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.*

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Sand shape may contribute to the physical properties of a rootzone mixture because shape can have an effect on bulk density, total porosity, air-filled and capillary porosity, and saturated hydraulic conductivity. Sand grain shape may also influence the stability of the playing surface because of its effects on how individual particles can lock together. Sand shape is currently determined by visual ratings. These ratings are difficult and quite subjective. The purpose of our project is to: 1) determine a non-subjective method for measuring sand grain shape; and 2) determine how sand shape influences rootzone mix physical properties.

Our methodology for determining sand shape involves visual and mechanical assessments of sand shape. While these visual and mechanical tests are being conducted on our sands, we also have been determining the physical properties of the sand materials as outlined by USGA specifications. At the end of this study we will be able to state if any of our methods can accurately determine shape and how shape relates to the physical properties of the rootzone mixes.

The physical properties of a round (smooth) sand and angular (rough) sand having similar sphericities have been measured alone or in various combinations with peat and/or soil. The round sand had a higher bulk density (BD), lower total porosity (TP), lower air-filled porosity (AP), higher capillary porosity (CP), and lower saturated hydraulic conductivity (Ksat) than the angular sand. This is due to the round sand grains having a tighter soil matrix because it can settle more easily than the angular sand.

These round and angular sands were tested in three-way mixes made of sand, peat and soil. To summarize these findings, shape did have an impact on the changes that occurred in bulk density, total porosity, capillary porosity, and aeration porosity when amendments were added. However, any effect of sand shape on these physical properties only resulted in minor changes in saturated hydraulic conductivity.

Mechanical methods being tested include:

- *Direct shear method - this determines the amount of sidewards force (shear force) required to cause the sand to slide over itself while a downward force is being applied. An angular material should require more shear force than a round material due to the frictional resistance of the individual grains towards sliding;*
- *Rotatable drum method - this method determines the critical angle that an uncompacted sand can reach before it begins to avalanche. A less smooth and less spherical sand should have a greater critical angle than a smooth, spherical sand;*
- *Dense soil angle of repose - In this technique the sand is compacted with a vibrator. The sand is 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; and*
- *The cone penetrometer - The force required to push a cone shaped tip into a confined sand sample is measured. A spherical, round sand should offer less resistance than a non-spherical, non-round sand.*

The direct shear method, an excepted mechanical engineering procedure for determining the strength of non-cohesive soils, has not been able to separate sands due to their shape. The procedure gives good reproducible results but angular, sub-angular, sub-rounded, and rounded sands yield approximately equal internal friction angles.

The dense soil angle of repose method gives reproducible results for separating sands after they are densified at 40 volts. Round sand strength increases as voltage increases until 80 volts is applied after which the sand can no longer be compacted. The angular, sub-angular, and sub-rounded sand mixtures have greater strength than the round sand mixture up until 50 volts. These sands then weaken. This method appears promising for the separation of differently shaped sands.

Another promising method for sand separation is cone penetrometry. In studies conducted this year we have been able to separate rounded sands from angular sands. Further work is necessary to determine if we can separate a round sand from a sub-rounded sand, or a sub-angular sand from an angular sand.

Work on the computer imaging sand shapes includes two principal software methods. Parameters include: (a) number of line segments defining the polygon perimeter, (b) polygon area, (c) average length of line segments, (d) perimeter length, (e) average angle of deviation formed by two connected line segments, and (f) major and minor axis lengths. Correlation between graphical shape parameters and sand grains of pre-determined shape class will be calculated to determine if the shape parameters can be used to effectively classify sand shape.