Root Zone Bulk Density

by Larry Stowell, Ph.D.

The bulk density of a soil is a combination measure of the particle density and how tightly packed the particles are in the sample. Under ideal conditions, the bulk density of a soil is a measure of soil pore space and can therefore provide important information on the degree of compaction on golf course greens. In this article, the theoretical basis behind the bulk density measurement will be reviewed and its possible applications will be discussed through presentation of data recently generated at California golf courses.

Theory
Under ideal USGA specification greens construction conditions, a root zone sand will have 50% total pore space and 50% solid sand particles. The size of the pores are also important because a root is seldom smaller than 60 um (micro meters, 60 millionths of a meter) in diameter. If the pores are smaller than 60 um, the root must be able to move the particles out of its path (Adams and Gibbs, 1994). If the soil is too compacted, the root will not be able to penetrate the soil. The 1/4 inch hollow core aeration programs that have recently become more popular will greatly improve soil porosity and reduce bulk density until the holes close and become compacted again.

Bulk density alone, however, does not provide sufficient information to accurately determine the level of soil porosity and compaction. The particle density must also be known. Pure quartz has a density of 2.65 g/cm^3 (grams per cubic centimeter, water weighs 1 g/cm^3 at standard temperature and pressure). Southern California silica sands also have a particle density of 2.6 g/cm^3. However, some sands are composed of calcite (lime) materials that have a particle density of 2.83 g/cm^3. And organic matter has a low particle density of about 1.5 g/cm^3 (Carter, 1993). Each root zone mix will have a different particle density based on the ratios of these and other components to one another.

Figure 1. Solid quartz parent material of many silica sands in Southern California. Particle density of the parent material is 2.6 g/cm^3.

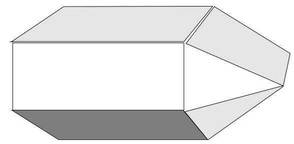


Figure 2. Quartz root zone sand that meets USGA particle size specifications. The bulk density will be around 1.5 g/cm^3. Note that uniform size prevents tight packing of the particles and results in pores.

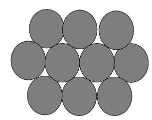
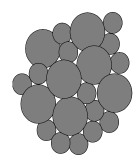


Figure 3. Quartz root zone sand of mixed particle sizes. The bulk density is about 2.0 g/cm^3. Note that the compacted sand with mixed particle sizes will pack more tightly and result in a bulk density closer to that of the parent material.



Field evaluation of root zone bulk density was conducted at Mesa Verde Country Club with cooperation of Reed Yenny and La Jolla Country Club with cooperation of Bruce Duenow.

To interpret the results, let's make a crude assumption that the particle density of all of the sands discussed below is equal to quartz, 2.65 g/cm^3. For ballpark purposes, Table 1 illustrates the change in total porosity with changes in bulk density using this assumption.

Table 1. Total porosity and corresponding bulk density when the sand is assumed to have a particle density of 2.65 g/cm3. USGA specifies between 35% and 55% total porosity is needed for proper greens performance.

Bulk Density g/cm^3	% total porosity
1.5	43.4
1.6	39.6
1.7	35.8
1.8	32.1
1.9	28.3
2.0	24.5

A USGA root zone sand should have between 35% and 55% total porosity. Using the quartz particle density assumption, sands with a bulk density greater than 1.72 g/cm^3 will not have sufficient porosity Only the nursery without traffic at Mesa Verde (see data below) reported a bulk density that provided the minimum porosity specified by USGA.

The first measurements were collected from a bentgrass nursery at Mesa Verde CC that only experiences light compaction from mowing. Three replicate samples were collected from 0-2 inches and three replicates from the 2-4 inch depth. If the soil is not compacted, both the 0-2 and 2-4 inch depths would have equivalent bulk densities, below 1.72 g/cm^3. The bulk density of the top 2 inches was 1.71±0.06 g/cm^3. The 2-4 inch layer was 1.65±0.03 g/cm^3. Analysis of variance did not detect a difference between these two layers at the 95% confidence level. In other words, there was no difference between the 0-2 inch and 2-4 inch layers, and assuming the particle density was 2.65 g/cm^3 the root zone mix was not severely compacted and would have approximately 36% pore space.

Several other greens were sampled at Mesa Verde to provide a range of bulk densities. An old green reported a bulk density of 1.87 g/cm^3 in the 0-2 inch layer and 1.93 g/cm^3 for the 2-4 inch layer. A green that was constructed with USGA specification root zone sands within the past few years reported a bulk density of 1.84 g/cm^3 in the 0-2 inch layer and 1.89 g/cm^3 for the 2-4 inch layer. Because these values were greater than 1.72 g/cm^3, some degree of compaction is indicated here. These ball park values provide some guidance in developing additional testing methods. When coupled with particle density, which we plan to measure in 1996, they will provide a more accurate assessment of pore space and compaction, and possibly aid in determining how frequently aeration is needed.

Similar sampling was conducted at La Jolla Country Club on a practice putting green that was divided into two areas. One area was designated "no-spikes" where tennis shoes or soft spikes could be worn. The other area was designated for conventional spikes. The visual difference between turfgrass quality was obvious with the no-spikes area providing the higher quality turf. However, the number of golfers using each side of the practice putting green is unknown. When bulk densities were compared between the two areas (Table 2), there were no significant differences in bulk density between the no-spike area and the spike area. However, there was a significant difference between the 0-2 inch depth and the 2-4 inch depth with the deeper samples having a significantly higher bulk density. The lower values for the 0-2 inch measurements at Mesa Verde and La Jolla probably reflect the success of aeration programs in place at both courses.

Table 2. Results of bulk density evaluation on practice putting green at La Jolla Country Club. No-spikes refers to an area where shoes without spikes or with soft spikes were worn. Spikes refers to an area where conventional spikes were worn. Values followed by the same letter are not significantly different (Fisher's LSD, p,0.05).

Sample Depth	Bulk Density g/cm^3
0-2 inches	
no-spikes	1.81 a
spikes	1.85 a
2-4 inches	
no-spikes	1.97 b
spikes	1.91 b

How much porosity is needed to grow healthy turf? We don't know yet. However, most, if not all, California golf course greens have lower total porosity than is optimum. Aeration is a critical component of greens management and the preliminary bulk density measurements indicate that more aeration is needed. The value of using bulk density and particle density measurements to evaluate existing root zone mixtures will be investigated further in 1996. The preliminary data are encouraging because the factors leading to short rooting depths are now beginning to come to light and corrective measures might now be investigated further.

A New Disease of *Poa*?

by Larry Stowell, Ph.D.

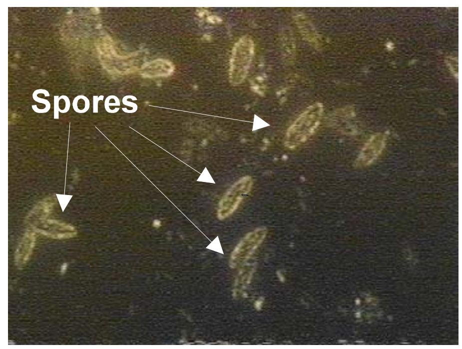
As a rule of thumb, new diseases do not happen. However, after seeing what appears to be a new pathogen for a couple of years, I have become concerned that we have a new turf disease killing poa in California. The first description of the disease symptoms and a brief sketch of what the pathogen may be are listed below. In order to arrive at a speedy solution to the question of whether this is really a new disease and what methods we should incorporate to control the problem, Dr. Houston Couch at Virginia Polytechnic Institute has been recruited and is also working on the identification of the organism.

The disease looks something like dollar spot in some cases with small quarter to dollar size spots of bleached foliage and water soaked margins. The disease appears rapidly with healthy turf dying over a weekend in several cases. The disease does not appear to move rapidly from the initial infection centers. However, several closely spaced infection zones can coalesce into large patches of dead turf. The patches of the new disease appear more distinct and smaller (with the exception of where patches coalesce) than pink snow mold, which is also distinguished by the reddish color of its patches.

The pathogen resembles a primitive group of water molds called Chytridiomycetes. There are at least four species that have been described to attack the genus *Poa*. They include *Physoderma alpina*, *P. gerhardtii*, *Synchytrium graminicola*, and a *Synchytrium* spp. (Farr et. al. 1989). This group of fungi is known to cause diseases on poa but they have not been described to attack sports turf. The Turfgrass Information File (TGIF) had zero citations for these organisms.

The reason why these organisms are not frequently subjects of research is because they are difficult to handle. The Chytridiomycetes are obligate parasites. They require a living host to grow and reproduce. This greatly reduces a researchers ability to study and understand the organism's genetics, physiology and interaction with the host.

The digital micrograph below is the first published look at the alleged pathogen. Its spores or sporangia are thin walled and about 7X25um in size. Determining whether this is really a new pathogen will require additional study.



Control has been evaluated using Subdue (2 oz/1000 sq ft) in combination with Fore (4 oz/1000 sq ft) at Santa Ana Country Club by David Zahrte who had the disease hit a single green. The disease appeared to be stopped by the application. However, a non-treated area also appears to be recovering. Once the pathogen has been confirmed to be the cause of the disease, additional control methods can be evaluated. Several years will be needed to characterize and understand this new disease.

References:

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