A GREEN SECTION RESEARCH PROJECT

The Necessity of the Two-Inch Sand Layer In Greens Construction[1]

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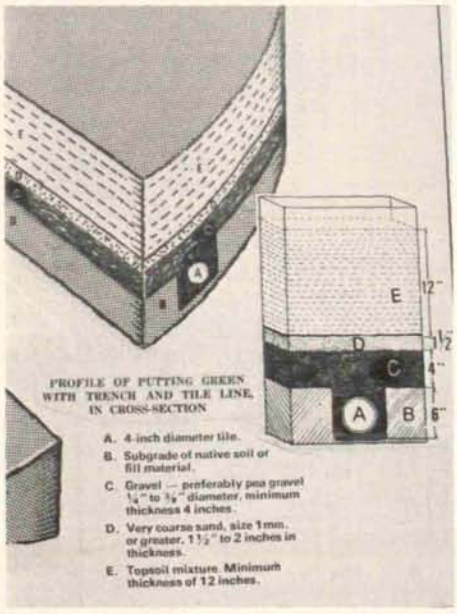
THE USGA GREEN Section, in 1960 and 1973, published specifications for putting green construction which recommend construction in layers. The bottom layer, overlying the subgrade, consists of four inches of pea gravel around a drain tile to insure adequate drainage. A two-inch middle layer of coarse sand is used over the gravel to prevent the soil particles from migrating downward into the gravel and blocking the drain. The 12-inch upper layer usually consists of a mixture of sand, soil, and organic matter and results in the establishment of a perched reservoir of water. The construction of the two-inch sand layer is difficult and expensive, and therefore many seek to omit it. This research was undertaken to determine the effect of the sand layer on the migration of sand and soil particles into the gravel layer.

This work, under the sponsorship of the USGA Green Section, consisted of field and greenhouse phases. Particle migration was assessed in the field in greens which had been installed eight years earlier (Brown and Duble, 1974). Briefly, each of these 21 greens measured 10 feet to a side, hydrologically isolated from one another, equipped with gravel drainage systems and constructed on a raised subgrade to allow for leachate collection. Mixtures used in the field experiment included one replication of 100 percent fine sand, four replications of 90 percent fine sand and 10 percent peat; four replications of 85 percent fine sand, 5 percent soil and 10 percent peat over a two-inch sand layer; four replications of 85 percent fine sand, 5 percent soil and 10 percent peat without a sand layer; four replications of 80 percent fine sand, 10 percent soil and 10 percent peat; and four replications of 100 percent sandy loam soil, two of



(Left) The sand layer involved is the "D" layer in the profile shown.

(Below) Figure 1. Photograph of the lower portion of a field green profile composed of 85% sand, 10% peat and 5% soil directly over pea gravel.

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TABLE 1
Gravel, Sand, Silt and Clay Contents of Samples from Field Greens

Topmix (Sand-Peat-Soil)	Section	% Gravel	% Sand	% Silt	% Clay	% Total Silt & Clay
85-10-5	Topmix	0.8	95.7	2.2a*	1.3a	3.5
with sand	0-2" above sand	1.3	95.2	2.2a	1.3a	3.5
layer	Sand	1.5	95.6	1.8	1.1	2.9
	Gravel	96.7	2.8	—	—	0.5
85-10-5	Topmix	2.0	93.9	2.5a*	1.6a	4.1
without sand	0-2" above gravel	2.2	93.2	2.4a	2.2a	4.6
layer	Gravel	95.3	3.9	—	—	0.8
100-0-0	Topmix	0.9	96.3	2.4	1.4	2.8
without sand	0-2" above gravel	0.3	96.2	2.5	1.0	3.5
layer	Gravel	93.9	4.1	—	—	2.0
90-10-0	Topmix	0.2	95.6	2.5	1.7	4.2
without sand	0-2" above gravel	0.9	96.2	5.0	1.9	6.9
layer	Gravel	94.4	4.8	—	—	0.8
80-10-10	Topmix	1.2	94.4	2.9	1.5	4.4
without sand	0-2" above gravel	1.3	91.8	4.4	2.5	6.9
layer	Gravel	95.5	3.8	—	—	0.9
0-0-100	Topmix	0.0	82.0	15.0	3.0	18.0
with sand	0-2" above sand	0.0	82.4	15.0	2.6	17.6
layer	Sand	0.7	96.8	1.5	1.0	2.5
	Gravel	96.9	2.4	—	—	0.7
0-0-100	Topmix	6.8	80.8	15.2	3.2	18.4
without sand	0-2" above gravel	13.7	71.6	12.0	2.7	14.7
layer	Gravel	92.9	4.9	—	—	2.2

*Values in a given column of a given treatment followed by the same letter do not differ significantly at the 5% level.

which were directly over gravel and two of which were over a two-inch sand layer. Of the mixtures used, the 85-10-5 and 80-10-10 mixtures would be considered USGA mixes. The pure sand and 90-10 sand-peat mixes were too deficient in water retention to be considered USGA mixes. All plots were planted to Tifdwarf bermudagrass. To assess the particle migration, six-inch diameter holes were dug in the greens down to the gravel base. Samples were taken of the gravel, two-inch sand layer if present, the zero to two inches of topmix immediately above the gravel or sand layer, and a composite sample of the remaining top mixture. All samples were analyzed for sand, silt and clay contents.

THE RESULTS FROM plots constructed with 85-10-5, 90-10-0 and 80-10-10 sand-peat-soil mixtures in the absence of a sand layer indicate that there was no particle migration into the gravel drainage layer. Slight accumulation of about 2 percent total silt and clay was measured in the gravel below

TABLE 2
Physical Properties of the Three Sands and Two Gravels

					SAND FRACTIONS				
Sand	Gravel > 2mm %	Total Sand .05-2mm %	Silt .002-.05mm %	Clay < .002mm %	Very Coarse 1-2mm %	Coarse 0.5-1mm %	Medium 0.25-5mm %	Fine 0.25-.5mm %	Very Fine 0.05-.1mm %
A	0.0	96.2	1.9	1.9	5.2	23.4	50.6	14.8	2.2
B	0.1	98.1	0.3	1.5	0.2	5.8	66.8	22.9	2.4
C	1.5	96.7	2.9	0.4	16.6	27.3	39.2	11.3	1.8

Gravel	>12.7mm	12.7-9.5mm	9.5-6.35mm	6.35-4.0mm	4.0-2.0mm	> 2.0mm
Pea	0.0	0.5	2.1	64.5	30.1	2.9
⅜"	13.4	48.5	24.9	13.0	0.0	0.1

TABLE 3
Physical Properties of the Three Top Mixtures

MIXTURES Sand	Soil	Amndmnt.	Gravel 2mm	Total Sand .05-2mm %	Silt .002-.05mm %	Clay .002mm %	Bulk Density g/cm^{-3}	% PORE SPACE Capillary	Non. Cap.	Inf. Rate in. of H_2O/hr.	40 cm of H_2O Retention %
—— % by volume ——											
60A	20	20	0.0	94.7	3.1	2.2	1.36	20.2	28.8	7.8	14.8
60B	20	20	0.0	95.6	2.3	2.1	1.33	20.2	29.6	9.2	15.2
60C	20	20	0.0	95.0	3.1	1.9	1.45	17.3	28.0	7.1	11.9

Figure 2. Photograph of the profile of a greenhouse green composed of topmix B overlying a two-inch sand layer over 1 cm gravel.

the 100 percent sand plot and also below the 100 percent soil plot without a sand layer. The movement of silt and clay from the 100 percent sand into the gravel indicates that if this sand were used for the sand layer, it very likely would not prevent sand and silt movement into the gravel. Also, the case of 100 percent soil plot without a sand layer indicates that only very small amounts of silt and clay will move, even though large amounts may be present in the overlying topmix. An extensive root system network extending down to the gravel layer may have been instrumental in binding the soil together and preventing migration (Figure 1).

In the greenhouse study, golf green profiles were constructed in 12-inch diameter metal cylinders equipped with drainage ports at the bottom. Four inches of pea gravel or ⅜-inch gravel were placed in each cylinder (Table 2). Two inches of sand C (Table 2) were added to one-half of the cylinders of each gravel size to act as the specified sand layer. Top mixtures of three sands (fine, medium, and coarse) A, B and C with Lakeland soil and peat moss (Table 3) were designed according to the USGA specifications and placed above the sand layers. A cover of Tifdwarf bermudagrass was established and the equivalent of 100 inches of water was passed through the profile. Profiles using topmix A (60A-20-20, Table 4) showed no evidence of vertical silt and clay movement. The total silt and clay content in the overall topmix was 3.1 percent and only 3 percent immediately above the sand layer. When the sand layer was omitted the overall topmix silt and clay content was 3 percent and only 3.5 percent above the gravel layer. The presence or absence of the two-inch sand layer made no significant difference in the total pore space reduction in the gravel layer due to particle migration (Table 5). Profiles constructed using USGA mixtures of sands B and C with Lakeland soil and peat moss behaved similarly and did not exhibit any significant particle migration into either the sand or gravel layers (Figure 2).

THUS, BOTH THE data from eight-year-old field greens and simulated green profiles in the greenhouse which had been subjected to prolonged

saturated flow, indicate a lack of downward silt and clay migration in golf greens built to USGA standards. In all cases, no significant effect of the two-inch sand layer was evident when proper size gravel was used. Thus, with properly sized gravel, a minimum amount of top mixture is washed into the gravel layer, and the presence of a coarse sand layer does not influence the amount of mobile materials. It is possible that most of the migrations take place during construction or shortly after, before grass roots have completely penetrated the top mixture. In all cases, the grass roots had penetrated down to the gravel layer by the time measurements were made, and they may have been instrumental in binding the topmix materials together and thus preventing particle migration.

Editor's Note — Please read carefully and note that only under certain circumstances can the sand layer be eliminated in putting greens built to USGA Green Section specifications. This is possible only when the particle size relation between the gravel and the top mixture (layer E in cross section profile on page 1) is correct. This means the use of pea gravel, where commercially available, or crushed stone in the ¼ to ⅜ inch range and a top mix that meets specifications described in the article "Refining The Green Section Specifications for Putting Green Construction," USGA GREEN SECTION RECORD, Vol. 11, No. 3, May, 1973. The recommendation for eliminating the two-inch sand layer *can only be determined* by physical soil analysis in laboratories equipped to test soils to USGA Green Section specifications for putting green construction.

TABLE 4

Gravel, Sand, Silt and Clay Contents of Topmix A from Greenhouse Greens

Topmix (Sand-Peat-Soil)	Gravel Size	Section	% Sand	% Silt	% Clay	% Total Silt & Clay
60A-20-20 with sand layer	Pea	Topmix	97.0a*	1.8a	1.3a	3.1a
		0-2" above sand	93.3a	2.3a	1.4a	3.7a
		Top sand layer	99.1a	0.5a	0.5a	1.0a
		Bottom sand layer	99.3a	0.4a	0.3a	0.7a
		Top gravel	8.8a	NA**	NA	0.8a
		Bottom gravel	4.0b	NA	NA	0.7a
60A-20-20 without sand layer	Pea	Topmix	97.0a	1.9a	1.1a	3.0a
		0-2" above gravel	96.4a	1.9a	1.6a	3.5a
		Top gravel	6.0a	NA	NA	0.9a
		Bottom gravel	5.0a	NA	NA	0.8a

*Values in a given column of a given section followed by the same letter do not differ significantly at the 5% level.

**Not analyzed.

TABLE 5

Percentage of Pore Space in Four-Inch Gravel Layer Filled with Sand, Silt and Clay after Passage of 100 Inches of Water Through Greenhouse Greens

			% Pore Space Lost Due to:		
Topmix Sand-Peat-Soil	Gravel	Presence or Absence of Sand Layer	Sand	Silt	Total Sand, Silt & Clay
60A-20-20	Pea	With sand layer	10.7a*	1.2a	12.0a
		Without sand layer	9.0a	1.4a	10.4a
60A-20-20	⅜"	With sand layer	4.5a	1.3a	5.8a
		Without sand layer	15.0a	1.4a	16.4a

*Values in a given column of a given gravel size followed by the same letter do not differ significantly at the 5% level.

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