but certainly not density.

One of the measurements used by the engineer is called the plasticity index. Obviously, plasticity of base material is inimical to support of pavement. Charts are available which indicate the amount of granular aggregrate material necessary to stabilize soils of any given plasticity index. It occurred to us that a similar chart might be constructed which would show the percentage of a given soil which could be used if sand and organic matter were of a specified type.

Raymond Kunze embarked upon a period of graduate study at Texas A&M in 1953, and he chose this subject for his thesis work. As might be expected, the problem turned out to be more complex than it appeared.

Kunze collected cores from putting greens, determined density, made textural analyses and recompacted the material to its original density. He then studied the particle sizes of sands and their influence on turf growth and compactibility. He found that sand particles of fairly uniform size in the range of .5 mm. to 1 mm. were preferable, but securing such uniformly graded sand was generally too expensive to be practical. Some sources provide concrete sand or mason's sand which will serve the purpose satisfactorily. However, one must select carefully because there is much variability in such products.

Kunze also worked with different types of clay. He found that much more kaolinite clay could be used than montmorillonite. Montmorillonite is a highly plastic clay that tends to envelope and cement the sand particles.

A great many mixtures were made up and studied with respect to their ability to support growth under conditions of close mowing and compaction. One interesting observation was that the mixture containing the least sand and the most soil supported the most vigorous turf at the outset. However, as compaction was imposed, the response became completely reversed, and those mixtures containing the greatest amount of sand and least soil were most vigorous.

In 1956, Leon Howard began work toward his Master's degree and he continued Kunze's work. Howard used many different soils and sands, and compared these in field plots and in the laboratory. He found that variations in sand or in soil could be tolerated so long as the mixture produced some common measurable physical qualities in the end product.

He found that in general after compaction, the non-capillary (large) pore space should amount to 12 to 18% of the volume. Capillary (small) pore space should range between 18-27%. Hydraulic conductivity, according to Howard should range between .5 and 1.5 inches per hour. (Note: It has been found that in practice, the upper range is preferable.)

In the meantime, other workers had contributed to the literature, and attempts were made to incorporate these findings into the work Kunze and Howard had done. W. L. Garman, working in Oklahoma, had observed that about 20% of peat, by volume, was the maximum desirable amount. Richard Davis at Purdue and Ray Lunt at ULCA had found that most compaction occurred very near the surface of the soil. Lunt had tried building some greens, using a layer of pure fine sand about 4 inches thick over the existing soil. Such greens were satisfactory, but watering had to be done very carefully.

At about this time Reese Coltrane, superintendent of Lakewood Country Club in New Orleans, built a pitching green using a porous soil mixture on a base of muck from Lake Pontchartrain. The green was almost impossible to keep because the muck pulled moisture from the porous soil mixture very rapidly. Obviously, some way of interrupting this capillary attraction was necessary.

We also learned during this period that Willie Tucker, who was one of the pioneer golf architects in America, used a layer of gravel and manure at a depth of about 9 or 10 inches in greens he built at the University of New Mexico in Albuquerque.

We assumed the gravel was for drainage, but could not understand the purpose of the manure until Mr. Tucker told us that the layers were not necessarily for drainage. They simply broke up the capillary pathway whereby salts from the caliche subsoil crept to the surface. The manure layer above the gravel was Mr. Tucker's way of preventing soil particles from migrating downward and filling the spaces between gravel particles.

We had long been aware of the detrimental effects of texturally different layers near the soil surface. and it had become apparent from the observations cited that layers could be made to serve useful purposes if they were placed deeper in the soil profile. This thinking was reinforced when Charles Wilson brought to our attention some of the demonstrations of Walter Gardner, at Washington State University. Gardner has shown in a dramatic way the effect of

Good design, good contsruction, a well chosen grass, and adequate maintenance contribute to near perfection on some of the modern putting greens.

The Arlington Turf Gardens provided the site for testing many of the putting green grasses now in use. The grass in this picture is the original test plot of Arlington (C-1) creeping bent

layering upon water movement through the soil.

The many bits of information from various sources finally began to permit their fitting together into a concept of putting green construction. In 1957 and 1958, Leon Howard rebuilt the greens at Texarkana Country Club using the method we had devised. In 1958, he rebuilt the greens at Albuquerque Country Club. None of these greens has ever experienced serious trouble. They have been relatively easy to keep, and they continue to be in good condition.

By 1960 we felt we had enough information to publish an article entitled "Specifications for a Method of Putting Green Construction." The method is described in detail in the September 1960 issue of "USGA Journal and Turf Management." An article outlining progress and redefining these specifications appeared in the "USGA Green Section Record" in November 1965.

The articles were controversial. Some people automatically rejected the concept because it emphasized the use of a large proportion of sand, and these people thought the sand content was too high. Others argued that the information available did not justify the advocacy of the method. This view has some justification, but it is a philosophical matter to decide when to publish information which one thinks is an improvement. Inasmuch as it is not practical to declare a moratorium on green construction until the ultimate answer is found, we chose to publish the information available because it appeared to be better than anything previously recommended.

It is our feeling that time has justified our position. The method has proved to be workable under almost any condition. Furthermore, the very fact that the recommendations were controversial has stimulated a great deal of research.

There have been some problems with greens which were purportedly built by these specifications. Most of the problems came as a result of failure to follow directions. One club did no mixing, but simply placed the various components in layers, one on top of another.

One builder used tile in the subgrade base —glazed tile with the bell joints cemented. Obviously, this person lacked an understanding of the manner in which tile works.

A third club built the greens correctly, but sodded them with bentgrass sod grown on a muck soil.

While it is difficult to comprehend the reasons for such errors, the mistakes are so obvious and such serious blunders that one does not worry too much about their being repeated.

Less obvious mistakes, and therefore more likely to occur, are such things as borrowing a neighbor's formula and applying it to soil materials that may be quite different; failure to include a buffer layer to keep soil from migrating into the gravel; leaving out the gravel layer; leaving out the tile; or otherwise taking a short cut that may negate the entire concept of a Green Section green.

There are sometimes problems concerned with learning to water adequately. Learning to fertilize such a green may be the source of some difficulty. There are some legitimate complaints of hard greens when they are first constructed, but this complaint is not very frequent. Grass is more difficult to establish on a sandy soil and this is the source of some complaints.

There is still much to learn about putting green construction and it is gratifying to see a great deal of research effort being expended on the matter. As new information becomes available we shall be able more nearly to approach a trouble-free putting green. It is an evolutionary process that will come about through the piecing together of many bits of knowledge.