Methods for Classifying Sand Shape and the Effects of Sand Shape on USGA Specification Rootzone Physical Properties

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Goals:

- *Determine if a simple, inexpensive and quantitative procedure can be used to give a reliable estimate of sand shape without having to examine individual grains.*
- *Determine the effect of sand shape on the physical properties of rootzone sands and whether particle size distributions of USGA rootzone sands should be modified to account for differences in sand shape.*

Cooperators:

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Sand shape has been shown to have an influence on soil bulk density, compactibility, total porosity, aeration and capillary porosity, playing surface stability, and root penetration. However, specifications and recommendations concerning the shape of sand for use in USGA rootzone mix construction is lacking. The purpose of this project is to determine a fast, inexpensive and quantitative way to determine the shape of sands used in putting green rootzone mixes. In addition, we will determine the effect of shape on rootzone mix physical properties.

Our methodology for determining sand shape involves visual and mechanical assessments. The visual methods being tested include the *Riley Sphericity Index* and a *Krumbein Roundness Chart*. These methods are subjective. Another way for determining sand shape may be through the use of the shape analysis software program ArcInfo. This software was developed for global information systems and land analysis. ArcInfo determines the number and lengths of arcs required to outline the sand grain silhouettes, as well as perimeter lengths, volume and axis lengths.

Mechanical methods being tested include: *1) Direct Shear Method* - This determines the amount of sidewards force (shear force) required to cause the sand to slide over itself while a static downward force is being applied. An angular material should require more shear force than a round material. So far we are finding that mixtures of sand sizes and compaction help to delineate between round and angular sands; *2) Rotatable Drum Method* - This method determines the critical angle that an uncompacted sand can reach before it begins to avalanche. Our angular sand has a greater critical angle than the round sand, but further testing is still needed to maximize these differences; *3) Dense Soil Angle of Repose* - In this technique the sand is compacted with a vibrator and then tilted until it fails at some critical angle. As in the rotatable drum method, the critical angle should be related to the surface characteristics of the sand. We are currently building the apparatus required to perform this test; and *4) Cone Penetrometer* - The force required to push a cone-shaped tip into a confined sand sample is measured. An angular sand should offer more resistance. We have not begun testing this method yet.

We are also determining the physical properties of the sand materials as outlined by USGA guidelines while visual and mechanical tests are being performed. Recently we have completed USGA testing on the round and angular sands when mixed with different proportions of fine or coarse peat, as well as with small amounts of a silt loam soil.

Table 15. Comparison of physical properties of 0.25 mm fractions of a round, spherical sand and an angular, non-spherical sand. Compacted data are shown in parentheses.

Parameter	Round Sand	Angular Sand
Bulk Density	1.62	1.52 (1.8)
Total Porosity (v/v)	39.2	45.8 (16.4)
Aeration Porosity (v/v)	33.1	32.2 (4.3)
Capillary Porosity (v/v)	6.1	13.6 12.1)
K_{sat} (in/hr)	74.5	32.9 (12.0)
Sphericity Index	0.87	0.77
Krumbein Roundness	0.83	0.57

Table 14. Internal friction angle values for a round and angular sand under different uniformities and bulk densities.

Shape	Size	Bulk Density	Friction Angle
Round	0.25 mm	1.4	34.0
Angular	0.25 mm	1.4	35.5
Round	Mix[1]	1.4	39.0
Angular	Mix	1.4	35.5
Round	0.25 mm	1.5	38.7
Angular	0.25 mm	1.5	36.9
Round	0.25 mm	1.6	45.0
Angular	0.25 mm	1.6	36.0
Round	Mix	1.5	39.8
Angular	Mix	1.5	33.7

[1] Mix = 0.5 mm:0.25 mm:0.15 mm sand in ration 8:10:2