# Engineering Characteristics and Maintenance of Golf Putting Greens


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**Goals:**

- *Study the engineering characteristics of sands used in putting green construction to ensure a stable and agronomically sound rootzone mixture.*
- *Compare post grow-in (3-7 years) changes which occur under traffic on a USGA specification putting green to two other construction methods for differences in putting green quality and speed as well as long term differences in the organic matter, rooting, edaphic and nutritional characteristics.*

**Cooperators:**

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***Phase I***

To initiate the project, the strength of the selected sands were evaluated under dry and moist conditions. Even though putting greens are not built with dry sands, we need to understand how these sands behave under different moisture levels. From the literature review, we know that bulk density, porosity, moisture content, and particle-size distribution influence sand behavior.

There were no surprises for the tests evaluating soil bulk density before and after compaction under both dry and moist conditions. The data confirm that bulk density increases with compaction.

The results of sieve analysis for cohesionless soils are presented as grain-size distribution curves. The diameter in the grain-size distribution curve corresponding to 10 percent finer is defined as the effective size $D_{10}$; 60 percent finer is $D_{60}$. The uniformity coefficient, Cu, is then expressed as $Cu = D_{60}/D_{10}$. A higher value of Cu indicates the soil sample is well-graded.

Friction angles of six sands were determined when dry. The friction angle is determined by plotting the relationship of normal stress (confining force) verses shear stress (pulling force). The angle of the resultant regression line yields the friction angle. As this angle increases, more energy is required to shear the soil and indicates a the sand will have a higher bearing capacity.

The greatest friction angle was derived from the compacted, well-graded sand. The lowest angle was derived from an uncompacted, uniform sand sample. From the review of the literature, this is the expected result. In order to increase the strength and stability of high sand putting green root zone mixtures, the particle-size distribution should be increased, resulting in a higher uniformity coefficient (Cu).

There are some agronomic disadvantages of increasing the Cu of sands. For example, we find a greater reduction in soil porosity after compaction with the well-graded sands as compared to the uniform sands. Although we have not yet measured the hydraulic conductivity of these sands, the implication is that the well-graded sands would yield a lower conductivity than the uniform sands.

We feel we are making substantial progress in understanding the variables that control the engineering properties of high sand content root zones. We know the wider the particle-size distribution of the sand, the greater will be its friction angle and the greater will be its strength and bearing capacity. Agronomically, as the distribution of the sand is widened, soil porosity decreases. With a decreased porosity, saturated hydraulic conductivity will also decrease.

During 1997, we will concentrate our efforts on completing the testing matrix of the six selected sands, determining agronomically important effects, and expanding our testing to the field with the CBR (California Bearing Ratio) testing device to better understand the conditions in the field.

***Phase II***

The research answering this set of objectives is conducted on a 14,400 ft$^2$ (120 x 120 ft) experimental putting green constructed in summer 1992 and seeded in spring 1993. The three rootzone mixes are: an 80:20 (sand:peat) mixture built to USGA recommendations, a 80:10:10 (sand:soil:peat) mixture built with subsurface tile drainage; and an unamended sandy clay loam textured (58% sand, 20.5% silt, and 21.5% clay) "push-up" style green. These putting greens are 1,600 ft$^2$ (40 x 40 ft), replicated three times, and have individual irrigation control.

The area was mowed six times a week at a 0.157-inch cutting height. To simulate golf course management practices, the entire experimental area was sand topdressed lightly and frequently throughout the growing season. Each of the nine subplots were irrigated as necessary to prevent moisture stress. Core cultivation was performed in fall 1996 with a vertically operating, hollow-tine unit.

Traffic to simulate wear on a putting green was applied 6 times per week with a triplex greensmower modified with spiked rollers in lieu of reel units. The rollers are 60 cm long and 20 cm in diameter. Metal spikes (6 mm) are spaced at 2.5 cm intervals on the unit. Data was collected with a Stimpmeter three hours after rolling in 1996.

The most significant finding regarding green speed was obtained from the "roll then mow" data. When talking with golf course managers and students who return from internships, it was learned that greens are often rolled first and then mowed. This most likely occurs because rollers and mowers are on the course at the same time. With this scenario, there was a substantial decrease in green speed compared to the gain recorded for the "mow then rolling" treatment.

Color and quality ratings of the putting greens were recorded over the growing season. Though not always statistically significant, rolling appears to have decreased color and quality. It is noteworthy that the 80:10:10 mix suffered a large decrease in color and quality after 14 weeks of rolling.

Dollar spot data was collected in 1995 and 1996. In 1995, differences in dollar spot activity were observed between rolled and unrolled plots as the year progressed. In 1996, dollar spot activity was statistically significant on most dates, with the rolled plots showing two- to three-fold decreases in dollar spot severity.

In July 1996, soil physical properties were determined from putting green samples. Measurements include bulk density, total porosity and porosities at 0.04, 0.1, and 0.33 bar. No significant differences occurred between rolled and non-rolled plots for bulk density and total porosity. However, at 0.04 bar the rolled USGA and 80:10:10 greens had significantly less macropores than their non-rolled counterparts. The 80:10:10 mix also had less porosity at 0.1and 0.33 bars.

The preliminary results indicate that light weight rolling decreased macro-porosity without decreasing total porosity This could explain why less localized dry spot was observed on the rolled plots. Also of interest, was that more nitrogen was found in the clippings from the rolled plots. This may be linked to the decrease in macropores and the presence of less dollar spot and increased pink snow mold activity on the rolled plots. Certainly, more data is necessary before any conclusions can be drawn.

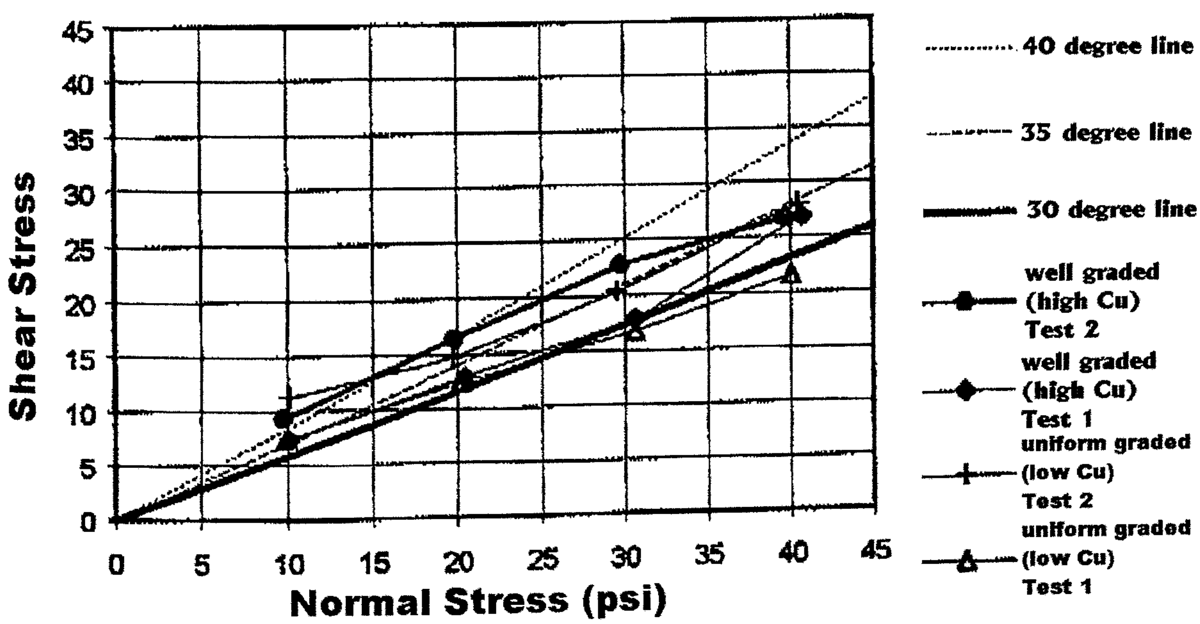


**Figure 17. Plot of shear stress verses normal stress for the intermediate sized, well graded (high Cu) and uniform sands (low Cu) before and after compaction.**

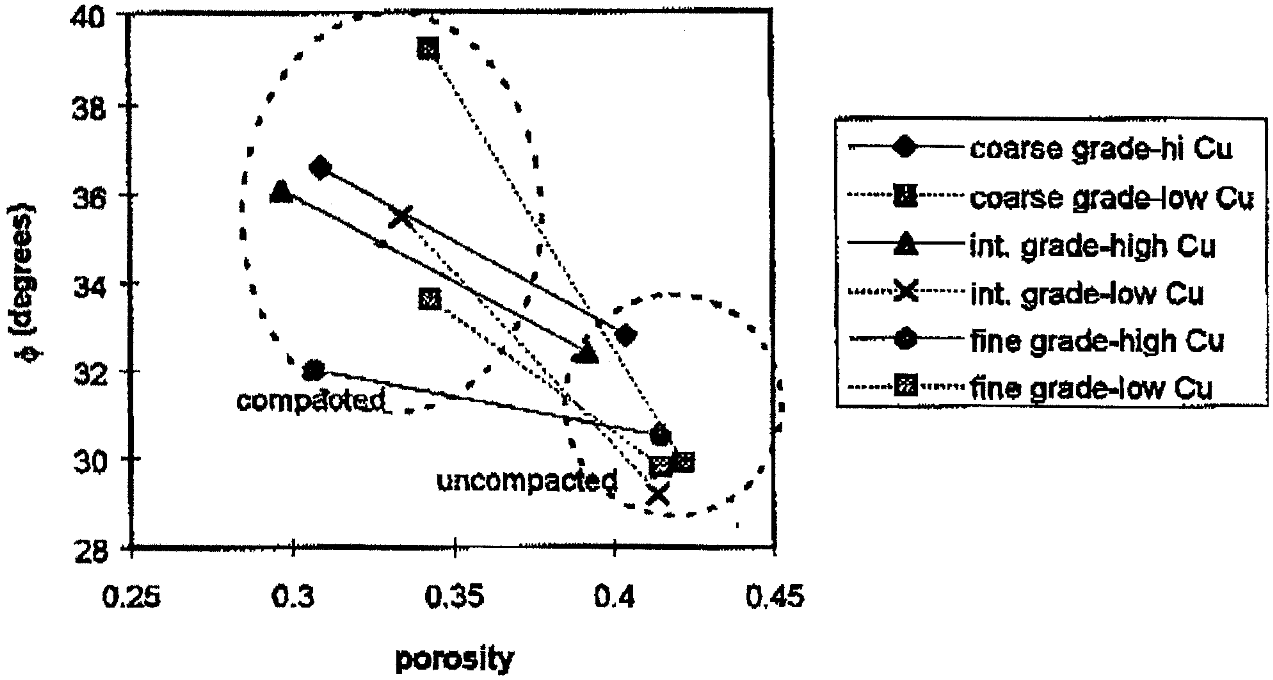


**Figure 18. Plot of porosity versus friction angle (Φ) before and after compaction of the six selected sands.**

**Table 13. Soil physical properties for three putting green construction methods measured four years after construction.**

| Treatment | Bulk Density | Porosity 0.04 bar | Porosity 0.1 bar | Porosity 0.33 bar | Total Porosity |
|---|---|---|---|---|---|
| USGA Rolled | 1.57 | 20.7 | 24.7 | 26.0 | 40.7 |
| USGA Check | 1.54 | 23.0 | 27.0 | 28.0 | 41.0 |
| 80:10:10 Rolled | 1.62 | 11.0 | 14.7 | 17.3 | 38.0 |
| 80:10:10 Check | 1.57 | 14.3 | 19.0 | 21.7 | 38.3 |
| Native Rolled | 1.72 | 6.7 | 8.7 | 10.7 | 36.3 |
| Native Check | 1.71 | 5.3 | 7.0 | 8.3 | 36.3 |
| Prob. @ 0.05 | ns | 0.029 | 0.027 | 0.013 | ns |
| $LSD_{0.05}$ | | 2.3 | 2.8 | 2.7 | |