A properly built USGA green starts with good drainage.

Thirty Years of Green Section Greens

by **JAMES M. LATHAM**
Director, Great Lakes Region, USGA Green Section

THE PUBLICATION by the USGA Green Section in 1989 of *Specifications for a Method of Putting Green Construction* provided another step in the evolution of practices that enable golf course superintendents to cope with pressure for flawless turf on true, fast, putting surfaces which receive heavier play than ever before. The story of the USGA green actually began in the late 1940s and early 1950s, when studies began on the comparison of soils in "good" greens and "poor" greens. Observations on construction and topdressing mixtures published by the Green Section date from the early 1920s, but the soils were not subjected to scientific scrutiny in soils laboratories until after World War II.

Not all of the greens of that era were poor. Many are still in use and are maintained in the same manner as more recent greens, but it is practically impossible to duplicate them today. The early Green Section specifications closely followed the results of physical analyses of the soils in what were then considered good greens. Attempts to modify the poor greens were usually unscientific and often caused even worse conditions. Snake oils will always be with us to provide the desperate with what they hope will be miracle cures.

One of the early investigations on good versus poor soil conditions was made by R. R. Davis, at Purdue University. He measured water percolation and compared the capillary and non-capillary porosity of soils in putting greens under play. His investigation noted the effect of compaction on reducing the large pore space in the upper 3½ inches of soil, leading to a suggestion that 40% to 50% sand, with particles larger than 0.25 mm, be used in green construction mixes. One of his observations was particularly noteworthy: "In most instances air circulation is believed to be better around the best greens. More trees are found around the poorest greens, and tree roots are prevalent in these greens."

Almost a decade of investigation after this and other research, the USGA Green Section published *Specifications for a Method of Putting Green Construction* in the September 1960 issue of *USGA Journal and Turf Management*.

TABLE I
Changes in specified sand particle size distribution between 1960 and 1989.

— 1960 —
There was no preference indicated. The laboratory made the decision on the proportion of components from any materials submitted.

— 1973 —
The preferred sand had particles of which
100% were smaller than 1.00 mm,
35% were smaller than 0.50 mm,
not more than 15% were smaller than .25 mm,
not more than 5% were smaller than 0.06 mm.

— 1974 —
The statements were simplified to suggest that ideally 75% of the particles should be between 0.25 and 1.0 mm.

— 1989 —
100% should be below 1.00 mm in diameter, with a maximum of 10% below 0.25 mm and a preferred range between 0.25 and 0.75 mm.

It should be noted that laboratories have the capability to deal with almost any components submitted, but may have strong reservations about the playing quality of the finished greens.

TABLE II
Recommended porosities, by volume, of root zone mixtures after compaction.

Porosity	1960	1989
Capillary	15-21%	15-25%
Non-Capillary	12-18%	15-25%
Total	Minimum 33%	35-50%

Increased non-capillary pore space provides more available oxygen for root and microbiological respiration.

TABLE III
Variations in Peat Quality*
(Species of original vegetation was not determined)

Source	pH	% Organic Matter (Loss on Ignition)	Water Holding Capacity %
Canada	3.0	92	713
Minnesota	7.0	86**	832
Michigan	3.5	77	683
Iowa	6.4	61**	222

*Values are reported in percentage by weight.
**The ash in these samples contained significant amounts of silt.

It presented a construction technique that could be used anywhere in the world, including areas where ideal components were not easily or economically available. The strategy was based on developing a growing medium that provided resistance to compaction and drained readily, yet retained an adequate level of capillary moisture and nutrients to sustain turfgrass growth with normal maintenance.

The introductory remarks in the 1960 publication are applicable today:

> The pace of golf activity and the traffic on golf courses is presently at a peak, however, which has never been equaled in our country. Many of the construction methods that were satisfactory in an earlier day, will no longer produce greens which will withstand the wear which is now imposed upon them.

Research into construction procedures and soil mixtures was sponsored by the Green Section at its own research station, in Beltsville, MD, and at Oklahoma State University, UCLA, and Texas A&M. The projects proved that "problems of construction procedures and methods, and those of physical behavior of soils cannot be separated . . . and must be considered together if a desired result is to be produced."

Literature cited in the 1960 specifications provides a list of distinguished researchers who studied the problems and prescribed a means of solving them; R. B. Alderfer, M. E. Bloodworth, R. R. Davis, W. L. Garman, H. L. Howard, R. P. Humbert and F. V. Grau, J. R. Kunze, O. R. Lunt, and A. M. Radko. The key man on the project was Dr. Marvin Ferguson, the Green Section's Director of Research, who worked closely with the soil scientists at Texas A&M University to devise a reproducible means of testing the components of a growing medium for greens. The tests, still in use, are standard procedures in any soils laboratory and require only one special piece of equipment, the compactor, which can be easily assembled.

THE new construction method made use of a common principle of water movement in soil — a perched water table. This principle is graphically illustrated in the time-lapse movie *Water Movement in Soils*, produced by Dr. Walter Gardner, at Washington State University, in 1957. (It should be *must* viewing for any turf manager). This means that water resists flow from a fine-textured soil into a coarser

Sandy soil (Pine Valley)

A 1-1-1 mix (Des Moines)

Dense clay (Louisville)

Figure 1: Note that even though the profiles are uniform, there is a wide variation of components which affect the permeability and porosity of each. (Photos by O. J. Noer, 1952. Courtesy Milorganite Division MMSD.)

material below it until the upper profile has become saturated and gravity overcomes the adhesive nature of water for soil and the cohesive force of water molecules. Thus, even a sandy surface mixture need not be droughty if there is an abrupt change in particle size between the root zone mixture and the drainage layers below. In effect, it made use of stratification (often called layering) for beneficial results.

Prior to these investigations, the soils used in green construction were usually a mechanical mixture of available soil from the vicinity of the green site, some kind of organic matter, and easily accessible sand, in a 1:1:1 or 2:1:1 ratio. Whenever time and materials were available, manure was used and the mixture was composted prior to being put into place on the green site. During the post World War II boom, neither manure nor time was available, so the quality of new greens was suspect from the outset. The popularity of golf meant heavier traffic than originally anticipated on new and older courses, and the failure rate of greens grew, season after season. Various means of reducing soil compaction were devised, but it became apparent that a fundamental change in construction techniques was necessary.

During the 30 years since the original "Green Section Specs" first appeared, there have been many changes in the criteria used to evaluate the playing quality of greens. In the 1950s and 1960s, most of the greens in this country were mown at ¼ inch. The mowing height was often raised on bentgrass greens during the summer and on bermudagrass greens after they were overseeded in the fall. Major USGA championships were played on greens cut at 3/16 inch until the late 1970s. It is unlikely that the turf grown on old soil mixes could withstand present mowing heights or the amount of traffic to which greens are now subjected. (Keep in mind that although many old greens are still in use, their upper profiles have been modified with sand or high sand content topdressing mixtures.)

THERE have been several refinements in the standards set for acceptable mixtures through the past 30 years. Less soil is being used now, since the adverse physical effects of silt and clay on internal drainage have been acknowledged. The particle size distribution of the sand used in the mixture is now a primary concern, as is the quality of organic matter. This evolution is a natural result of the transition from soil to a soilless growing medium, which serves as a means of coping with ever-increasing play and a demand for better putting trueness and speed, shot retention, and overall playing consistency.

Initially, an effort was made to take *any* available sand, soil, and organic source and combine them into an acceptable green. It was basically successful, but some of the creations were hard and required more time to mature than expected. The higher porosity and lower nutrient retention also demanded that these greens be managed differently from the other greens, and this became a problem in some instances. At that time color and the quantity of clippings removed were criteria of turf health. Nevertheless, these greens grew grass quite well where previous attempts were unsatisfactory.

The early acceptance of high-sand greens was hampered to some degree by the experience at courses that built only one or two of them. The new greens had probably replaced one or two of the worst greens on the course and, naturally, played much differently than the comfortably mature 30- or 40-year-old greens remaining, so player resentment ran high until a cushion of turf (thatch and topdressing) was developed. It was, and still is, difficult to run two entirely different management programs in an effort to produce green-to-green consistency.

The prevalence of finer sands in coastal regions and the Central Plains prompted investigations on their use in preference to coarse sand. Apparently, the silt and clay content of the soil used in mixtures with these finer sands presented a major problem in water infiltration and percolation with these mixtures, and a trend away from the use of soil began. The smaller non-capillary pores were more easily plugged by the plate-like silt particles.

On-site mixing failed (Georgia, 1958)

Off-site mixing succeeded (Wisconsin, 1988)

Figure 2: The profiles on the left and right are in greens "mixed" on-site by attempting to disk or roto-till peat into sand. Note varying thicknesses of components in green on left, at a course in Atlanta, Georgia, in 1958 which had been built two or three years earlier. On the right is another non-mixed profile from a new Colorado course in 1986. The profile views were made possible by excavation prior to rebuilding. In the center is the profile of a green in which the components were mixed off-site before placing on the green.

The fine sands found on some beaches and the blow sands of the plains have problems of their own, so the pendulum of change has come to rest in the medium range, where the particles are between 0.25 and 0.50 mm in diameter. This grade should be the predominant size in the sand component of mixtures, although a small percentage of slightly finer and coarser particles seems to lend stability to the final mix. Even so, a sand with a high percentage of round grains requires a period of time to settle down.

WHEN USGA specifications were first published in 1960, they differed significantly from those of 1989 because they were based on data extrapolated from the best soil-based greens in play at the time. For example, the acceptable water infiltration rate (in the laboratory) was in a range from ½ to 1½ inches per hour. This was raised to 4 to 6 inches per hour after a few years, and today the water infiltration rate in the laboratory is not considered to be as important a criterion for selection or rejection of a putting green soil mix, because it changes under field conditions.

Perhaps the most noticeable change in the specifications deals with the selection of sand (Table I). The general dissatisfaction with greens built with concrete or certain masonry sands and the ready acceptance of greens built with more uniform particles in the medium size range brought a major breakthrough in material selection. Medium sand is a technical term and was (and is) confusing to laymen, because it appears to be quite fine grained when subjected to a visual test. Once the terminology was understood, however, the high-sand/low-soil or no-soil mixtures became predominant. There is today a high degree of confidence in using this technique, but only if the components and the final mixture are subjected to testing by an experienced soils laboratory competent in running physical analyses for golf course use. Even small deviations from the specified parameters can be troublesome.

While not as apparent as the recommendations on sand or permeability, the revisions in porosity standards are very important. This change is shown in Table II.

Modifications to the USGA green-building method have been tried by architects and builders over the years. Many of these modifications have failed or have, at the very least, caused maintenance difficulties. Some pure sand greens, for instance, have turned out to be either hard or so physically soft and unstable that the weight of standard equipment leaves wheel marks for several years after play begins,

On-site mixing failed (Colorado, 1986)

depending upon the characteristics of the sand. Excessively deep layers of a topmix have resulted in very dry surfaces, while shallow profiles of topmix have remained very wet. The need for uniformly stratified profiles demands that the final surface contours must be designed into the subgrade.

The principal controversy in the Green Section Method of Construction is the intermediate layer of coarse sand between the drainage bed of $\frac{1}{4}$- to $\frac{3}{8}$-inch-diameter stone and the sandy topmix of particles smaller than 1 mm. Builders do not like it because they say it is difficult to put into place. Some scientists believe the intermediate layer is unnecessary because untrafficked test plugs showed little infiltration of fine particles into the drainage bed.

Questions have also arisen on the use of a geotextile fabric as a substitute. At present, the Green Section's policy is to specify the intermediate sand layer until research and field experience prove otherwise. More than anything else, it ensures a sharp textural interface between the finer material in the topmix and the drainage bed. This is the key to maintaining a perched water table, the principle on which this method of construction is based.

ONE OF THE more difficult problems encountered is the selection of organic components. It can be washed out of sand during the screening operation, but cannot be removed from peats or other organic sources. Unfortunately, it cannot be quantified in the field, so laboratory analyses are mandatory. Table III shows the variations of some peat samples collected in the Midwest. Sometimes, samples from the same source show a lot of variation because peat deposits are not necessarily uniform. This is a good reason to begin the search for high-quality components well in advance of construction time.

Despite their high failure ratio, there are those who think components of greens can be mixed on site by some kind of tillage apparatus. But these builders do not have to manage these greens or pay the higher annual costs involved in maintaining turf quality and playing consistency. Physical laboratory tests of components mean nothing in these cases, since the surface profile cannot possibly be uniform. This is a throwback to the by-guess-and-by-gosh era when turf failure was not uncommon.

Granted, some of these till-in jobs produce acceptable turf until their promoters have been paid and are gone, but the added cost of future maintenance to make up for the fundamental shortcomings in these greens has only just begun. The differences in sand:peat ratios from one area of a green to another, perhaps only a few feet apart, mean the turf will react differently to heat or moisture stress. Fertility retention will also vary, as will the percolation of water through the profile. Figure 1 illustrates what slow learners we can be. Both of these greens, which had been on-site mixed, were being rebuilt in less than five years.

The initial cost of green construction according to Green Section Specifications can be greater than some other methods, but these costs are low when total operations or maintenance costs over the long term are considered. Pay now or pay later has never meant more, and when golfer inconvenience due to poor playing quality is considered, Green Section greens are downright cheap!

Further revisions or fine tuning of the 1989 Specifications may be made in future years, but they will be small. Greens built strictly according to these rules, and properly managed during establishment, are performing admirably. They do require different maintenance than old soil-based greens, but that should be expected. The sandy profiles retain adequate moisture yet provide the quantity of soil oxygen required for root and microbiological respiration. Nutrient retention is not as high as with soil, but the trend toward light and frequent fertilizer applications greatly reduces loss by leaching.

These Specifications encompass a method of green construction in which the Green Section has the utmost confidence. Greens built according to this plan have been widely accepted by golf course superintendents nationwide. More important, though, is the praise these greens are receiving from golfers. That is ample reward for the scientists and superintendents who have worked toward this goal during these 30 years.